NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT
BIOLOGICAL OPINION

Agency: Federal Energy Regulatory Commission (FERC)

Activity Considered: **Amendment of License for the Mattaceunk Project**
F/NER/2013/9640

Conducted by: National Marine Fisheries Service
Northeast Region

Date Issued: 6/20/13

Approved by: [signature] for JOHN BULLARD
MORRIS

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1. INTRODUCTION AND BACKGROUND

This constitutes the biological opinion (Opinion) of NOAA's National Marine Fisheries Service (NMFS) under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543) concerning the effects of the Federal Energy Regulatory Commission's (FERC) approval of an application to amend the operating license of the Mattaceunk Project (P-2520). FERC is proposing to amend the Mattaceunk Project license to incorporate provisions described in a proposed Interim Species Protection Plan (ISPP) for Atlantic salmon that was filed by Great Lakes Hydro America, LLC (GLHA or Licensee). The ISPP also contains measures to protect and monitor Atlantic salmon during necessary repairs to a roller gate and fishways at the project. The Mattaceunk Project is an existing hydroelectric project on the Penobscot River in Maine.

In a letter February 28, 2013, GLHA requested that the license for the Mattaceunk Project be amended to incorporate the provisions of a six-year ISPP (2013-2018). FERC designated GLHA as its non-federal representative to conduct informal ESA consultation in a letter issued March 23, 2013. The specific measures contained in the ISPP that would be incorporated by FERC into the license of the Mattaceunk Project would require GLHA to: 1) immediately expand the period that the downstream fish passage facility is operated; 2) immediately initiate use of the log sluice as the primary spillage route; 3) develop a protection plan for Atlantic salmon specific to the roller gate repair activities in 2013; 4) refurbish the existing upstream fishway in 2013; 5) repair and adjust the configuration of the existing downstream fishway to enhance effectiveness; 6) study upstream and downstream survival of Atlantic salmon for a period of three years; 7) if necessary based on studies, modify fishways to improve effectiveness/survival for Atlantic salmon.

The current FERC license for the Mattaceunk Project expires in 2018, and GLHA has started the process to obtain a new license from FERC. At the end of the six-year period (2018) covered under the ISPP, our Opinion will no longer be valid. Therefore, consultation under section 7 of the ESA will be reinitiated between FERC and NMFS in 2017. GLHA will develop a final SPP to be effective from 2018 to expiration of any new license issued by FERC (likely 2048). We expect FERC to incorporate the provisions of the final SPP into any new license issued to GLHA; therefore, the consultation on the final SPP will consider the effects of operating the project under the terms of the new license so that a single consultation under section 7 can occur during relicensing. The final SPP would include additional Atlantic salmon enhancement measures as determined to be necessary based on the results of monitoring conducted from 2014 through 2017.

This Opinion is based on information provided in FERC's March 14, 2013 Biological Assessment (BA) and ISPP as well as other sources of information. A complete administrative record of this consultation will be maintained by the NMFS's Maine Field Office in Orono, Maine. Formal consultation was initiated on March 14, 2013.

No other federal agencies have actions associated with the proposed project. Pursuant to the section 7 regulations (50 CFR §402.07), when a particular action involves more than one Federal agency, the consultation responsibilities may be fulfilled through a lead agency. FERC is the lead Federal agency for the proposed actions under consideration in this consultation.

1.1. Consultation History

- On January 5, 2011, GLHA submitted a letter to NMFS outlining a plan and process for addressing ESA issues for Atlantic salmon at the Mattaceunk Project.
- On January 5, 2011, GLHA filed a letter with FERC requesting that FERC designate them as FERC's non-federal representative for the purpose of conducting informal consultation with NMFS pursuant to Section 7 of the ESA regarding Atlantic salmon.
- On February 7, 2011, GLHA met with NMFS to review the proposed Section 7 approach to ESA consultation and the draft BA outline.
- On March 31, 2011, FERC designated GLHA as their non-federal representative for informal section 7 consultation.
- On August 23, 2012 GLHA provided a draft BA and interim SPP to the NMFS and USFWS Services for review.
- On November 1, 2012, GLHA met with NMFS and USFWS to discuss the draft ISPP and BA.
- On February 5, 2013, GLHA provided a revised ISPP to NMFS and USFWS for review.
- On February 6, 2013, NMFS submitted comments on the draft BA and ISPP to GLHA.
- On February 19, 2013, USFWS submitted comments on the draft ISPP and BA to GLHA.
- On February 28, 2013, GLHA requested FERC to amend the license for the Mattaceunk Project to incorporate provisions of a six-year ISPP (2013-2018). As part of the filing, GLHA provided FERC with draft copies of the ISPP and BA.
- On March 14, 2013, FERC initiated formal section 7 consultation with NMFS.

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 14 and are cited directly throughout the body of the document. Primary sources of information include: 1) information provided in FERC's March 14, 2013 initiation letter and attached BA and ISPP in support of formal consultation under the ESA; 2) Determination of Endangered Status for the Gulf of Maine Distinct Population Segment of Atlantic salmon; Final Rule (74 FR 29345; June 19, 2009); 3) Status Review for Anadromous Atlantic Salmon (*Salmo salar*) in the United States (Fay *et al.* 2006); and 4) Designation of Critical Habitat for Atlantic salmon Gulf of Maine Distinct Population Segment (74 FR 29300; June 19, 2009).

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 rangewide with respect to biological requirements indicative of survival and recovery and the essential features of any

designated critical habitat (Section 3);
- Evaluates the current status of the species and designated critical habitat within the specific salmon habitat recovery unit (Section 4);
- 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 5);
- Evaluates the relevance of climate change on environmental baseline and status of the species (Section 6);
- 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 7);
- Determines and evaluates any cumulative effects within the action area (Section 8); 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 9).

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

The critical habitat analysis determines whether the proposed action will destroy or adversely modify designated or proposed critical habitat for ESA-listed species by examining any change in the conservation value of the primary constituent elements of that critical habitat. This analysis focuses on statutory provisions of the ESA, including those in section 3 that define "critical habitat" and "conservation", in section 4 that describe the designation process, and in section 7 that set forth the substantive protections and procedural aspects of consultation. Although some "properly functioning" habitat parameters are generally well known in the fisheries literature (e.g., thermal tolerances), for others, the effects of any adverse impacts are considered in more qualitative terms. The analysis presented in this Opinion does not rely on the regulatory definition of "adverse modification or destruction" of critical habitat at issue in the 9th Circuit Court of Appeals (Gifford Pinchot Task Force *et al.* v. U.S. Fish and Wildlife Service, No. 03-35279, August 6, 2004).

2. PROJECT DESCRIPTION AND PROPOSED ACTION

The Mattaceunk Project is located on the Penobscot River in the town of Mattawamkeag, Maine (Figure 1). GLHA, an affiliate of Brookfield Renewable Energy Group, owns and operates the project to generate electricity for the New England power pool. Construction of the project was completed in 1940 and the current FERC license for the Project expires on August 31, 2018.

2.1. Existing Hydroelectric Facilities and Operations

Following the expected removal of the Veazie Dam during the summer of 2013, the Mattaceunk Project will be the third mainstem dam in the Penobscot River. The dam has a total length of 1,060 feet and a maximum height above riverbed of approximately 45 feet. For most of its length, the dam is a concrete gravity-type structure. It consists of a 657.5 foot long spillway section (crest elevation 236 feet) with four foot flashboards.

The Mattaceunk Project impounds a reach of the Penobscot River, which includes a section of the West Branch downstream of Medway Dam, as well as a portion of the East Branch that joins the West Branch just downstream of Medway. The impounded water at full pond elevation has a surface area of approximately 1,664 acres, with storage capacity of approximately 20,891 acre-feet at the normal full pond elevation of 240.0 (USGS) feet.

A 90-foot long by 19-foot high roller (drum) gate is used to release surplus waters during plant shutdowns or when flows are in excess of turbine capacity. The gate is operated by a motor-driven chain hoist located at its easterly end.

Adjacent to the roller gate is a 37-foot section containing a 10-foot wide log sluice and a 21.5-foot wide fish ladder. Adjacent to the fish ladder is the 142-foot long by 99-foot wide reinforced concrete powerhouse that forms an integral part of the dam. The remaining 110 feet of the structure consists of earth fill with a concrete core wall.

The powerhouse contains four vertical shaft turbines (two Kaplan and two fixed blade propeller turbines) directly connected to umbrella-type synchronous generators. The powerhouse has an authorized installed capacity of 19.2 MW. It has an enclosed gatehouse over the trash racks and two 12-foot-wide by 16-foot-high head gates per turbine.

There are eight head gates 12 feet wide by 16 feet high operated by two 18-ton electrical hoists mounted on a trolley beam in the roof. A trash rack rake is operated by an electric hoist on a trolley beam parallel to the head gate hoist trolley.

Operations

The Mattaceunk Project is typically operated with minimal fluctuations of the reservoir surface elevation for the protection of aquatic resources in the Penobscot River. However, flexibility on reservoir elevations is needed to provide for safe installation of the flashboards and to allow an adequate margin for wave action, debris loads, or sudden pool increases that might cause the flashboards to fail. As such, the license was amended in 1990 to stipulate that reservoir surface elevation is maintained no lower than 1.0 feet below the dam crest elevation of 236 feet (USGS datum) when the four-foot-high flashboards are not in use, and maintained no lower than 2.0 feet below the flashboard crest elevation of 240 feet when the four-foot-high flashboards are in use.

The facility utilizes a maximum of 7,438 cfs through the four turbines at the station. Due to the close regulation of upstream storage for power generation, inflow to the Mattaceunk Project exceeds total station hydraulic capacity less than 20% of the time, as recorded over a 20-year period. In accordance with the FERC Order on Rehearing issued on June 21, 1991 (55 FERC ¶61,472), the Mattaceunk Project is required to release a continuous minimum flow of 1,674 cfs, or inflow, whichever is less, throughout the year, and maintain a daily average minimum flow of 2,392 cfs from July 1 through September 30 and 2,000 cfs from October 1 through July 30, unless inflow is less than the stated daily average minimum flows (in which case outflow from the project must equal the inflow to the project). The reservoir elevation limitations and minimum flows may be temporarily modified under emergency conditions or with agreement from the Maine Department of Environmental Protection (MDEP).

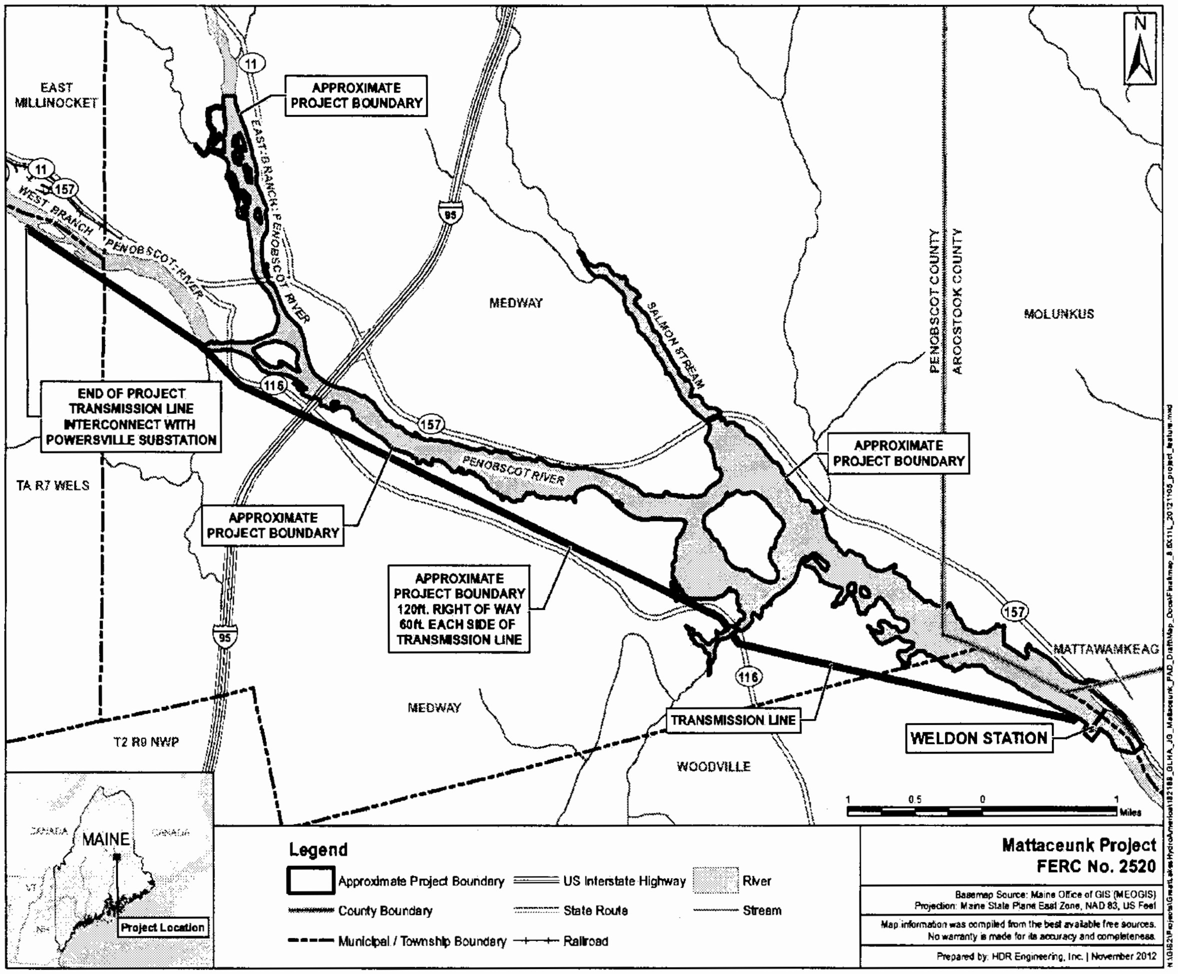

Figure 1. Location of the Mattaceunk Project (GLHA 2013).

Fish Passage

The upstream fishway at the Mattaceunk Project is a pool and weir design, consisting of 36 pools with a drop of approximately 14 inches between pools. Fish are able to ascend the fishway by way of either submerged orifices or weir notches. A gravity fed pipe provides auxiliary water for additional attraction flow to the entrance pool. A fish trap is located at the exit of the fishway so that fish enter the trap for monitoring purposes through a funnel-like opening after negotiating the fishway.

The permanent downstream fish passage facilities at the Mattaceunk Project consist of single surface outlets integral with the trashracks at two of the four project forebays (the forebays of turbine units #3 and #4 have the surface inlets). The surface inlets are capable of passing 2% of the station flow (70 cfs each) in conjunction with 1-inch bar spacing trashracks covering the top 16 feet of the water column (from full pond; at depths greater than 16 feet, the trashracks have 2 5/8 inch bar clear-spacing). The downstream passage facilities have typically been operated from October 17 to December 1 for salmon kelts, as well as from April 25 to June 25 for smolts and kelts (Letter from GLHA to USFWS dated March 8, 2006). In consultation with the

USFWS, NMFS, and MDMR, a minimum flow of 70 cubic feet per second (cfs) is required through each surface inlet.

In addition, for system performance and fish condition studies, a trapping and monitoring facility was installed at the discharge of the downstream passage facilities (GNP 1993). This monitoring facility is comprised of an entrance chamber, an inclined dewatering system, and a holding chamber. Water flows passing through the downstream passage system empty into the monitoring facility's entrance chamber from an underground 42-inch fish passage pipe. During trapping operations, flows are then filtered over the inclined screen to separate the bulk of the water from the fish and other debris. All collected fish and debris then drop off the end of the screen into the monitoring facility's holding chamber. A constant water flow is maintained to the holding chamber through a six-inch pipe which originates in the entrance chamber (GNP 1993). This temporary monitoring facility is used for system performance and fish condition studies, and when agencies or researchers request wild smolts, such as recently for the University of Maine and U.S. Geological Survey (USGS) smolt acoustic studies conducted in 2010 and 2011.

Maintenance

Several actions are routinely employed to ensure that the fishways at the Mattaceunk Project are functioning properly. The upstream fishway and its attraction water pipe are checked periodically to make sure that they are operating properly, and debris is removed as soon as possible. Maintenance issues (concrete and wood planking repairs; winter damage) are typically addressed prior to spring start-up, but they may also be addressed during the operational season (if needed) through agency consultation and brief fishway dewatering. For the downstream fish passage facilities, maintenance typically consists of periodic inspections of the surface inlets and rectangular collection chambers for lodged debris, and repairs are made as needed to any broken or malfunctioning components of the system. Debris is also removed from the monitoring facility on a daily basis when it is in use.

During times of high debris load in the river (springtime; fall leaf-drop; high water events), the trashracks at the project are frequently raked. And depending on debris load, the project is briefly shut down during most years to flush debris downstream that builds up in the station's forebay. This action helps stave off debris issues with the fishways.

2.2. Proposed Actions

The FERC is proposing to amend the Mattaceunk Project license to incorporate provisions described in a proposed ISPP for Atlantic salmon that was filed by GLHA. As described below, the ISPP is valid for a six-year period (2013-2018) to allow GLHA to study and improve fish passage for Atlantic salmon at the Mattaceunk Project. The ISPP will expire on August 31, 2018, when the current FERC license expires. The results of passage studies conducted under the ISPP will be used by GLHA to develop a final SPP that will be valid during the term of any new license issued by FERC in 2018. The final SPP will be filed with FERC in 2017 and we or FERC will reinitiate formal section 7 consultation at that time.

In addition to the license amendment, this Opinion will address the effects of proposed repairs to a roller gate and fish passage facilities at the Mattaceunk Project planned for the summer of 2013 as described below.

2.2.1. Interim Species Protection Plan

GLHA presently implements a number of Atlantic salmon protection measures at the Mattaceunk Project, such as providing upstream and downstream passage, near run-of-river operations (with pondage), maintaining instream flows, collaboration on Atlantic salmon research activities, and debris management measures. GLHA developed the ISPP in order to identify additional measures to avoid and minimize impacts from the operation of the Mattaceunk Project on Atlantic salmon. The ISPP will be used to specify what actions are necessary to avoid jeopardizing the continued existence of Atlantic salmon, promote recovery of the species, and avoid adverse modification or destruction of designated critical habitat for the species. The ISPP and incidental take authorization will cover the interim period through August 31, 2018, when the current Project license expires.

The specific measures contained in the ISPP that would be incorporated by FERC into the license of the Mattaceunk Project would require GLHA to: 1) immediately expand the period that downstream fish passage facility is operated; 2) immediately initiate use of the log sluice as the primary spillage route; 3) develop a protection plan for Atlantic salmon specific to the roller gate repair activities in 2013; 4) refurbish the existing upstream fishway in 2013; 5) adjust the configuration of the existing downstream fishway to enhance effectiveness; 6) study upstream and downstream survival of Atlantic salmon for a period of three years; 7) if necessary based on studies, modify fishways to improved effectiveness/survival for Atlantic salmon. Table 1 below provides a timeline for the provisions of the ISPP.

Upstream Passage

Past studies have demonstrated that the existing upstream fishway at the Mattaceunk Project is effective at passing Atlantic salmon (see Section 6.0). However, because upstream fishway maintenance and repair is needed, GLHA proposes to refurbish the fishway. Following FERC's amendment of the license, GLHA will develop a refurbishment plan for the upstream fishway in consultation with NMFS, the US Fish and Wildlife Service (USFWS), the Maine Department of Marine Resources (MDMR), and the Penobscot Indian Nation (PIN) and then refurbish the fishway accordingly during the summer/fall of 2013.

The upstream fishway needs repairs to the concrete floors and wooden baffles. Once these repairs are completed, GLHA proposes to evaluate the effectiveness of the fishway starting in 2015. GLHA will develop an upstream passage monitoring plan in consultation with NMFS, USFWS, MDMR, and PIN. The study would be conducted in cooperation with other Penobscot River dam owners that may be conducting similar evaluations, to the extent practicable. GLHA anticipates that three years of upstream studies consisting of radio telemetry studies using a sample size of 20 adult salmon each year will be conducted during the interim period covered under the ISPP. Depending on the monitoring results, GLHA would work to modify the fishway as necessary, in coordination with resource agencies.

Table 1. Overview of ISPP timing.

2013	2013 – 2017	2017 – 2018
• GLHA develops interim SPP and Draft BA. • FERC issues BA. • NMFS issues BO and Incidental Take Statement if a determination of no jeopardy and no adverse modification to habitat is reached. • GLHA expands period that downstream fish passage facility is operated. • GLHA initiates use of the log sluice as the primary spillage route. • GLHA develops protection plan for Atlantic salmon specific to the roller gate repair activities. • GLHA continues to cooperate with USGS and University of Maine on upstream and downstream Atlantic salmon passage monitoring studies (2013-TBD).	• GLHA develops an upstream fishway refurbishment plan, develops an approach to evaluate upstream fishway effectiveness, and refurbishes the upstream fishway in consultation with agencies (2013). • GLHA conducts upstream monitoring (2015-17). • GLHA evaluates downstream fish passage facility to identify improvement opportunities, adjusts existing system to enhance effectiveness, and develops report summarizing additional improvement options (2013-2014). • GLHA conducts paired release downstream passage monitoring study (2014-TBD). • Based on the 2014 monitoring results, GLHA may undertake additional modifications to the downstream fishway (2015).	• GLHA consults with NMFS to determine if, based on monitoring study results, additional protection measures are necessary. • FERC reinitiates section 7 consultation with NMFS. • NMFS issues a BO with Incidental Take Statement to cover term of new license if a determination of no jeopardy and no adverse modification to habitat is reached.

Provisions for upstream passage for other anadromous fish species including river herring, American shad, and American eel will be addressed during relicensing of the Mattaceunk Project. An important characteristic of the critical habitat of Atlantic salmon is thought to be the presence of a diverse native fish community that serves as a protective buffer against predation. Restoration of these diadromous fish communities is likely to be initiated by state and federal fisheries agencies in the Mattaceunk Project area of the Penobscot River in the next license term.

Downstream Passage

Past studies have demonstrated that the existing downstream fishway at the Mattaceunk Project is relatively ineffective at passing Atlantic salmon smolts and kelts (see Section 6.0). To improve passage conditions at the project for kelts, GLHA proposes to expand the period during which the downstream fishway is operated. Currently, the downstream fish bypass is operated to facilitate passage in both the spring and fall salmon downstream migration seasons (April 25 to June 25, and October 17 to December 1). Beginning in 2013, GLHA plans to operate the downstream fishway from April 1 to June 15 during the spring migration period (with no change to the fall operating period) as an immediate protection measure. Starting operation of the fishway earlier in the spring will provide improved passage for kelts, which have been shown to migrate soon after ice-out occurs. The fishway will be closed sooner since smolt emigration in the upper reaches of the Penobscot River are known to cease prior to June 15.

To improve passage for smolts and kelts, GLHA will utilize the log sluice beginning April 1, 2013 as the first spill option at the Mattaceunk Project (i.e., the roll gate will be used for spillage when river flows exceed the hydraulic capacity of the turbines, fishways, and the log sluice). Since the log sluice is not currently operated remotely, its operation will require onsite manual operation during fishway operation periods when spillage is occurring. This operational change will enhance downstream fish passage at the Mattaceunk Project during spillage periods, since the log sluice would likely provide a safer migration route for downstream migrants than passage through the roll gate.

In addition, GLHA will utilize a fish passage expert to evaluate the downstream fish passage facility in order to identify improvement opportunities and changes to the existing facility for implementation in the spring of 2015. GLHA and its fish passage expert will develop a plan and schedule through agency consultation for implementation of any identified measures. A report detailing the work will be submitted to us in 2014.

In 2013, GLHA will repair the collection chamber of the downstream fishway. During the spring of 2014, GLHA will conduct a study to evaluate downstream passage survival of smolts at the project. A study plan will be prepared in consultation with NMFS, USFWS, MDMR, and PIN. Study methods are expected to consist of radio tagging hatchery smolts or similarly accepted methods. It is expected that approximately 100 radio-tagged hatchery smolts will be released upstream of project, along with a paired release of 50 hatchery smolts in the project tailwater. Two or three release groups will be used, and the evaluation will occur when river flows are within the 10-90th percentile for average May flows.

After reviewing results of the 2014 study, GLHA will consult with NMFS, USFWS, MDMR, and PIN, and will undertake additional modifications to the existing fishway in 2015. GLHA anticipates that up to three years (total) of downstream studies may be needed at the project under the ISPP.

Decision Making Process and Study Design

The agreed upon Atlantic salmon protection measures will be implemented within an adaptive management framework with integration of management and research in order to provide feedback and the ability to adapt these measures, as necessary. The proposed interim process is intended to be adaptive and, as such, GLHA will be coordinating and consulting with NMFS throughout the six year period. If early study results indicate that the study design is not adequately measuring passage efficiency, GLHA will work with us to correct it. Likewise, if the early study results indicate that the upstream and downstream fishways at the Mattaceunk Project are not highly efficient at passing Atlantic salmon, GLHA will coordinate with us and modify operations at the Mattaceunk Project as necessary to avoid and minimize effects to Atlantic salmon to the extent practicable. To that end, GLHA will meet with NMFS annually to discuss study results, potential modifications to the study design and/or potential changes to the operation of the facility that may be necessary to reduce adverse effects to the species.

GLHA will prepare annual reports to review the previous year's study results with resource agencies, assess the need to continue studies, and detail progress on development and implementation of agreed upon fishway improvements. In addition, GLHA will conduct daily fishway inspections regarding the operation and condition of upstream and downstream fishways at the project. GLHA will provide a summary of the fishway inspections to us on a monthly basis.

No passage survival standards for Atlantic salmon smolts and kelts have been proposed as part of this ISPP. However, it is anticipated that downstream survival standards will be incorporated as part of the final SPP and that they will likely need to be between 96 and 100% given analysis conducted on downstream hydroelectric projects in the Penobscot River. It is possible that the proposed studies will indicate that the downstream passage facilities currently in place are not sufficient to achieve high survival for smolts and kelts and that significant structural and/or operational changes may be necessary to achieve such a high level of survival. The interim period will be used to determine how best to operate or modify the project to achieve sufficiently high survival rates. In addition, over the term of the interim period, we will use the results of survival studies at Mattaceunk to update the NEFSC DIA model to support our analysis during the final SPP consultation.

2.2.2. Roller Gate and Fishway Repairs

The 9th Part 12D Safety Inspection Report for the Mattaceunk Project included several recommendations for maintenance and repair measures. The Safety Inspection Report recommendations included several repairs needed for the roller gate and associated concrete sill base. The repair is scheduled to start July 2013 which will avoid impacting any Atlantic salmon smolts or kelts in the project area. The nearest mapped Atlantic salmon spawning and rearing habitat to the project impoundment occurs approximately 30.5 miles upstream of the project; therefore, no parr would be expected to be impacted by the repairs. To minimize effects of the maintenance effort on fisheries resources, GLHA agreed to develop and implement a fish stranding plan.

GHLA intends to perform maintenance at the Mattaceunk Project in the summer 2013 which will require a large scale drawdown (20-25 feet) of the project impoundment. The focus of this maintenance will be dam safety maintenance and repairs to the roller gate section of the dam that were recommended by the Part 12D dam safety inspection report. Specifically, these repairs (which were approved and adopted by FERC in 2011) include:

1. Repairing the roller gate's bottom and side seals and bracket assembly.
2. Making concrete repairs to roller gate sill beam, and to areas adjacent to upper right gate track and chain pocket.
3. Making concrete repairs to the gate piers.
4. Repainting the exterior of the roller gate.
5. Shielding vent holes to prevent water spray from entering the roller gate.
6. Seal welding the perimeter of the plate cover over a hole on the upstream face of the roller gate between Frames 1 and 2.
7. Replacement of the roller gate hoist chain.

In addition to these required repairs, GLHA also intends to take advantage of the drawdown to perform additional maintenance and repairs at the dam that can best be done "in the dry", including:

1. Permanent repairs to the downstream fishway (temporary repairs were made to the damaged fishway in 2012 using divers).
2. Maintenance repairs to the upstream fishway.

The concrete floor and wooden baffles of the upstream fishway will be repaired/replaced during the summer of 2013. GLHA will also repair the collection chamber of the downstream fishway during the summer of 2013. This work will occur in the dry once the impoundment is drawn down to facilitate repairs to the roller gate. GLHA is coordinating with resource agencies on the planning for this drawdown, and protection measures are being developed to address potential impacts to freshwater mussels, fish passage, eagle nesting, and to fish that may become stranded. In addition, a water management plan is being developed to minimize potential impacts from high water (rain) events to both the maintenance work at the Mattaceunk Project and to the planned downstream removal of Veazie Dam in 2013.

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). The action area must encompass all areas where both the direct and indirect effects of the proposed action would affect listed species and critical habitat. Direct effects of the Mattaceunk Project on anadromous Atlantic salmon and designated critical habitat affect the Penobscot River and tributaries from the confluence of the East and West Branches in Medway, Maine (RM 160) downstream to its confluence with the Mattawamkeag River (RM 143). Indirect effects to Atlantic salmon would affect the headwaters of the Penobscot River upstream of the Mattaceunk Project that were naturally accessible to Atlantic salmon. Based on these considerations, the action area is best defined as the headwaters of the Penobscot River downstream to the confluence of the Mattawamkeag River, a distance of approximately 60 miles.

3. STATUS OF AFFECTED SPECIES AND CRITICAL HABITAT RANGEWIDE

We have determined that the following endangered or threatened species may be affected by the proposed action:

Fish
Gulf of Maine DPS of Atlantic salmon Endangered

Critical Habitat
Designated for the Gulf of Maine DPS of Atlantic salmon

This section will focus on the status of the listed Atlantic salmon 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 Atlantic salmon is an anadromous fish species that spends most of its adult life in the ocean but returns to freshwater to reproduce. The Atlantic salmon is native to the North Atlantic Ocean, from the Arctic Circle to Portugal in the eastern Atlantic, from Iceland and southern Greenland, and from the Ungava region of northern Quebec south to the Housatonic River (Bigelow and Schroeder 1953). In the United States, Atlantic salmon historically ranged from Maine south to Long Island Sound. However, the Central New England DPS and Long Island Sound DPS have both been extirpated (65 FR 69459; November 17, 2000).

The GOM DPS of anadromous Atlantic salmon was initially listed jointly by the USFWS and NMFS (collectively, the Services) as an endangered species on November 17, 2000 (65 FR 69459). In 2009 the Services finalized an expanded listing of Atlantic salmon as an endangered species (74 FR 29344; June 19, 2009). The decision to expand the range of the GOM DPS was largely based on the results of a Status Review (Fay *et al.* 2006) completed by a Biological Review Team consisting of Federal and State agencies and Tribal interests. Fay *et al.* (2006) conclude that the DPS delineation in the 2000 listing designation was largely appropriate, except in the case of large rivers that were partially or wholly excluded in the 2000 listing determination. Fay *et al.* (2006) conclude that the salmon currently inhabiting the larger rivers (Androscoggin, Kennebec, and Penobscot) are genetically similar to the rivers included in the GOM DPS as listed in 2000, have similar life history characteristics, and occur in the same zoogeographic region. Further, the salmon populations inhabiting the large and small rivers from the Androscoggin River northward to the Dennys River differ genetically and in important life history characteristics from Atlantic salmon in adjacent portions of Canada (Spidle *et al.* 2003; Fay *et al.* 2006). Thus, Fay *et al.* (2006) conclude that this group of populations (a "distinct population segment") met both the discreteness and significance criteria of the Services' DPS Policy (61 FR 4722; February 7, 1996) and, therefore, recommend the geographic range included in the new expanded GOM DPS.

The current GOM DPS includes all anadromous Atlantic salmon whose freshwater range occurs in the watersheds from the Androscoggin River northward along the Maine coast to the Dennys River, and wherever these fish occur in the estuarine and marine environment. The following impassable falls delimit the upstream extent of the freshwater range: Rumford Falls in the town of Rumford on the Androscoggin River; Snow Falls in the town of West Paris on the Little

Androscoggin River; Grand Falls in Township 3 Range 4 BKP WKR on the Dead River in the Kennebec Basin; the un-named falls (impounded by Indian Pond Dam) immediately above the Kennebec River Gorge in the town of Indian Stream Township on the Kennebec River; Big Niagara Falls on Nesowadnehunk Stream in Township 3 Range 10 WELS in the Penobscot Basin; Grand Pitch on Webster Brook in Trout Brook Township in the Penobscot Basin; and Grand Falls on the Passadumkeag River in Grand Falls Township in the Penobscot Basin. The marine range of the GOM DPS extends from the Gulf of Maine, throughout the Northwest Atlantic Ocean, to the coast of Greenland.

Included in the GOM DPS are all associated conservation hatchery populations used to supplement these natural populations; currently, such conservation hatchery populations are maintained at Green Lake National Fish Hatchery (GLNFH) and Craig Brook National Fish Hatchery (CBNFH), both operated by the USFWS. Excluded from the GOM DPS are landlocked Atlantic salmon and those salmon raised in commercial hatcheries for the aquaculture industry (74 FR 29344; June 19, 2009).

Atlantic salmon have a complex life history that includes territorial rearing in rivers to extensive feeding migrations on the high seas. During their life cycle, Atlantic salmon go through several distinct phases that are identified by specific changes in behavior, physiology, morphology, and habitat requirements.

Adult Atlantic salmon return to rivers from the sea and migrate to their natal stream to spawn; a small percentage (1-2%) of returning adults in Maine will stray to a new river. Adults ascend the rivers within the GOM DPS beginning in the spring. The ascent of adult salmon continues into the fall. Although spawning does not occur until late fall, the majority of Atlantic salmon in Maine enter freshwater between May and mid-July (Meister 1958; Baum 1997). Early migration is an adaptive trait that ensures adults have sufficient time to effectively reach spawning areas despite the occurrence of temporarily unfavorable conditions that naturally occur within rivers (Bjornn and Reiser 1991). Salmon that return in early spring spend nearly five months in the river before spawning, often seeking cool water refuge (e.g., deep pools, springs, and mouths of smaller tributaries) during the summer months.

In the fall, female Atlantic salmon select sites for spawning in rivers. Spawning sites are positioned within flowing water, particularly where upwelling of groundwater occurs, allowing for percolation of water through the gravel (Danie *et al.* 1984). These sites are most often positioned at the head of a riffle (Beland *et al.* 1982); the tail of a pool; or the upstream edge of a gravel bar where water depth is decreasing, water velocity is increasing (McLaughlin and Knight 1987, White 1942), and hydraulic head allows for permeation of water through the redd (a gravel depression where eggs are deposited). Female salmon use their caudal fin to scour or dig redds. The digging behavior also serves to clean the substrate of fine sediments that can embed the cobble and gravel substrates needed for spawning and consequently reduce egg survival (Gibson 1993). One or more males fertilize the eggs that the female deposits in the redd (Jordan and Beland 1981). The female then continues digging upstream of the last deposition site, burying the fertilized eggs with clean gravel.

A single female may create several redds before depositing all of her eggs. Female anadromous Atlantic salmon produce a total of 1,500 to 1,800 eggs per kilogram of body weight, yielding an average of 7,500 eggs per two sea-winter (2SW) female (an adult female that has spent two winters at sea before returning to spawn) (Baum and Meister 1971). After spawning, Atlantic salmon may either return to sea immediately or remain in fresh water until the following spring before returning to the sea (Fay *et al.* 2006). From 1996 to 2011, approximately 1.3% of the "naturally-reared" adults (fish originating from natural spawning or hatchery fry) in the Penobscot River were repeat spawners (USASAC 2012).

Embryos develop in redds for a period of 175 to 195 days, hatching in late March or April (Danie *et al.* 1984). Newly hatched salmon, referred to as larval fry, alevin, or sac fry, remain in the redd for approximately six weeks after hatching and are nourished by their yolk sac (Gustafson-Greenwood and Moring 1991). Survival from the egg to fry stage in Maine is estimated to range from 15% to 35% (Jordan and Beland 1981). Survival rates of eggs and larvae are a function of stream gradient, overwinter temperatures, interstitial flow, predation, disease, and competition (Bley and Moring 1988). Once larval fry emerge from the gravel and begin active feeding, they are referred to as fry. The majority of fry (>95%) emerge from redds at night (Gustafson-Marjanen and Dowse 1983).

When fry reach approximately four centimeters in length, the young salmon are termed parr (Danie *et al.* 1984). Parr have eight to eleven pigmented vertical bands on their sides that are believed to serve as camouflage (Baum 1997). A territorial behavior, first apparent during the fry stage, grows more pronounced during the parr stage, as the parr actively defend territories (Allen 1940; Kalleberg 1958; Danie *et al.* 1984). Most parr remain in the river for two to three years before undergoing smoltification, the process in which parr go through physiological changes in order to transition from a freshwater environment to a saltwater marine environment. Some male parr may not go through smoltification and will become sexually mature and participate in spawning with sea-run adult females. These males are referred to as "precocious parr." First year parr are often characterized as being small parr or 0+ parr (four to seven centimeters long), whereas second and third year parr are characterized as large parr (greater than seven cm long) (Haines 1992). Parr growth is a function of water temperature (Elliott 1991); parr density (Randall 1982); photoperiod (Lundqvist 1980); interaction with other fish, birds, and mammals (Bjornn and Reiser 1991); and food supply (Swansburg *et al.* 2002). Parr movement may be quite limited in the winter (Cunjak 1988; Heggenes 1990); however, movement in the winter does occur (Hiscock *et al.* 2002) and is often necessary, as ice formation reduces total habitat availability (Whalen *et al.* 1999). Parr have been documented using riverine, lake, and estuarine habitats; incorporating opportunistic and active feeding strategies; defending territories from competitors including other parr; and working together in small schools to actively pursue prey (Gibson 1993, Marschall *et al.* 1998, Pepper 1976, Pepper *et al.* 1984, Hutchings 1986, Erkinaro *et al.* 1998a, O'Connell and Ash 1993, Erkinaro *et al.* 1995, Dempson *et al.* 1996, Halvorsen and Svenning 2000, Klemetsen *et al.* 2003).

In a parr's second or third spring (age 1 or age 2, respectively), when it has grown to 12.5 to 15 cm in length, a series of physiological, morphological, and behavioral changes occur (Schaffer and Elson 1975). This process, called "smoltification," prepares the parr for migration to the ocean and life in salt water. In Maine, the vast majority of naturally reared parr remain in fresh water for two years (90% or more) with the balance remaining for either one or three years (USASAC 2005). In order for parr to undergo smoltification, they must reach a critical size of ten centimeters total length at the end of the previous growing season (Hoar 1988). During the smoltification process, parr markings fade and the body becomes streamlined and silvery with a pronounced fork in the tail. Naturally reared smolts in Maine range in size from 13 to 17 cm, and most smolts enter the sea during May to begin their first ocean migration (USASAC 2004). During this migration, smolts must contend with changes in salinity, water temperature, pH, dissolved oxygen, pollution levels, and various predator assemblages. The physiological changes that occur during smoltification prepare the fish for the dramatic change in osmoregulatory needs that come with the transition from a fresh to a salt water habitat (Ruggles 1980, Bley 1987, McCormick and Saunders 1987, McCormick *et al.* 1998). The transition of smolts into seawater is usually gradual as they pass through a zone of fresh and saltwater mixing that typically occurs in a river's estuary. Given that smolts undergo smoltification while they are still in the river, they are pre-adapted to make a direct entry into seawater with minimal acclimation (McCormick *et al.* 1998). This pre-adaptation to seawater is necessary under some circumstances where there is very little transition zone between freshwater and the marine environment.

The spring migration of post-smolts out of the coastal environment is generally rapid, within several tidal cycles, and follows a direct route (Hyvarinen *et al.* 2006, Lacroix and McCurdy 1996, Lacroix *et al.* 2004). Post-smolts generally travel out of coastal systems on the ebb tide and may be delayed by flood tides (Hyvarinen *et al.* 2006, Lacroix and McCurdy 1996, Lacroix *et al.* 2004, Lacroix and Knox 2005). Lacroix and McCurdy (1996), however, found that post-smolts exhibit active, directed swimming in areas with strong tidal currents. Studies in the Bay of Fundy and Passamaquoddy Bay suggest that post-smolts aggregate together and move near the coast in "common corridors" and that post-smolt movement is closely related to surface currents in the bay (Hyvarinen *et al.* 2006; Lacroix and McCurdy 1996; Lacroix *et al.* 2004). European post-smolts tend to use the open ocean for a nursery zone, while North American post-smolts appear to have a more near-shore distribution (Friedland *et al.* 2003). Post-smolt distribution may reflect water temperatures (Reddin and Shearer 1987) or the major surface-current vectors (Lacroix and Knox 2005). Post-smolts live mainly on the surface of the water column and form shoals, possibly of fish from the same river (Shelton *et al.* 1997).
During the late summer and autumn of the first year, North American post-smolts are concentrated in the Labrador Sea and off of the west coast of Greenland, with the highest concentrations between 56°N. and 58°N. (Reddin 1985, Reddin and Short 1991, Reddin and Friedland 1993). The salmon located off Greenland are composed of both 1SW fish and fish that have spent multiple years at sea (multi-sea winter fish or MSW) and also includes immature salmon from both North American and European stocks (Reddin 1988, Reddin *et al.* 1988). The first winter at sea regulates annual recruitment, and the distribution of winter habitat in the Labrador Sea and Denmark Strait may be critical for North American populations (Friedland *et al.* 1993). In the spring, North American post-smolts are generally located in the Gulf of St. Lawrence, off the coast of Newfoundland, and on the east coast of the Grand Banks (Reddin 1985, Dutil and Coutu 1988, Ritter 1989, Reddin and Friedland 1993, and Friedland *et al.* 1999). Some salmon may remain at sea for another year or more before maturing. After their second winter at sea, the salmon over-winter in the area of the Grand Banks before returning to their natal rivers to spawn (Reddin and Shearer 1987). Reddin and Friedland (1993) found immature adults located along the coasts of Newfoundland, Labrador, and Greenland, and in the Labrador and Irminger Sea in the later summer and autumn.

3.2. Status and Trends of Atlantic Salmon in the GOM DPS

The abundance of Atlantic salmon within the range of the GOM DPS has been generally declining since the 1800s (Fay *et al.* 2006). Data sets tracking adult abundance are not available throughout this entire time period; however, a comprehensive time series of adult returns to the GOM DPS dating back to 1967 exists (Fay *et al.* 2006, USASAC 2001-2012) (Figure 2). It is important to note that contemporary abundance levels of Atlantic salmon within the GOM DPS are several orders of magnitude lower than historical abundance estimates. For example, Foster and Atkins (1869) estimated that roughly 100,000 adult salmon returned to the Penobscot River alone before the river was dammed, whereas contemporary estimates of abundance for the entire GOM DPS have rarely exceeded 5,000 individuals in any given year since 1967 (Fay *et al.* 2006, USASAC 2010).

Contemporary abundance estimates are informative in considering the conservation status of the GOM DPS today. After a period of slow population growth between the 1970s and the early 1980s, adult returns of salmon in the GOM DPS peaked between approximately 1984 and 2001 before declining during the 2000s. Adult returns have been increasing again over the last few years. The population growth observed in the 1970s is likely attributable to favorable marine survival and increases in hatchery capacity, particularly from GLNFH that was constructed in 1974. Marine survival remained relatively high throughout the 1980s, and salmon populations in the GOM DPS remained relatively stable until the early 1990s. In the early 1990s marine survival rates decreased, leading to the declining trend in adult abundance observed throughout 1990s and early 2000s. The increase in the abundance of returning adult salmon observed between 2008 and 2011 may be an indication of improving marine survival.

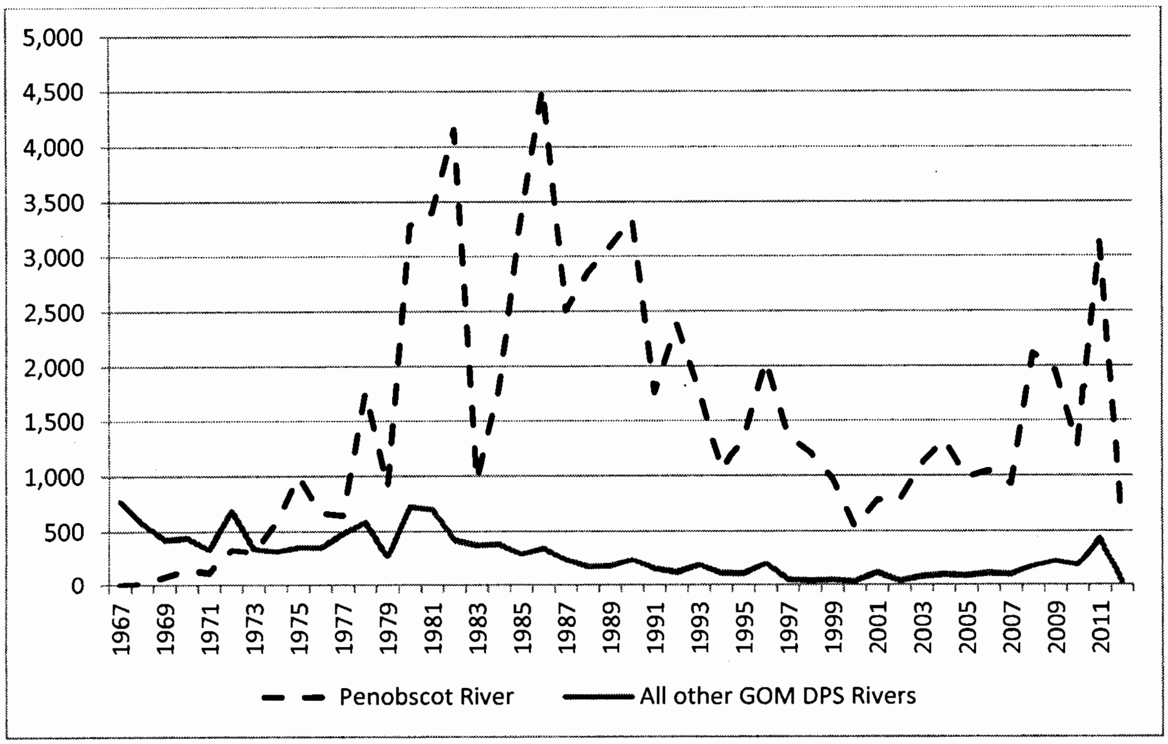

Figure 2. Adult returns to the GOM DPS Rivers between 1967 and 2012 (Fay *et al.* 2006, USASAC 2001-2013).

Adult returns to the GOM DPS have been very low for many years and remain extremely low in terms of adult abundance in the wild. Further, the majority of all adults in the GOM DPS return to a single river, the Penobscot, which accounted for 91% of all adult returns to the GOM DPS between 2000 and 2011. Of the 3,125 adult returns to the Penobscot in 2011, the vast majority are the result of smolt stocking; and only a small portion were naturally-reared. The term "naturally-reared" includes fish originating from both natural spawning and from stocked hatchery fry (USASAC 2012). Hatchery fry are included as naturally-reared because hatchery fry are not marked and, therefore, cannot be distinguished from fish produced through natural spawning. Because of the extensive amount of fry stocking that takes place in an effort to recover the GOM DPS, it is possible that a substantial number of fish counted as naturally-reared were actually hatchery fry.

Low abundances of both hatchery-origin and naturally-reared adult salmon returns to Maine demonstrate continued poor marine survival. Declines in hatchery-origin adult returns are less sharp because of the ongoing effects of consistent hatchery supplementation of smolts. In the GOM DPS, nearly all of the hatchery-reared smolts are released into the Penobscot River -- 560,000 smolts in 2009 (USASAC 2010). In contrast, the number of returning naturally-reared adults continues at low levels due to poor marine survival.

In conclusion, the abundance of Atlantic salmon in the GOM DPS has been low and either stable or declining over the past several decades. The proportion of fish that are of natural origin is very small (approximately 6% over the last ten years) but appears stable. The conservation hatchery program has assisted in slowing the decline and helping to stabilize populations at low levels. However, stocking of hatchery products has not contributed to an increase in the overall abundance of salmon and as yet has not been able to increase the naturally reared component of the GOM DPS. Continued reliance on the conservation hatchery program could prevent extinction in the short term, but recovery of the GOM DPS must be accomplished through increases in naturally reared salmon.

3.3. Critical Habitat for Atlantic Salmon in the GOM DPS

Coincident with the June 19, 2009 endangered listing, NMFS designated critical habitat for the GOM DPS of Atlantic salmon (74 FR 29300; June 19, 2009) (Figure 3). The final rule was revised on August 10, 2009. In this revision, designated critical habitat for the expanded GOM DPS of Atlantic salmon was reduced to exclude trust and fee holdings of the Penobscot Indian Nation and a table was corrected (74 FR 39003; August 10, 2009).

Primary Constituent Elements of Atlantic Salmon Critical Habitat

Designation of critical habitat is focused on the known primary constituent elements (PCEs), within the occupied areas of a listed species that are deemed essential to the conservation of the species. Within the GOM DPS, the PCEs for Atlantic salmon are: 1) sites for spawning and rearing, and 2) sites for migration (excluding marine migration[1]). NMFS chose not to separate spawning and rearing habitat into distinct PCEs, although each habitat does have distinct features, because of the GIS-based habitat prediction model approach that was used to designate critical habitat (74 FR 29300; June 19, 2009). This model cannot consistently distinguish between spawning and rearing habitat across the entire range of the GOM DPS.

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

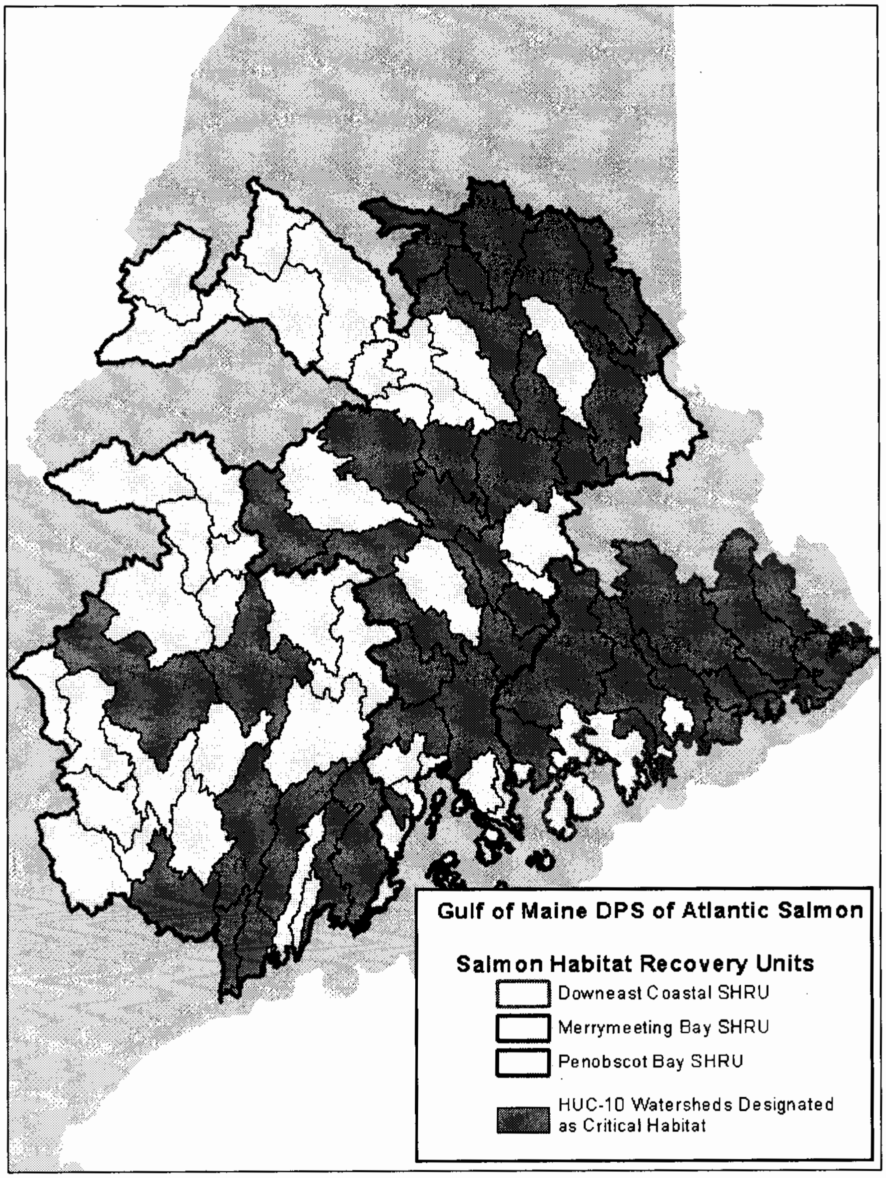

Figure 3. HUC-10 Watersheds Designated as Atlantic Salmon Critical Habitat within the GOM DPS.

The physical and biological features of the two PCEs for Atlantic salmon critical habitat are as follows:

Physical and Biological Features of the Spawning and Rearing PCE

1. Deep, oxygenated pools and cover (*e.g.*, boulders, woody debris, vegetation, etc.), near freshwater spawning sites, necessary to support adult migrants during the summer while they await spawning in the fall.
2. Freshwater spawning sites that contain clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support spawning activity, egg incubation, and larval development.
3. Freshwater spawning and rearing sites with clean, permeable gravel and cobble substrate with oxygenated water and cool water temperatures to support emergence, territorial development and feeding activities of Atlantic salmon fry.
4. Freshwater rearing sites with space to accommodate growth and survival of Atlantic salmon parr.
5. Freshwater rearing sites with a combination of river, stream, and lake habitats that accommodate parr's ability to occupy many niches and maximize parr production.
6. Freshwater rearing sites with cool, oxygenated water to support growth and survival of Atlantic salmon parr.
7. Freshwater rearing sites with diverse food resources to support growth and survival of Atlantic salmon parr.

Physical and Biological Features of the Migration PCE

1. Freshwater and estuary migratory sites free from physical and biological barriers that delay or prevent access of adult salmon seeking spawning grounds needed to support recovered populations.
2. Freshwater and estuary migration sites with pool, lake, and instream habitat that provide cool, oxygenated water and cover items (*e.g.*, boulders, woody debris, and vegetation) to serve as temporary holding and resting areas during upstream migration of adult salmon.
3. Freshwater and estuary migration sites with abundant, diverse native fish communities to serve as a protective buffer against predation.
4. Freshwater and estuary migration sites free from physical and biological barriers that delay or prevent emigration of smolts to the marine environment.
5. Freshwater and estuary migration sites with sufficiently cool water temperatures and water flows that coincide with diurnal cues to stimulate smolt migration.
6. Freshwater migration sites with water chemistry needed to support sea water adaptation of smolts.

Habitat areas designated as critical habitat must contain one or more PCEs within the acceptable range of values required to support the biological processes for which the species uses that habitat. Critical habitat includes all perennial rivers, streams, and estuaries and lakes connected to the marine environment within the range of the GOM DPS, except for those areas that have been specifically excluded as critical habitat. Critical habitat has only been designated in areas (HUC-10 watersheds) considered currently occupied by the species. Critical habitat includes the stream channels within the designated stream reach and includes a lateral extent as defined by the ordinary high-water line or the bankfull elevation in the absence of a defined high-water line.

In estuaries, critical habitat is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of extreme high water, whichever is greater.

For an area containing PCEs to meet the definition of critical habitat, the ESA also requires that the physical and biological features essential to the conservation of Atlantic salmon in that area "may require special management considerations or protections." Activities within the GOM DPS that were identified as potentially affecting the physical and biological features of salmon habitat and, therefore, requiring special management considerations or protections include agriculture, forestry, changing land-use and development, hatcheries and stocking, roads and road-stream crossings, mining, dams, dredging, and aquaculture.

In conclusion, the June 19, 2009 final critical habitat designation for the GOM DPS (as revised on August 10, 2009) includes 45 specific areas occupied by Atlantic salmon that comprise approximately 19,571 km of perennial river, stream, and estuary habitat and 799 km^2 of lake habitat within the range of the GOM DPS and on which are found those physical and biological features essential to the conservation of the species. Within the occupied range of the GOM DPS, approximately 1,256 km of river, stream, and estuary habitat and 100 $km^2$of lake habitat have been excluded from critical habitat pursuant to section 4(b)(2) of the ESA.

3.4. Summary of Factors Affecting Recovery of Atlantic Salmon

There are a wide variety of factors that have affected and continue to affect the status of the GOM DPS. The potential interactions among these factors are not well understood, nor are the reasons for the seemingly poor response of salmon populations to the many ongoing conservation efforts for this species.

3.4.1. Threats to the Species and Critical Habitat

The recovery plan for the previously designated GOM DPS (NMFS and USFWS 2005), the latest status review (Fay *et al.* 2006), and the 2009 listing rule all provide a comprehensive assessment of the many factors, including both threats and conservation actions, that are currently affecting the status and recovery of listed Atlantic salmon. The Services are writing a new recovery plan that will include the current, expanded GOM DPS and its designated critical habitat. The new recovery plan provides the most up to date list of significant threats affecting the GOM DPS. These are the following:

- Dams
- Inadequacy of existing regulatory mechanisms for dams
- Continued low marine survival rates for U.S. stocks of Atlantic salmon
- Lack of access to spawning and rearing habitat due to dams and road-stream crossings

In addition to these significant threats, there are a number of lesser stressors. These are the following:

- Degraded water quality
- Aquaculture practices, which pose ecological and genetic risks
- Climate change
- Depleted diadromous fish communities

- Incidental capture of adults and parr by recreational anglers
- Introduced fish species that compete or prey on Atlantic salmon
- Poaching of adults in DPS rivers
- Recovery hatchery program (potential for artificial selection/domestication)
- Sedimentation of spawning and rearing habitat
- Water extraction

Fay *et al.* (2006) examined each of the five statutory ESA listing factors and determined that each of the five listing factors is at least partly responsible for the present low abundance of the GOM DPS. The information presented in Fay *et al.* (2006) is reflected in and supplemented by the final listing rule for the new GOM DPS (74 FR 29344; June 19, 2009). The following gives a brief overview of the five listing factors as related to the GOM DPS.

1. **Present or threatened destruction, modification, or curtailment of its habitat or range** – Historically and, to a lesser extent currently, dams have adversely impacted Atlantic salmon by obstructing fish passage and degrading riverine habitat. Dams are considered to be one of the primary causes of both historic declines and the contemporary low abundance of the GOM DPS. Land use practices, including forestry and agriculture, have reduced habitat complexity (e.g., removal of large woody debris from rivers) and habitat connectivity (e.g., poorly designed road crossings) for Atlantic salmon. Water withdrawals, elevated sediment levels, and acid rain also degrade Atlantic salmon habitat.

2. **Overutilization for commercial, recreational, scientific, or educational purposes** – While most directed commercial fisheries for Atlantic salmon have ceased, the impacts from past fisheries are still important in explaining the present low abundance of the GOM DPS. Both poaching and by-catch in recreational and commercial fisheries for other species remain of concern, given critically low numbers of salmon.

3. **Predation and disease** – Natural predator-prey relationships in aquatic ecosystems in the GOM DPS have been substantially altered by introduction of non-native fishes (e.g., chain pickerel, smallmouth bass, and northern pike), declines of other native diadromous fishes, and alteration of habitat by impounding free-flowing rivers and removing instream structure (such as removal of boulders and woody debris during the log-driving era). The threat of predation on the GOM DPS is noteworthy because of the imbalance between the very low numbers of returning adults and the recent increase in populations of some native predators (e.g., double-crested cormorant), as well as non-native predators. Atlantic salmon are susceptible to a number of diseases and parasites, but mortality is primarily documented at conservation hatcheries and aquaculture facilities.

4. **Inadequacy of existing regulatory mechanisms** – The ineffectiveness of current federal and state regulations at requiring fish passage and minimizing or mitigating the aquatic habitat impacts of dams is a significant threat to the GOM DPS today. Furthermore, most dams in the GOM DPS do not require state or federal permits. Although the State of Maine has made substantial progress in regulating water withdrawals for agricultural use, threats still remain within the GOM DPS, including those from the effects of irrigation wells on salmon streams.

5. **Other natural or manmade factors** – Poor marine survival rates of Atlantic salmon are a significant threat, although the causes of these decreases are unknown. The role of

ecosystem function among the freshwater, estuarine, and marine components of the Atlantic salmon's life history, including the relationship of other diadromous fish species in Maine (e.g., American shad, alewife, sea lamprey), is receiving increased scrutiny in its contribution to the current status of the GOM DPS and its role in recovery of the Atlantic salmon. While current state and federal regulations pertaining to finfish aquaculture have reduced the risks to the GOM DPS (including eliminating the use of non-North American Atlantic salmon and improving containment protocols), risks from the spread of diseases or parasites and from farmed salmon escapees interbreeding with wild salmon still exist.

3.4.2. Efforts to Protect the GOM DPS of Atlantic salmon

Efforts aimed at protecting Atlantic salmon and their habitats in Maine have been underway for well over one hundred years. These efforts are supported by a number of federal, state, and local government agencies, as well as many private conservation organizations. The 2005 recovery plan for the originally-listed GOM DPS (NMFS and USFWS 2005) presented a strategy for recovering Atlantic salmon that focused on reducing the most severe threats to the species and immediately halting the decline of the species to prevent extinction. The 2005 recovery program included the following elements:

1. Protect and restore freshwater and estuarine habitats;
2. Minimize potential for take in freshwater, estuarine, and marine fisheries;
3. Reduce predation and competition for all life-stages of Atlantic salmon;
4. Reduce risks from commercial aquaculture operations;
5. Supplement wild populations with hatchery-reared DPS salmon;
6. Conserve the genetic integrity of the DPS;
7. Assess stock status of key life stages;
8. Promote salmon recovery through increased public and government awareness; and
9. Assess effectiveness of recovery actions and revise as appropriate.

A wide variety of activities have focused on protecting Atlantic salmon and restoring the GOM DPS, including (but not limited to) hatchery supplementation; removing dams or providing fish passage; improving road crossings that block passage or degrade stream habitat; protecting riparian corridors along rivers; reducing the impact of irrigation water withdrawals; limiting effects of recreational and commercial fishing; reducing the effects of finfish aquaculture; outreach and education activities; and research focused on better understanding the threats to Atlantic salmon and developing effective restoration strategies. In light of the 2009 GOM DPS listing and designation of critical habitat, the Services are producing a new recovery plan for the expanded GOM DPS of Atlantic salmon. We expect new recovery plan to be issued in 2013 or 2014.

4. STATUS OF ATLANTIC SALMON IN THE PENOBSCOT BAY SHRU

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 Penobscot Bay SHRU. In describing critical habitat for the GOM DPS, we divided the DPS into three Salmon Habitat Recovery Units or SHRUs. The three SHRUs include the Downeast Coastal, Penobscot Bay, and Merrymeeting Bay. The SHRU delineations were designed by NMFS to: 1) ensure that a recovered Atlantic salmon population has widespread geographic distribution to help maintain genetic variability; and 2) provide protection from demographic and environmental variation. A widespread distribution of salmon across the three SHRUs will provide a greater probability of population sustainability in the future, as will be needed to achieve recovery of the GOM DPS.

The Penobscot Bay SHRU includes the entire Penobscot basin and extends west as far as, and including the Ducktrap watershed, and east as far as, and including the Bagaduce watershed. The Penobscot Bay SHRU is dominated by a large, complex river system (Penobscot River) which serves as the primary migration corridor to numerous watersheds representing diverse habitats. As stated previously, 500 adult spawners in each of the three SHRUs is being used as a benchmark for evaluating the entire GOM DPS for recovery.

4.1. Status and Trends of Atlantic Salmon in the Penobscot Bay SHRU

Returning Adults

The Penobscot River watershed supports the largest runs of Atlantic salmon in the GOM DPS. This is due to the large amount of available habitat and large-scale stocking program that includes smolt, parr, fry, and restocking of captured sea-run adults after spawning at the Craig Brook National Fish Hatchery (CBNFH). Roughly 600,000 smolts are stocked in the Penobscot River watershed annually. In addition, over two million fry and parr are stocked in the Penobscot River watershed annually.

All adults returning to the Penobscot River are collected at the Veazie Dam fishway. Once removal of the Veazie Dam is completed in 2014, broodstock will be collected at the Milford Dam. Adults captured at the fishway are either taken to CBNFH for captive breeding or returned to the river upstream of the Veazie Dam. Since the initial listing of the GOM DPS of Atlantic salmon in 2000, the number of returning adults (both naturally-reared and conservation hatchery stocked) captured at the fishway trap at the Veazie Dam has ranged from as low as 534 in 2000 to as many as 3,123 in 2011(USASAC 2012). The majority of adult returns to the Penobscot River are of hatchery origin (Fay *et al.* 2006). In 2011, 92% of adult Atlantic salmon returns were of hatchery smolt origin, and the balance (8%) originated from fry stocking or natural reproduction (USASAC 2012).

The Veazie fishway trap is operated each year from May 1 to October 31 (MDMR, MDIFW 2009). The majority of the adult salmon captures at Veazie occur in June, with the median capture date occurring around the last week of June (MDMR 2008). Use of the rubber dam system at the Veazie spillway has led to improved and earlier captures of adult salmon in the river (MDMR 2007). Although the overall size of the salmon run differs from year to year, the monthly breakdown and median capture dates are similar (Table 2)(MDMR 2007, MDMR 2008, Dube *et al.* 2011).

Table 2. Monthly total and median capture dates of Atlantic salmon collected at the Veazie Trap during 2007-2010.

	2007		2008		2009		2010		Mean
Month	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**Distribution**
May	48	5%	267	13%	173	9%	344	26%	13%
June	458	50%	1465	69%	1382	71%	782	59%	65%

July	268	29%	236	11%	370	19%	141	11%	16%
August	79	9%	111	5%	14	1%	18	1%	4%
September	45	5%	18	1%	11	1%	27	2%	2%
October	18	2%	15	1%	8	0%	4	0%	1%
Total Run	**916**	**100%**	**2112**	**100%**	**1958**	**100%**	**1316**	**100%**	**100%**
Median Capture Date	23-Jun-07		26-Jun-08		18-Jun-09		9-Jun-10		

According to current broodstock management plans, 650 adult salmon are typically collected each year at Veazie Dam for transport to the CBNFH (MDMR 2007). Because of the goal of providing an equal ratio of male and female spawners for hatchery breeding purposes, as well as a proportion of 1-sea winter returns ("grilse"), the goal of 650 spawners is not consistently achieved. Table 3 below presents broodstock targets and number of broodstock collected at the Veazie Dam since 2000.

Table 3. Atlantic salmon broodstock collected at the Veazie Trap during (2000-2011).

Year	Broodstock Target	Total Broodstock Collected
2000	600	328
2001	600	502
2002	600	377
2003	600	605
2004	600	606
2005	600	475
2006	650	537
2007	650	590
2008	650	650
2009	650	679
2010	650	700
2011	650	739

Adult salmon that are collected at Veazie and not transported to the hatchery for broodstock are put back in the river above the dam and allowed to continue their upstream migration. Although there are fishways at dams above Veazie, including Milford and West Enfield, there are no annual counts of salmon using those fish passage facilities. Studies have shown, however, that upstream migration beyond Veazie proceeds relatively quickly unless dam flashboards are down or water temperature is elevated (Shepard 1995, Gorsky 2005).

Post-spawned Adults

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). Spring flows resulting in spillage at the dams facilitate out-migration of adult salmon (Shepard 1988). Downstream passage success of kelts was assessed as part of radio tag studies conducted for smolts in the Penobscot (GNP 1989, Shepard 1989a, Hall and Shepard 1990). Kelts tended to move downstream early in the spring (mostly mid-April through late May), regardless of whether fish were tagged in the spring or fall (i.e., most radio-tagged study fish generally stayed in the river near where they were placed until the following spring). Because kelt passage occurred during periods of spill at most dams, a large portion of study fish (90%) passed dams via spillage (i.e., over the dam). 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). At the upstream confluences (i.e., the Stillwater Branch and the main stem), kelts followed the routes in approximate proportion to flow in the two channels.

Smolts

Out-migrating Atlantic salmon smolts in the Penobscot River watershed are the result of wild production following natural spawning and juvenile rearing, or from stocking fry, parr, and smolts (Fay *et al.* 2006). The majority of the salmon run on the Penobscot are the result of stocked smolts; current management plans call for stocking 600,000 hatchery reared smolts at various locations in the main stem above Veazie Dam and in the Pleasant River (Piscataquis River sub-drainage) (MDMR, MDIFW 2009). Based on unpublished data from smolt-trapping studies in 2000 – 2005 by NMFS, smolts migrate from the Penobscot between late April and early June. The majority of the smolt migration appears to take place over a three to five week period after water temperatures rise to 10°C.

Rotary screw traps (RSTs) were used by NMFS during 2000-2005 to monitor downstream migrating smolts in the Penobscot River (Figure 4). Traps were deployed 0.87, 1.54, and 1.77 kilometers below the Veazie Dam. During the sampling period, the number of smolts captured in RSTs ranged from 72 to 3,165 annually. RST sampling in the Piscataquis River by MDMR in 2004 and 2005 captured 497 and 315 smolts, respectively. It is not currently possible to estimate the total number (wild and stocked) of smolts emigrating in the Penobscot or Piscataquis River, but the run is certainly related to the number of fish stocked annually.

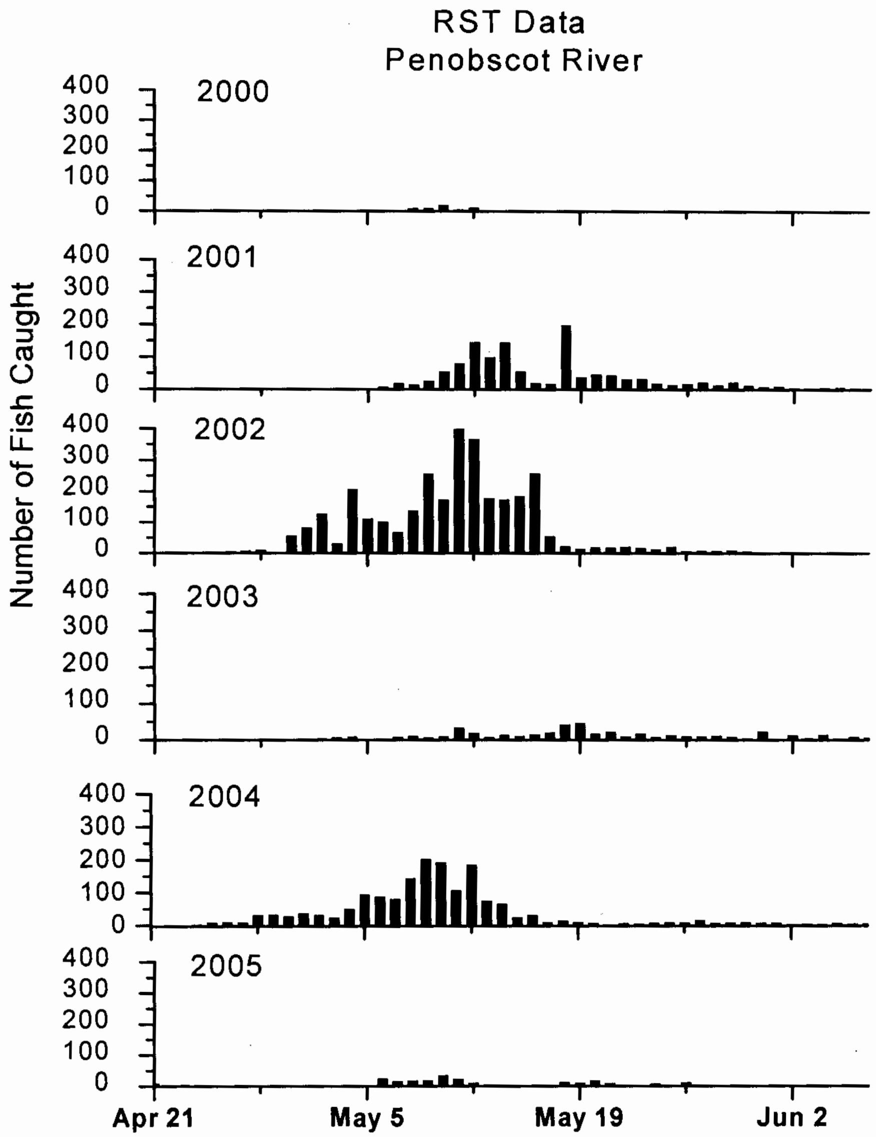

Figure 4. Total number of smolts collected using rotary screw traps in the Penobscot River from 2000 to 2005.

4.2. Critical Habitat for Atlantic Salmon in the Penobscot Bay SHRU

In Section 3.3, we present the factors affecting critical habitat throughout the GOM DPS of Atlantic salmon. In this section, we examine the status of critical habitat within the Penobscot Bay SHRU. Areas designated as critical habitat within each SHRU including Penobscot Bay are described in terms of habitat units. One habitat unit represents 100 m^2 of salmon spawning or rearing habitat. The quantity of habitat units in each SHRU was estimated through the use of a GIS-based salmon habitat model (Wright *et al.* 2008). For each SHRU, NMFS determined that there were sufficient habitat units available within the currently occupied habitat to achieve recovery objectives in the future; therefore, no unoccupied habitat (at the HUC-10 watershed scale) was designated as critical habitat.

The Penobscot Bay SHRU, which drains approximately 22,234,522 hectares (54,942,705 acres), contains approximately 315,574 units of spawning and rearing habitat for Atlantic salmon among approximately 17,440 km of rivers, lakes and streams. Of the 315,574 units of spawning and rearing habitat (within 46 HUC-10 watersheds), approximately 211,000 units of habitat are considered to be currently occupied (within 28 HUC-10 watersheds). Three HUC-10 watersheds (Molunkus Stream, Passadumkeag River, and Belfast Bay) are excluded from critical habitat designation due to economic impact. Certain tribal lands within the Penobscot Bay SHRU are also excluded from critical habitat designation.

4.3. Summary of Factors Affecting the Penobscot Bay SHRU

4.3.1. Threats to the Species and Critical Habitat

4.3.1.1.Hydroelectric Facilities

The Penobscot River SHRU has been extensively developed for hydroelectric power production. There are approximately 116 dams in the Penobscot River watershed; 23 of these dams operate under a FERC hydropower license or exemption (Fay *et al.* 2006). Hydroelectric dams are known to impact Atlantic salmon through habitat alteration, fish passage delays, and entrainment and impingement.

Habitat Alteration

While over 200,000 units of rearing habitat remains accessible in the Penobscot River watershed, historical and present day dams have eliminated or degraded vast, but to date unquantified, reaches of suitable rearing habitat. FERC (1997) estimated that 27% (19 miles) of main stem habitat (i.e., not including the Stillwater Branch segment) is impounded by the five dams between head-of-tide and the confluence of the East and West Branches in Medway. On the West Branch, approximately 57% of the 98 river miles is impounded (USACOE 1990). Approximately 11% of the approximately 74 miles of the Piscataquis River main stem, 28% of the approximately 43 miles of the Sebec River tributary to the Piscataquis, and 8% of the approximately 25 miles of the Passadumkeag River (below natural barrier at Grand Falls) is impounded (USACOE 1990).

Impoundments created by these dams limit access to habitat, alter habitat, and degrade water quality through increased temperatures and lowered dissolved oxygen levels. Furthermore, because hydropower dams are typically constructed in reaches with moderate to high underlying gradients, approximately 50% of available gradient in the main stem, and 41% in the West Branch, is impounded (USACOE 1990, FERC 1997). 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 on the East Branch, and especially on the West Branch of the Penobscot River, 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. Water drawn from impoundments in the West Branch often constitutes half or more of the streamflow in the main stem during the otherwise drier summer months (data analyzed from FERC 1996a).

The extent to which these streamflow modifications in the upper Penobscot 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

Pre-spawn adults

Among rivers within the range of the GOM DPS with hydropower dams that have one or more formal passage facility, most of the current understanding of fish passage efficiency comes from studies on the Penobscot River. Radio telemetry and other tracking studies by the MDMR and various hydropower project licensees have shown wide variation in site-specific upstream passage success, depending on the dam location and the environmental conditions (e.g., temperature, hydrology) during the year of study. For example, at the Veazie Dam, the percentage of radio tagged Atlantic salmon adults using the fishway ranged from 44% in 1990 to 89% in 1992, and averaged 68% over five years of study in the late 1980s and early 1990s (Dube 1988, Shepard 1989b, Shepard and Hall 1991, Shepard 1995). Shepard (1995) found that water temperatures above 23 C inhibited upstream movement, salmon did not hold in low velocity reaches such as impoundments, salmon did not enter tributaries during periods of low flow, spillage delayed passage at dams lacking fishway entrances at the spillway, and salmon stocked as smolts frequently did not migrate upstream of their stocking location.

MDMR (formerly the Maine Atlantic Salmon Commission (MASC)) tagged several hundred Atlantic salmon adults captured at the Veazie Dam fishway trap with Passive Integrated Transponder (PIT) tags from 2002 to 2004. This study monitored the date and time of passage with tag detectors located at the entrance and exit of the upstream fishway(s) at five main stem and five major tributary hydropower dams in the Penobscot watershed (Beland and Gorsky 2004, MASC unpublished data). Of the 379 total salmon tagged at Veazie in 2002, only 21% (78 fish) also passed the Mattaceunk Project fishway on the main stem, some 50 miles and four additional dams upstream. Less than 1% (3 fish) passed above the Guilford Dam on the Piscataquis River tributary, which is six additional dams upstream. The percentages in 2003 were 9% (41 of 461) and less than 1% (1 of 461) for Mattaceunk and Guilford Dam passages, respectively. In 2004, 19% (142) of the 709 PIT tagged salmon passed Mattaceunk and less that 1% (6) passed Guilford Dam. Many factors affect these results; the most important factor is homing motivation. As many of the study fish were hatchery smolts stocked below Mattaceunk or Guilford Dams, these fish would not be expected to pass the most upstream dams. Nevertheless, proportions of adults reaching two key upriver spawning reaches (East Branch Penobscot River and Piscataquis River above Guilford) are less than would be expected based on the proportion of available production habitat and numbers of fry stocked in those reaches.

At Milford Dam, upstream passage success ranged from 86% in 1987 to 100% in 1990, and averaged 90% (56 of 62) over five years of study using Carlin and radio tags (Dube 1988, Shepard 1995). Similarly, a three year study that was conducted between 2002 and 2004 that looked at migratory movements of adult Atlantic salmon using PIT tags indicated passage success at Milford ranging between 86% and 94% (Beland and Gorsky 2004, MASC unpublished data). In 2005 and 2006, Holbrook *et al.* (2009) conducted acoustic telemetry studies to assess upstream passage of adult salmon in the Penobscot River from the Veazie Dam upstream to the Howland and West Enfield Dams. Passage at Milford was 100% in 2005 (3 of 3) and 67% in 2006 (2 of 3). Based on all of these studies, Holbrook *et al.* (2009) calculated that passage at the Milford Project ranged between 67% and 100%, with an average of 90% and a median passage rate of 93%.

Upstream passage efficiency ranged between 85% and 100% over four years of study at the West Enfield and Howland Projects. Based upon radio telemetry studies conducted from 1989-1992, Shepard (1995) estimated pooled upstream passage rates for adult Atlantic salmon at the Howland and West Enfield at 88% for fish released below the Milford Dam and 89% for fish released above the dam. The pooled result for fish released above and below the Milford Dam over those years was 89% (41 out of 46). As part of a PIT tag study in 2002, Beland and Gorsky (2003) determined that 94% (290 of 308) of the Atlantic salmon that passed the Milford Project successfully passed either the Howland or West Enfield Projects. Of the fish that passed the Milford Project in the study conducted by Holbrook *et al.* (2009), 100% (3 of 3 in 2005; 2 of 2 in 2006) continued upriver and passed either the West Enfield or Howland Projects. It is difficult to assess passage rates at the West Enfield Project and the Howland Project separately, as passage at these dams is strongly influenced by the homing behavior of the migrating fish. As such, many of the salmon that pass upstream of the Milford Project are homing to the Piscataquis River and are not motivated to pass the West Enfield Project in the mainstem.

Migratory Delay

Early migration is an adaptive trait that ensures adult Atlantic salmon have sufficient time to effectively reach spawning areas despite the occurrence of temporarily unfavorable conditions that naturally occur within rivers (Bjornn and Reiser 1991). Gorsky (2005) found that migration in Atlantic salmon was significantly affected by flow and temperature conditions in the Penobscot River. He found that high flow led to a decrease in the rate of migration and that rates increased with temperature up to a point (around 23 degrees C) where they declined rapidly. To avoid high flows and warmer temperatures in the river, Atlantic salmon have adapted to migrating in the late spring and early summer, even though spawning does not occur until October and November. Between 2007 and 2010, 78% of migrating Atlantic salmon migrated past the Veazie Dam in May and June. According to USGS temperature data from Eddington, Maine, the 12-year median daily temperature in the Penobscot River exceeds 23°C in the first week of July.

To access high quality summer holding areas close to spawning areas in the Penobscot River watershed, Atlantic salmon must migrate past multiple dams. Delay at these 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 overripening of eggs, increased chance of egg retention, and reduced egg viability in pre-spawn female salmonids (deGaudemar and Beall 1998). It is not known what level of delay at each of these dams would significantly affect a migrant's ability to access suitable spawning habitat, as it would be different for each individual, and would vary from year to year depending on environmental conditions. We believe that 48 hours provide adequate opportunity for pre-spawn adult Atlantic salmon to locate and utilize well-designed upstream fishways at hydroelectric dams.

Available empirical data indicate a wide range in time needed for individual adult salmon to pass upstream of various dams in the Penobscot River once detected in the vicinity of a spillway or tailrace. The yearly pooled median passage time for adults at Milford Dam ranged from 1.0 days to 5.3 days over five years of study, while the total range of individual passage times over this study period was 0.1 days to 25.0 days. The yearly pooled median passage time for adults at the West Enfield or Howland Dam ranged from 1.1 days to 3.1 days over four years of study, while the total range of individual passage times over this study period was 0.9 days to 61.1 days (Shepard 1995).

Adult migrating salmon are attracted to the discharge of the existing powerhouse at the Orono Project, where they can be significantly delayed (greater than 48 hours). The Orono Project is in the Stillwater Branch, but the powerhouse discharges into the mainstem of the river, adjacent to the confluence with the Stillwater. Over a two year period (1988-1989), Shepard (1995) indicated that 46% (56% in 1988 and 37% in 1989) of tagged salmon were attracted to this discharge and delayed for a median of 8.30 hours in 1988 and 2.18 hours in 1989, prior to continuing upstream migration in the mainstem. The duration of the delay in 1988 ranged between 0.3 hours to 247.4 hours. Of the fish attracted to the discharge in that year, 33% were recorded spending more than 48 hours in the tailrace of the Project (S. Shepard, personal communication, 2012). Some of the salmon entered the Orono tailrace several times or were found to have migrated upstream prior to being attracted to the discharge at Orono. This behavior may be partially attributable to the fact that a proportion of the fish (56% in 1988 and 28% in 1989) were hatchery fish that were stocked as smolts in the mainstem of the Penobscot, rather than in the upper watershed. These fish may not have imprinted on upriver habitat and, therefore, may not have been highly motivated to continue migrating upstream. This would suggest that the proportion of Atlantic salmon that were attracted to the discharge at Orono may be greater than what would be expected for just wild fish. However, this study provides the best available information regarding what proportion of Atlantic salmon migrating through the Penobscot River could be attracted to, and delayed by, the discharge of the powerhouse at the Orono Project.

Outmigrating smolts

Smolts from the upper Penobscot River have to navigate through several dams on their migrations to the estuary every spring. Holbrook *et al.* (2011) found that migrating smolts split when encountering Orson and Marsh Islands, with >74% of smolts staying in the mainstem, and the remainder migrating through the Stillwater Branch. Hatchery smolts were found to use the Stillwater Branch less than wild smolts. In 2005, 14% of hatchery smolts and 26% of wild smolts chose to migrate through the Stillwater Branch. Based on Holbrook's data, NMFS's Northeast Fisheries Science Center (NEFSC) calculated median smolt usage of the Stillwater Branch as 19.7% (NMFS 2012). Smolts in the mainstem currently must navigate through the Mattaceunk, West Enfield, Milford, and Veazie Dams, while those in the Stillwater must navigate the Stillwater and Orono Dams. Multiple dam passage studies of smolts in the Penobscot River were conducted in 1989 and 1990. In 1989, net smolt survival past the three lower river mainstem dams (Milford, Great Works, Veazie) and the intervening habitat was between 30.5% and 61% (Shepard 1991). The wide range in these figures reflects the uncertainty as to how to classify tagged smolts that are detected at one or more upstream detection arrays, but then are not detected at the lowermost array at the last dam, where gaps in detection coverage were reported. In 1990, the net smolt survival past four dams (West Enfield, Milford, Great Works and Veazie for those choosing the mainstem route, or West Enfield, Stillwater, Orono, and Veazie for those choosing the Stillwater Branch route) and the intervening habitat was between 38% and 92% (Shepard 1991), again depending on the manner in which undetected fish were treated along the course of the study reach. It should be noted that Shepard studies in 1989 and 1990 were not designed to determine smolt mortality specifically due to turbine passage.

Smolt studies conducted by Holbrook (2007) documented significant losses of smolts in the vicinity of mainstem dams in the Penobscot River. Of the 355 radio tagged smolts released in 2005, 43% were lost in the vicinity of the West Enfield, Howland, and Milford Dams. In 2006, 60% of tagged smolts (n=291) were lost in the vicinity of the West Enfield, Howland, and Milford Dams. Although these data do not definitively reveal sources of mortality, these losses are likely attributable to the direct and indirect effects of the dams (e.g., physical injury, predation).

Very few studies have been conducted in Maine to directly assess fish entrainment and mortality on Atlantic salmon at hydroelectric facilities. In the only known study addressing turbine-passage mortality at a Penobscot River hydropower dam, Shepard (1993) estimated acute mortality of hatchery smolts passing through the two horizontal Kaplan turbines at the West Enfield Dam at 2.3% (n = approximately 410). Delayed mortality of the control group (smolts exposed to similar conditions except turbine passage) was quite high ranging from 20% in 1993 to 40% in 1992. Delayed mortality of turbine-passed smolts was considerably higher, ranging from 42% in 1993 to 77% in 1992. The high observed delayed mortality in the control group lead Shepard (1993) to conclude that any comparisons of delayed mortality between the control and treatment would be unreliable.

Studies conducted by NMFS in 2003 reported a much higher rate of dead smolts in the Penobscot smolt traps (5.2%) compared to parallel studies on the Narraguagus (0.3%) where there are no operating hydroelectric dams (USASAC 2004). Although some of this difference could be due to the fact that most of the smolts in the Penobscot study were hatchery origin while all of the Narraguagus smolts were wild or naturally reared, the nature of injuries observed for the 22 Penobscot smolt mortalities indicated that more than 60% were the result of entrainment (USASAC 2004). Injuries attributed to turbine entrainment were also noted on smolts collected alive during the studies.

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. However, based on the results of field trials looking at fish passage over spillways at five hydroelectric dams, only 97.1% of smolts are likely to survive passage via spillage (Normandeau Associates, Inc. 2011). Survival through turbines varies significantly based on numerous factors, but as described above can be significantly lower than the other two routes. A smolt study was conducted for Black Bear in 2010 to assess passage efficiency of the downstream bypass at the Orono Dam on the Stillwater Branch (Aquatic Science Associates, Inc. 2011). Radio and PIT tagged hatchery smolts were released under spill and non-spill conditions. Under spill conditions 13% of the smolts used the bypass, 17% went through the turbines, and 69% passed via spillage. Under non-spill conditions, 42% of smolts used the bypass and 58% went through the turbines.

Alden Research Laboratory, Inc. modeled current smolt survival rates at dams on the Penobscot River, based on turbine entrainment, spill mortality estimates and bypass efficiency (Alden Lab 2012). Alden Lab conducted a literature review to estimate survival rates based on passage route. Based on that review, it was estimated that mortality through a properly designed bypass would not exceed 1%, whereas mortality via spillage would not exceed 3%. The estimates of mortality due to passage through the turbines was calculated based on the characteristics of individual turbines (such as type of turbine, number of blades and the speed of rotation) and were therefore project specific. In addition to these route-specific estimates, Alden Lab estimated a 5% indirect mortality rate (due primarily to predation and sublethal injuries during passage), regardless of passage route (Alden Lab 2012, Appendix A). Using these assumptions, Alden Lab estimated that the mean survival rates of dams ranged between 86% and 92% (Table 4).

Table 4. Modeled smolt survival rates under current conditions at May flows for 15 dams on the Penobscot River (Alden Lab 2012) .

Project	Mean	Min	Max
Veazie	89.7%	82.7%	91.3%
Milford	91.6%	75.6%	92.0%
West Enfield	92.5%	92.3%	93.6%
Mattaceunk	86.0%	77.2%	89.8%
Orono	90.1%	81.6%	91.5%
Stillwater	91.9%	90.5%	92.1%
Medway	91.2%	88.4%	91.9%
Howland	91.5%	89.6%	92.7%
Brown's Mill	86.5%	61.5%	91.8%
Lowell Tann.	88.7%	84.7%	94.9%
Moosehead	87.9%	66.0%	91.0%
Milo	89.0%	85.2%	90.9%
Sebec	88.7%	83.4%	90.9%
Frankfort	92.0%	90.8%	94.4%

The potential for delays in the timely passage of smolts encountering hydropower dams is also evident in some tracking studies. At the Mattaceunk Dam, the average time needed for hatchery smolts to pass the dam, after being detected in the forebay area, was 15.6 hours (range 0 to 72 hours), 39.2 hours (range 0 to 161 hours), 14.6 hours (range 0 to 59.4 hours) and 30 hours (range 0.2 to 226 hours) in four different study years (GNP 1995, GNP 1997, GNP 1998, GNP 1999). At the West Enfield Dam, the median delay was 0.86 hours (range 0.3 to 49.7 hours) for hatchery smolts in 1993 (BPHA 1993), and approximately 13 hours (range 0.2 to 102.9 hours) for wild smolts in 1994 (BPHA 1994). At the Orono Dam, the median delay between release and passage of smolts was 3.4 hours (range 0.6 to 33.3 hours) in 2010 (Aquatic Science Associates, Inc 2011). While these delays can lead to direct mortality of Atlantic salmon from increased predation (Blackwell *et al.* 1998), migratory delays can also reduce overall physiological health or physiological preparedness for seawater entry and oceanic migration (Budy *et al.* 2002). Various researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible effects (McCormick *et al.* 1999). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration (McCormick *et al.* 1999). Similarly, artificially induced delays in migration from dams can result in a progressive misalignment of physiological adaptation of smolts to seawater entry, smolt migration rates, and suitable environmental conditions and cues for migration. If so, then these delays may reduce smolt survival (McCormick *et al.* 1999).

Outmigrating kelts

Atlantic salmon kelts move downstream after spawning in November or, alternatively, overwinter in freshwater and outmigrate early in the spring (mostly mid-April through late May). Lévesque *et al.* (1985) and Baum (1997) suggest that 80% of kelts overwinter in freshwater habitat prior to returning to the ocean. Downstream passage success of kelts has been assessed in the Penobscot (GNP 1989, Shepard 1989a, Hall and Shepard 1990). Kelt passage occurred during periods of spill at most dams, and a large portion of study fish used the spillage. Success over mainstem Penobscot River dams was usually greater than 90% at any one site. 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). At the upstream confluences (i.e., the Stillwater Branch and the mainstem), kelts followed the routes in approximate proportion to flow in the two channels (approximately 40%/60%). Shepard (1989a) documented that kelts relied on spillage flows to migrate past the Milford and Veazie Dams 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) modeled the current survival rates of kelts at the dams on the Penobscot River, based on turbine entrainment, spill mortality estimates and bypass efficiency (Table 5). 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 the dams (Medway is excluded) on the Penobscot range between 61% and 93%.

Table 5. Modeled kelt survival rates under current conditions at May flows for Black Bear's projects on the Penobscot River (Alden Lab 2012).

Project	April			May			November		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
Veazie	85.0%	80.6%	87.5%	80.8%	71.8%	86.1%	84.5%	71.8%	89.2%
Milford	86.2%	69.3%	89.3%	84.7%	69.3%	89.5%	81.8%	65.8%	88.4%
West Enfield	91.0%	90.2%	91.6%	91.0%	90.2%	91.6%	90.8%	90.2%	94.1%
Mattaceunk	82.7%	75.8%	87.7%	85.2%	75.8%	89.5%	85.0%	75.8%	89.5%
Orono	87.9%	81.2%	90.1%	86.6%	65.8%	90.2%	83.6%	65.8%	89.4%
Stillwater	88.0%	65.8%	90.2%	85.7%	65.8%	90.3%	82.5%	65.8%	89.5%
Medway	31.0%	0.0%	60.0%	67.8%	0.0%	84.2%	66.6%	47.0%	79.8%
Howland	92.6%	92.3%	94.1%	92.8%	92.3%	94.1%	92.9%	92.4%	94.1%
Brown's Mill	92.7%	92.4%	94.1%	92.9%	92.4%	94.1%	93.1%	92.4%	94.1%
Lowell Tannery	82.8%	74.9%	94.5%	83.3%	74.9%	94.5%	81.2%	47.0%	94.5%
Moosehead	92.2%	92.2%	92.2%	82.3%	0.0%	92.2%	76.3%	0.0%	92.2%
Milo	64.5%	43.6%	82.0%	66.8%	43.6%	83.2%	61.6%	0.0%	89.5%
Sebec	89.7%	86.0%	94.1%	89.8%	86.0%	92.3%	89.7%	86.0%	94.1%

Frankfort	68.4%	53.5%	90.8%	70.9%	53.5%	94.1%	71.6%	53.5%	94.1%

Delayed Effects of Downstream Passage

In addition to direct mortality sustained by Atlantic salmon at hydroelectric projects, Atlantic salmon in the Penobscot River will also sustain delayed mortality as a result of repeated passage events at multiple hydroelectric projects. Studies have investigated what is referred to as latent or delayed mortality, which occurs in the estuary or ocean environment and is associated with passage through one or more hydro projects (Budy *et al.* 2002, ISAB 2007, Schaller and Petrosky 2007, Haeseker *et al.* 2012). The concept describing this type of mortality is known as the hydrosystem-related, delayed-mortality hypothesis (Budy *et al.* 2002, Schaller and Petrosky 2007, Haeseker *et al.* 2012).

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

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 described above clearly support the delayed-mortality hypothesis proposed by Budy *et al.* (2002). However, only one of the studies quantified delayed mortality, and the estimates varied considerably. Although Rechisky *et al.* (2012) found no evidence of hydrosystem related delayed mortality between juvenile Snake River and Yakima River chinook salmon they acknowledged limitations within their study.

Although delayed mortality following passage through a hydrosystem has been demonstrated by the studies discussed above, effectively quantifying such losses remains difficult, mainly because of practical limitations in directly measuring mortality after fish have left a river system (i.e., during time spent in estuaries and the marine environment). Evaluations of delayed mortality have generally produced indirect evidence to support the link between hydrosystem experience and estuary and marine survival rates (and smolt-to-adult returns). In fact, in a review of delayed mortality experienced by Columbia River salmon, ISAB (2007) recommended that attempts should not be made to provide direct estimates of absolute delayed mortality, concluding that measuring such mortality relative to a damless reference was not possible. Alternatively, it was suggested that the focus should be on estimating total mortality of in-river fish, which was considered more critical to the recovery of listed salmonids. Consequently, it is difficult to draw absolute or quantifiable inferences from the Columbia River studies to other river systems beyond the simple conclusion that delayed mortality likely occurs for most anadromous salmonid populations. Additionally, although there is evidence of differential mortality between upper and lower river smolts in the Columbia River basin (Schaller and Petrosky 2007), data are not available for estimating a cumulative mortality rate based on the number of dams passed by downstream migrants.

Given the difficulty in estimating this type of mortality at the present time, we do not have sufficient data to specifically assess the effect of hydrosystem-related mortality in the Penobscot River. Nevertheless, considering that there are presently 14 FERC licensed hydroelectric projects in the Penobscot River watershed, it can be assumed that practically all smolts and kelts in the river must pass at least two hydroelectric dams during the downstream migrations and the resulting loss of endangered Atlantic salmon could be significant. According to a model developed by NMFS (2012; Figure 5), even a small cumulative mortality rate (1-10%) could have a significant effect on the number of returning 2 SW female Atlantic salmon in the Penobscot River watershed. It should be noted, however, that removal of the Veazie and Great Works Projects and decommissioning the Howland Project should significantly reduce the hydrosystem-related mortality of smolts and kelts in the river (see Section 4.3.2).

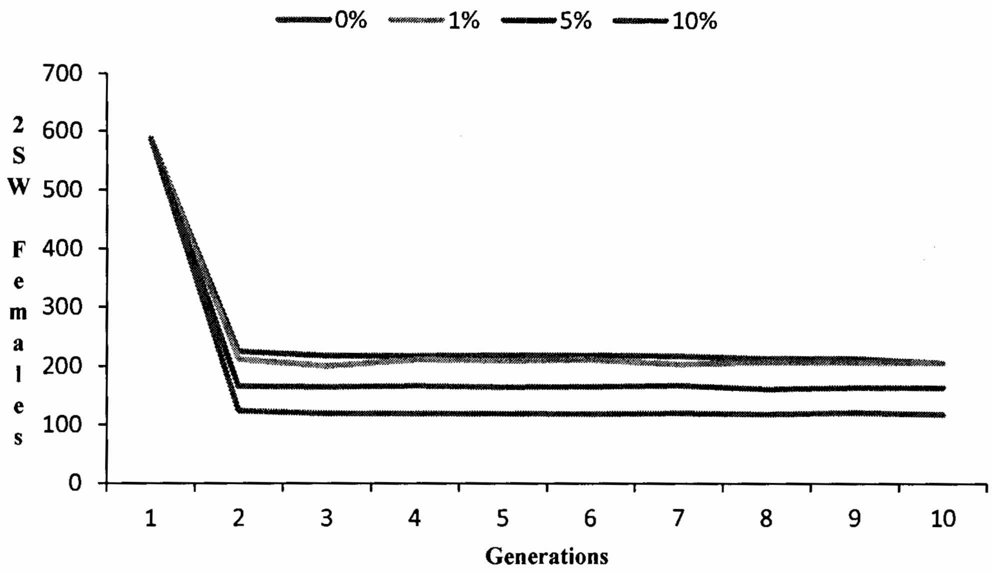

Figure 5. The potential effects of cumulative delayed mortality on the abundance of returning 2SW female Atlantic salmon over ten generations (NMFS 2012).

4.3.1.2.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).

Predation upon Penobscot River smolts has been studied by Blackwell (1996), as it relates to double crested cormorants, and by Van den Ende (1993) for certain fish species. In addition, the Penobscot River smolt migration studies described above have documented high smolt loss rates throughout the river system including free-flowing sections which implicate these same predators.

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 Penobscot River—smallmouth bass inhabit the entire main stem migratory corridor as well as many of the juvenile Atlantic salmon rearing habitats such as the East Branch Penobscot River and the Piscataquis River. 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 Pushaw Lake which drains to the Lower Penobscot River (Fay *et al.* 2006). Northern pike have expanded their range in the Penobscot River to include the Pushaw Stream outlet, nearby Mud Pond and probably portions of the main stem Penobscot River, since there are no barriers to their movement. 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. Cormorants were present in the Penobscot River during the spring smolt migration as migrants, stopping to feed before resuming northward migrations, and as resident nesting birds using Penobscot Bay nesting islands (Blackwell 1996, Blackwell and Krohn 1997). 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). Common mergansers and belted kingfishers are likely the most important predators of Atlantic salmon fry and parr in freshwater environments.

4.3.1.3.Contaminants and Water Quality

Pollutants discharged from point sources affect water quality within the Penobscot Bay SHRU. 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 (DEP) 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. The DEP has a schedule for preparing a number of TMDLs for rivers and streams within the Penobscot River watersheds. TMDLs allocate a waste load for a particular pollutant for impaired waterbodies. The main stem of the Penobscot River from its confluence with the Mattawamkeag River to Reeds Brook in Hampden has restricted fish consumption due to the presence of dioxin from industrial point sources. Combined sewer overflows from Milford, Old Town, Orono, Bangor, and Brewer produce elevated bacteria levels, thus inhibiting recreation uses of the river (primary contact). The lower area of the river south of Hampden to Verona Island is impaired due to contamination of mercury, PCBs, dioxin, and bacteria from industrial and municipal point sources. The West Branch of the Penobscot River is impaired due to hydro development and water withdrawals, which creates aquatic life issues. Color inducing discharges in the West Branch of the Penobscot River are affecting water quality in the Penobscot River. Many small tributaries on the lower river in the Bangor area have aquatic life problems due to bacteria from both NPS and urban point sources. Parts of the Piscataquis River and its tributaries are impaired from combined sewer overflows and dissolved oxygen issues from agricultural NPS and municipal point sources. Approximately 160 miles of the Penobscot River and its tributaries are listed as impaired by the DEP.

4.3.2. Efforts to Protect the Penobscot Bay SHRU

Penobscot River Restoration Project

On December 23, 2009, we issued an Opinion to FERC concerning the surrender of licenses for the Veazie, Great Works and Howland Projects. The projects were decommissioned and purchased by the Penobscot River Restoration Trust. The Trust's intent is to restore migratory access and habitat for multiple species of diadromous fish in the Penobscot River. The Great Works Project was removed by the Trust during the summer of 2012. Removal of the Veazie Project will expected to occur during the summer of 2013 and 2014. The bypass around the Howland Dam will be constructed in 2014, at the earliest. Once the Veazie Project is removed, the Milford Project, located on the eastern side of Marsh Island in Milford, will be the lowermost dam on the mainstem Penobscot River.

The removal of the dams associated with the PRRP is anticipated to have significant effects on the survival of Atlantic salmon migrating in the mainstem of the Penobscot River. Two modeling efforts have been undertaken, one by USFWS and one by us, to predict the effect of this project on Atlantic salmon in the Penobscot River. NMFS's Northeast Fisheries Science Center (NEFSC) constructed a Dam Impact Analysis (DIA) model to assess the effects of these dam removals as well as other actions in the Penobscot River (NMFS 2012). According to NMFS' DIA model, the removal of the dams will increase both the proportion of outmigrating smolts surviving to Verona Island at the mouth of Penobscot Bay, and the proportion of returning 2SW females. The model predicts that the dam removals will lead to a 68% relative reduction in the proportion of outmigrating salmon smolts that are killed prior to reaching the estuary when compared to the existing conditions. The DIA model also predicts a 79% relative increase in the number of returning 2SW female Atlantic salmon when compared to existing conditions (Figure 6).

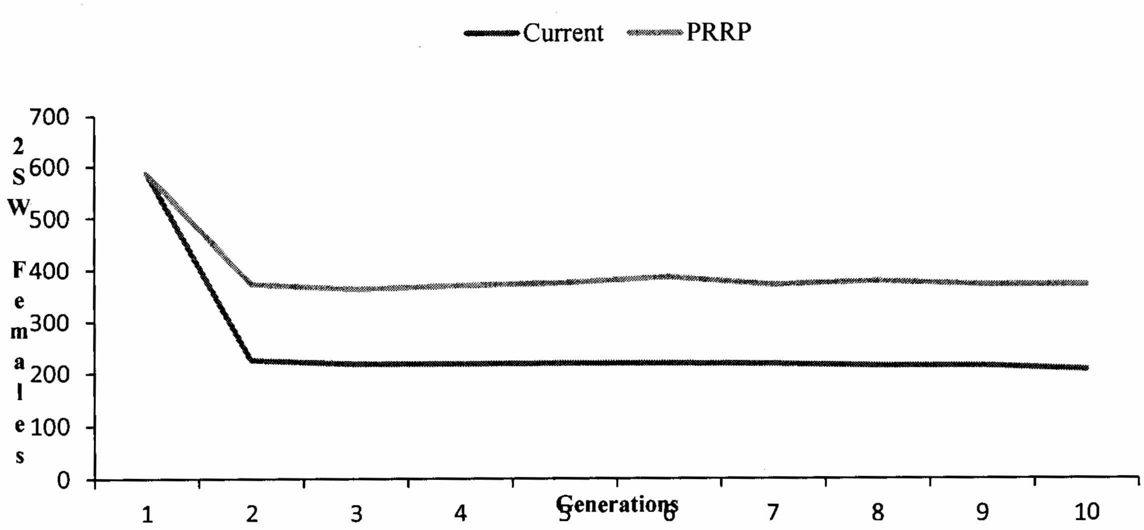

Figure 6. Comparison of the simulated number of returning 2SW female Atlantic salmon over ten generations according to the DIA model under existing conditions and conditions

expected after the removal of the Veazie and Great Works Dams, as well as the construction of a bypass around the Howland Dam (PRRP).

NMFS' DIA model also predicted the effect that the dam removals will have on the distribution of Atlantic salmon in the Penobscot River. The metric used for distribution was the proportion of Atlantic salmon runs where at least one 2SW female successfully migrated past the West Enfield Project in the mainstem of the Penobscot, or the Howland Project in the Piscataquis River. These landmarks were chosen as 92% of high quality spawning and rearing habitat in the Penobscot River watershed occurs upriver of these locations (NMFS 2009). Access to this habitat is critical to the survival and recovery of the species in the Penobscot Bay SHRU. The model indicates that after ten generations under existing conditions only 64% of runs will have individuals accessing the habitat in the Upper Penobscot and the Piscataquis Rivers. After the dam removals have been completed, however, the DIA model predicts that the proportion of successful runs could increase to 90%, a 41% relative increase over existing conditions (Table 6).

Table 6. The proportion of runs anticipated where 2SW female Atlantic salmon are able to access high quality habitat in the upper Penobscot River (above West Enfield) and in the Piscataquis River (above Howland) over ten generations.

	Upper Penobscot		Piscataquis	
Generation	**Current**	**PRRP**	**Current**	**PRRP**
1	100%	100%	100%	100%
2	68%	91%	68%	91%
3	64%	90%	65%	90%
4	64%	90%	65%	91%
5	63%	90%	64%	90%
6	64%	90%	65%	90%
7	64%	91%	64%	91%
8	63%	90%	64%	91%
9	64%	91%	65%	91%
10	64%	90%	64%	90%

USFWS (2012) conducted a separate life history model which also analyzed the effects of the dam removals on total smolt survival and adult returns in the Penobscot River (USFW 2012). The USFWS model shows similar results to the DIA model, indicating that the dam removals would increase total smolt survival from 64% to 74%, as well as increase cumulative upstream passage success through the Penobscot River dams from 72% to 95%. The USFWS model calculated a population growth rate (λ or lambda) for the various scenarios, and determined that the dam removals associated with the PRRP will increase λ in the Penobscot River from 0.65 to 0.82, assuming low marine survival. A population that has a λ below 1 is a declining population that is below the replacement rate; however, the PRRP under poor marine survival conditions still shows a significant increase in the population's rate of growth. USFWS (2012) also calculated λ under high marine survival conditions and determined that the dam removals associated with the PRRP would cause it to increase from 0.85 to 1.07. Lambda values above 1.0 indicate that a population has a positive growth rate.

Given the results of the NMFS and USFWS models, it is anticipated that the PRRP could significantly decrease the mortality of downstream migrating smolts, as well as increase the proportion of pre-spawn Atlantic salmon that can successfully migrate to suitable spawning habitat in the upper Penobscot River and Piscataquis River. Both models also indicate a corresponding increase in the population growth rate over the next several generations due to the dam removal activities associated with the PRRP.

5. STATUS OF ATLANTIC SALMON IN THE ACTION AREA (ENVIRONMENTAL BASELINE)

In order to put the effects of a proposed action on endangered species or critical habitat into meaningful context, we must first understand the status of the species and critical habitat as well as other environmental conditions that exist within the action area of the consultation (Sullins 1996). This "snapshot" in time is referred to as the environmental baseline of the action area. The environmental baseline requires us to understand existing conditions in the action area before we consider the effects of a proposed action on those conditions.

Regulations implementing the ESA (50 CFR 402.02) define the environmental baseline as "the past and present impacts of all Federal, state, or private actions and other human activities in the action area, including the anticipated impacts of all proposed Federal projects in the action area that have undergone Section 7 consultation and the impacts of state and private actions that are contemporaneous with the consultation in progress." In essence, we are charged with putting together all the pieces of past and present human activities that have created the existing "baseline' condition of the action area so that comparisons to the altered condition from the proposed action can be made. The environmental baseline condition of the action area does not include the effects of the action under review in the consultation (ESA Section 7 Consultation Handbook [USFWS and NMFS 1998] p. 4-22).

This consultation is for an ongoing project. Past aspects and impacts of the project are considered in the environmental baseline. The project's continued existence and operation represent the proposed action that is the subject of the consultation and the effects of those ongoing operations are considered and analyzed as effects of the action.

5.1. Status and Trends of Atlantic Salmon in the Action Area

All lifestages of Atlantic salmon occur in the action area of this consultation. Atlantic salmon are known to naturally reproduce upstream of the the Mattaceunk Project in the East Branch of the Penobscot River and its tributaries. Atlantic salmon fry are stocked annually upstream of the Mattaceunk Project in the East Branch of the Penobscot River and its tributaries (Figure 7)(TAC 1995; TAC 1996; TAC 1997; TAC 2000; MDMR 2008; MDMR 2009; MDMR 2010; MDMR 2011).

Table 7. Total Number of Fry Stocked in the East Branch of the Penobscot River and its Tributaries from 2002 – 2011.

Year	East Branch Penobscot River	Sebois River	Wassataquoik Stream	Total

2002	242,916	172,884	92,282	508,082
2003	201,469	88,213	104,298	393,980
2004	397,992	172,099	192,850	762,941
2005	446,163	239,834	209,604	895,601
2006	365,632	248,520	160,798	774,950
2007	416,624	201,732	247,190	865,546
2008	429,360	0	153,626	582,986
2009	250,480	166,650	99,597	516,727
2010	379,824	175,180	155,701	710,705
2011	246,470	326,855	133,669	706,994

Data have also been collected on downstream migrating smolts at the Mattaceunk Project through operation of a trap associated with the downstream fishway. Based on six years of monitoring data collected between 1988 and 1995 (GNP unpublished data), smolts migrate through the Mattaceunk Project from late April to mid-June, with peak numbers occurring in May (80% of migration). Smolt movements increased substantially when water temperatures reached 8 to 10°C.

Between 1983 and 2009, young-of-year and late summer salmon parr densities, as assessed using electrofishing techniques, have been low to moderate throughout much of the action area. Successful reproduction of Atlantic salmon as documented through redd counts has also been documented in the East Branch of the Penobscot River and its tributaries (MDMR 2009).

The best available information concerning adult, pre-spawn Atlantic salmon abundance in the action area is collected at the Mattaceunk Project. Upstream fishway counts have been conducted at the project since 1983, typically from June 10 to October 31. Data collected at the project show a peak in upstream migration during July and in September, with early June, August, and late October showing minimal salmon upstream movement (Figure 8). Table 7 shows the results of the documented Atlantic salmon returns at the Veazie Project, first dam on the lower river, and Atlantic salmon documented using the fishway at the Mattaceunk Project, approximately 61 miles upstream. There are several significant tributaries and substantial salmon habitat between the two projects, therefore, salmon returns in the upper reaches of the river would be lower.

Given the recent dam removal actions as part of the PRRP in the lower Penobscot River, we would expect the number of adults and smolts in the action area to either remain stable or increase in the future. According to models developed by NMFS and USFWS, it is anticipated that the PRRP could significantly decrease the mortality of downstream migrating smolts, as well as increase the proportion of pre-spawn Atlantic salmon that can successfully migrate to suitable spawning habitat in the upper Penobscot River.

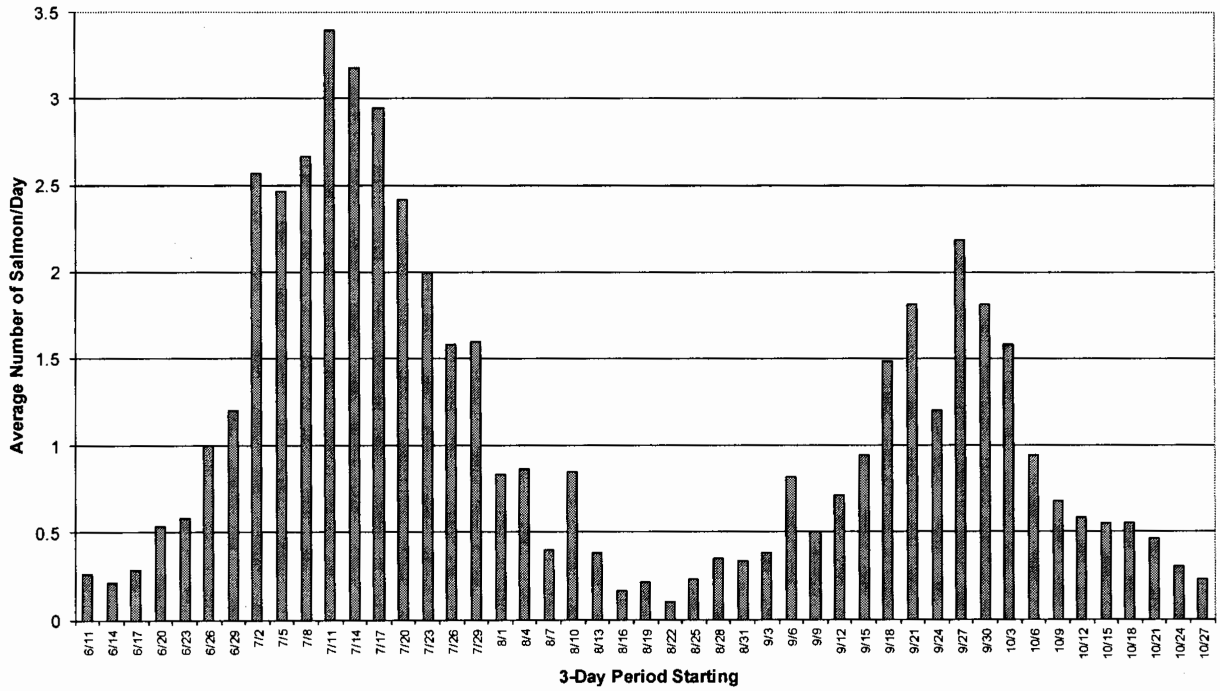

Figure 8. Seasonality of The Mattaceunk Project Atlantic Salmon Upstream Passage, 1983-2012.

Table 7. Adult Atlantic salmon returns to the Mattaceunk and Veazie Projects Between 1983 and 2012.

Year	Mattaceunk Project (FERC No. 2520)	Veazie Project (FERC No. 2403)
1983	10	952
1984	54	1,809
1985	119	3,370
1986	481	4,541
1987	314	2,519
1988	127	2,863
1989	293	3,120
1990	290	3,385
1991	158	1,767
1992	298	2,387
1993	101	1,774
1994	47	1,049
1995	37	1,336
1996	62	2,044
1997	20	1,355
1998	27	1,210
1999	52	968
2000	18	534
2001	20	785
2002	99	780

2003	40	1,112
2004	183	1,323
2005	37	985
2006	45	1,044
2007	60	925
2008	225	2,117
2009	345	1,958
2010	41	1,316
2011	194	3,125
2012	8	625
Total	**3,805***	**53,078***

* numbers indicate salmon from sport fishery, harvest, trap, and carcasses
Source: `Dubé et al. 2011; USASAC 2012, MDMR 2012

5.2. Critical Habitat for Atlantic Salmon in the Action Area

As discussed previously, critical habitat for Atlantic salmon has been designated in the Penobscot River, including the action area of this consultation. Both PCEs for Atlantic salmon (sites for spawning and rearing and sites for migration) are present in the action area as it was described in Section 3 of this Opinion (the entirety of the Penobscot River watershed). PCEs consist of the physical and biological elements identified as essential to the conservation of the species in the documents designating critical habitat. These PCEs include sites essential to support one or more life stages of Atlantic salmon (sites for spawning, rearing, and migration) and contain physical or biological features essential to the conservation of the species, for example, spawning gravels, water quality and quantity, unobstructed passage, and forage.

The East Branch sub-watershed contains 35,480 rearing units and 272,827 large parr production units for Atlantic salmon spawning and nursery area (MDMR and MDIFW 2009). The nearest mapped spawning and rearing habitat upstream of the Project is located in Wassataquoik Stream, a tributary of the East Branch of Penobscot River, the confluence of which is located approximately 30.5 miles upstream of the Mattaceunk Project. The nearest downstream mapped spawning and rearing habitat is in the Mattawamkeag River, a tributary that flows into the Penobscot River approximately 4.3 miles downstream of the project (USFWS 2011, Atlas of Maine 2009).

To facilitate and standardize determinations of effect for section 7 consultations involving Atlantic salmon critical habitat, we developed the "Matrix of PCEs and Essential Features for Designated Atlantic Salmon Critical Habitat in the GOM DPS" (Table 8). The matrix lists the PCEs, physical and biological features (essential features) of each PCE, and the potential conservation status of critical habitat within an action area. The two PCEs in the matrix (spawning and rearing, and migration) are described in regards to five distinct Atlantic salmon life stages: (1) adult spawning; (2) embryo and fry development; (3) parr development; (4) adult migration; and, (5) smolt migration. The conservation status of the essential features may exist in varying degrees of functional capacity within the action area. The three degrees of functional capacity used in the matrix are described in ascending order: (1) fully functioning; (2) limited function; and (3) not properly functioning. Using this matrix along with information presented in FERC's BA and site-specific knowledge of the project, NMFS determined that several essential features to Atlantic salmon in the action area have limited function or are not properly functioning currently (Table 9).

Table 8. Matrix of Primary Constituent Elements (PCEs) and essential features for assessing the environmental baseline of the action area.

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

TABLE 8 continued.

PCE	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 8 continued.

PCE	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 9. Current conditions of essential features of Atlantic salmon critical habitat having limited function or not properly functioning as part of the environmental baseline of the action area.

Pathway/Indicator	Life Stages Affected	PCEs Affected	Effect	Population Viability Attributes Affected
Passage/Access to Historical Habitat	Adult, juvenile, smolt	Freshwater migration	Upstream passage delays and inefficiencies limit access to spawning habitat. Poor downstream passage causes direct and delayed mortality of smolts and kelts.	Adult abundance and productivity
Habitat Elements, Channel Dynamics, Watershed Condition	Adult, incubating eggs, juvenile, smolt	Freshwater migration, spawning, and rearing	Impoundment degrades spawning and rearing habitat, increase predation, limit productivity, and delay migrations.	Adult abundance and productivity Juvenile growth rate
Water Quality	Adult, juvenile, incubating eggs	Freshwater spawning and rearing	Impoundment degrades spawning and rearing habitat.	Adult abundance and productivity Juvenile growth rate

The MDEP conducted water quality monitoring in the Penobscot River from August 11-17, 2011 at River Mile 66.3 (below the Mattaceunk Project) and at another station located eight miles downstream (River Mile 58.3)(MDEP 2012). Flows ranged from 4,400 cfs to 5,200 cfs, and data were collected at least once per hour (actual interval not specified) using remote multi-probe instruments (sondes) (MDEP 2011, 2012). The 2011 dissolved oxygen (DO) data are summarized in Figure 9. MDEP stated that, "It appears this reach of river was in attainment for DO during 2011. These data are representative of some of the lowest flows experienced in 2011 and all data are well above associated classification criteria of 5 mg/l at River Mile 66.3 (Class C stretch below the Mattaceunk Project) and 7 mg/l at River Mile 58.3 (Class B stretch below the Mattawamkeag River confluence)." While the Matteceunk Project impoundment continues to degrade Atlantic salmon spawning and rearing habitat, we have no information that indicates water quality conditions in the action area are not suitable for Atlantic salmon.

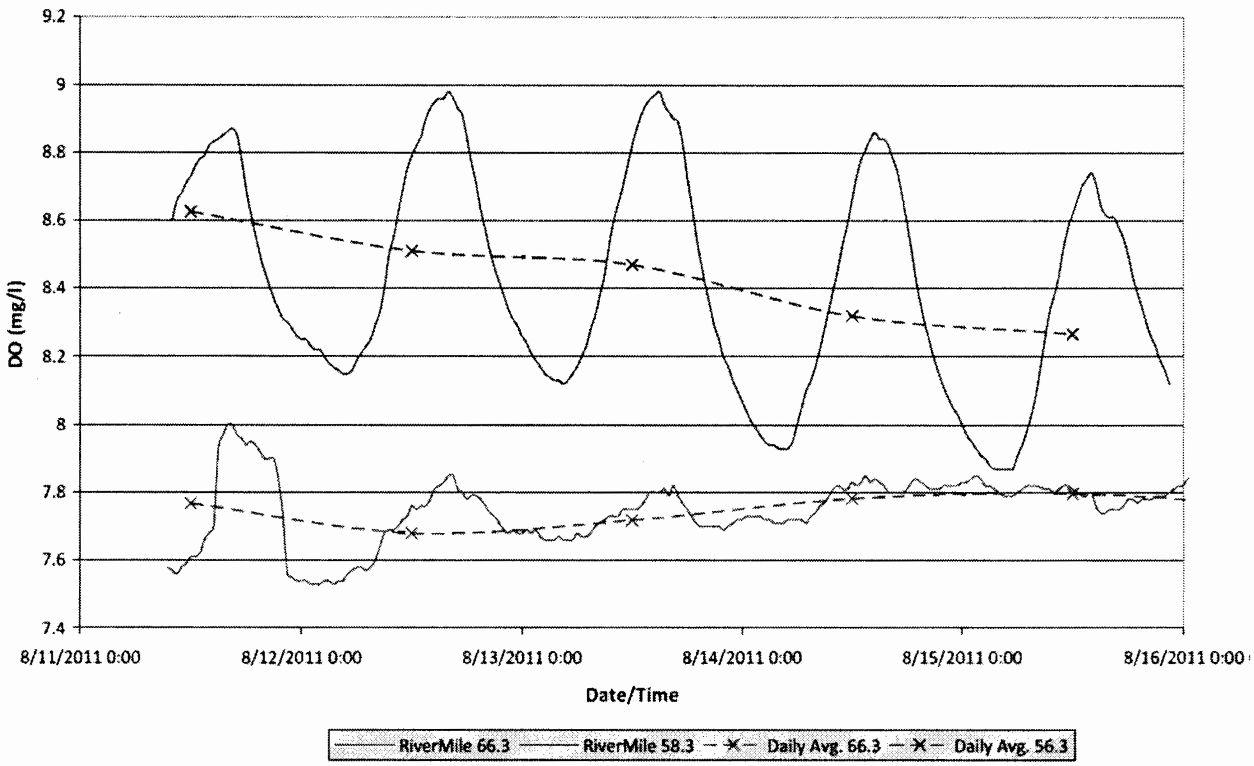

Figure 9. Dissolved Oxygen measured in the Penobscot River, River Mile 66.3 (below the Mattaceunk Project) and River Mile 58.3, in 2011. Source: MDEP 2012.

5.3. Formal or Early Section 7 Consultations

In the Environmental Baseline section of an Opinion, we discuss the anticipated impacts of all proposed Federal actions in the action area that have already undergone formal or early section 7 consultation. Effects of Federal actions that have been completed are encompassed in the Status of the Species section of the Opinion.

On August 30, 2012, we issued an Opinion to FERC analyzing the effects to listed Atlantic salmon regarding their proposal to amend the licenses for the Stillwater, Orono, Milford, West Enfield, and Medway Hydroelectric Projects in the Penobscot River in Maine (owned and operated by Blackbear Hydro LLC). The action area of the consultation encompassed the entire Penobscot River watershed and included the Mattaceunk Project area. As part of the proposed action, FERC proposed to amend the licenses of the Stillwater, Orono, Milford, West Enfield, and Medway Hydroelectric Projects to incorporate provisions of an Atlantic salmon Species Protection Plan (SPP). Among other provisions, the SPP required that the Stillwater, Orono, Milford, and West Enfield Projects achieve 96% downstream passage survival for Atlantic salmon. The SPP also required 95% upstream passage survival of Atlantic salmon at the Milford and West Enfield Projects. At Medway, the SPP requires Blackbear Hydro to meet with NMFS every five years to ensure that the project is being operated in a way that is consistent with recovery objectives for listed species. In the Opinion, we conclude that the proposed project may adversely affect but is not likely to jeopardize the continued existence of the GOM DPS of Atlantic salmon or result in adverse medication or destruction of Atlantic salmon critical habitat.

In our August 2012 Opinion, we modeled the anticipated effects of amending the licenses of

Blackbear Hydro's projects on the Penobscot River. Our model compared baseline conditions with the conditions of the river once the proposed actions have been implemented. The model results predicted a growth in the annual return rate of 2SW female Atlantic salmon by 11% in the tenth generation over the baseline conditions of the PRRP (Figure 10). As the metric being assessed is the change in the abundance of pre-spawn 2SW female Atlantic salmon, we assume that the increase in abundance corresponds with an increase in reproduction.

As illustrated in Figure 10, the model indicates a significant decline in 2SW female returns between the first and second generations prior to leveling out for the next nine generations. Although in generation one the model allows for 587 females to spawn in the system, the majority of their progeny do not survive to the adult stage due to freshwater and marine mortality factors. As such, they have very little effect on the subsequent adult returns and generations two through ten are primarily being driven by the return rate for the stocked smolts. In short, the 'wild' spawners in generation one are providing very little benefit to the subsequent adult returns under the baseline survival conditions and any benefit provided quickly dissipates as the generations progress.

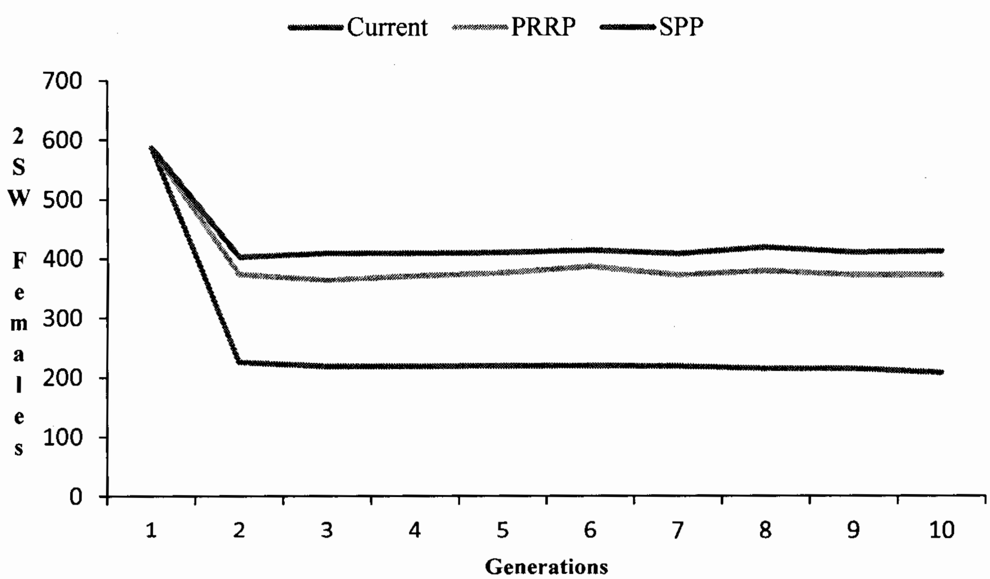

Figure 10. Comparison of the simulated number of returning 2SW female Atlantic salmon over ten generations according to the DIA model under current, environmental baseline (PRRP), and SPP passage conditions (NMFS 2012).

We have not completed any other consultations for listed Atlantic salmon in the action area of this consultation.

5.4. 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 action area of this consultation while the proposed action is carried out. The information gained from these activities will be used to further salmon conservation actions in the GOM DPS.

We are also a sub-permittee under USFWS' ESA section 10 endangered species blanket permit. Research authorized under this permit is currently ongoing with respect to Atlantic salmon in the Penobscot River. However, our research activities are not expected to affect Atlantic salmon in the action area of this consultation.

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 600,000 smolts are stocked annually in the Penobscot River. The hatcheries provide a significant buffer from extinction for the species.

5.5. State or Private Activities in the Action Area

Information on the number of Atlantic salmon captured or killed in state fisheries is extremely limited. In 2007, the MDMR authorized a limited catch-and-release fall fishery (September 15 to October 15) for Atlantic salmon in the Penobscot River upstream of the former Bangor Dam. The fishery was closed prior to the 2009 season. There is no indication that the fishery will be reinstated in the future.

5.6. Impacts of Other Human Activities in the Action Area

Other human activities that may affect listed species and critical habitat in the action area of this consultation 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. In addition, the release of silt and other fine river sediments during dam maintenance can be deposited in sensitive spawning habitat nearby. These facilities also act as barriers to normal upstream and downstream movements, and block access to important habitats. Passage through these facilities may result in the mortality of downstream migrants.

6. CLIMATE CHANGE

The discussion below presents background information on global climate change and information on past and predicted future effects of global climate change throughout the range of the listed species considered here. Climate change is relevant to the Status of the Species, Environmental Baseline and Cumulative Effects sections of this Opinion; rather than include partial discussion in several sections of this Opinion, we are synthesizing this information into one discussion. Consideration of effects of the proposed action in light of predicted changes in environmental conditions due to anticipated climate change are included in the Effects of the

Action section below (Section 7.0).

6.1. 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.

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 Penobscot River, especially as climate variability is a dominant factor in shaping coastal and marine systems. The effects of future change will vary greatly in diverse coastal regions for the U.S. Warming is very likely to continue in the U.S. over the next 25 to 50 years regardless of reduction in GHGs, due to emissions that have already occurred (NAST 2000). It is very likely that the magnitude and frequency of ecosystem changes will continue to increase in the next 25 to 50 years, and it is possible that the rate of change will accelerate. Climate change can cause or exacerbate direct stress on ecosystems through high temperatures, a reduction in water availability, and altered frequency of extreme events and severe storms. Water temperatures in streams and rivers are likely to increase as the climate warms and are very likely to have both direct and indirect effects on aquatic ecosystems. Changes in temperature will be most evident during low flow periods when they are of greatest concern (NAST 2000). In some marine and freshwater systems, shifts in geographic ranges and changes in algal, plankton, and fish abundance are associated with high confidence with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation (IPCC 2007).

A warmer and drier climate is expected to result in reductions in stream flows and increases in water temperatures. Expected consequences could be a decrease in the amount of dissolved oxygen in surface waters and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing rate (Murdoch *et al.* 2000). Because many rivers are already under a great deal of stress due to excessive water withdrawal or land development, and this stress may be exacerbated by changes in climate, anticipating and planning adaptive strategies may be critical (Hulme 2005). A warmer-wetter climate could ameliorate poor water quality conditions in places where human-caused concentrations of nutrients and pollutants other than heat currently degrade water quality (Murdoch *et al.* 2000). Increases in water temperature and changes in seasonal patterns of runoff will very likely disturb fish habitat and affect recreational uses of lakes, streams, and wetlands. Surface water resources in the southeast are intensively managed with dams and channels and almost all are affected by human activities; in some systems water quality is either below recommended levels or nearly so. A global analysis of the potential effects of climate change on river basins indicates that due to changes in discharge and water stress, the area of large river basins in need of reactive or proactive management interventions in response to climate change will be much higher for basins impacted by dams than for basins with free-flowing rivers (Palmer *et al.* 2008). Human-induced disturbances also influence coastal and marine systems, often reducing the ability of the systems to adapt so that systems that might ordinarily be capable of responding to variability and change are less able to do so. Because stresses on water quality are associated with many activities, the impacts of the existing stresses are likely to be exacerbated by climate change. Within 50 years, river basins that are impacted by dams or by extensive development may experience greater changes in discharge and water stress than unimpacted, free-flowing rivers (Palmer *et al.* 2008).

While debated, researchers anticipate: 1) the frequency and intensity of droughts and floods will change across the nation; 2) a warming of about 0.2°C (0.4°F) per decade; and 3) a rise in sea level (NAST 2000). A warmer and drier climate will reduce stream flows and increase water temperature resulting in a decrease of DO and an increase in the concentration of nutrients and toxic chemicals due to reduced flushing. Sea level is expected to continue rising: during the 20th century global sea level has increased 15 to 20 cm (6-8 inches).

6.2. Effects to Atlantic Salmon and Critical Habitat

Atlantic salmon may be especially vulnerable to the effects of climate change in New England, since the areas surrounding many river basins where salmon are found are heavily populated and have already been affected by a range of stresses associated with agriculture, industrialization, and urbanization (Elliot *et al.* 1998). Climate effects related to temperature regimes and flow conditions determine juvenile salmon growth and habitat (Friedland1998). One study conducted in the Connecticut and Penobscot rivers, where temperatures and average discharge rates have been increasing over the last 25 years, found that dates of first capture and median capture dates for Atlantic salmon have shifted earlier by about 0.5 days/ year, and these consistent shifts are correlated with long-term changes in temperature and flow (Juanes *et al.* 2004). Temperature increases are also expected to reduce the abundance of salmon returning to home waters, particularly at the southern limits of Atlantic salmon spatial distribution (Beaugrand and Reid 2003).

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

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

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

In addition to temperature, stream flow is also likely to be impacted by climate change and is vital to Atlantic salmon survival. In-stream flow defines spatial relationships and habitat suitability for Atlantic salmon and since climate is likely to affect in-stream flow, the physiological, behavioral, and feeding-related mechanisms of Atlantic salmon are also likely to be impacted (Friedland 1998). With changes in in-stream flow, salmon found in smaller river systems may experience upstream migrations that are confined to a narrower time frame, as small river systems tend to have lower discharges and more variable flow (Elliot *et al.* 1998). The changes in rainfall patterns expected from climate change and the impact of those rainfall patterns on flows in streams and rivers may severely impact productivity of salmon populations (Friedland 1998). More winter precipitation falling as rain instead of snow can lead to elevated winter peak flows which can scour the streambed and destroy salmon eggs (Battin *et al.* 2007, Elliot *et al.* 1998). Increased sea levels in combination with higher winter river flows could cause degradation of estuarine habitats through increased wave damage during storms (NSTC 2008). Since juvenile Atlantic salmon are known to select stream habitats with particular characteristics, changes in river flow may affect the availability and distribution of preferred habitats (Riley *et al.* 2009). Unfortunately, the critical point at which reductions in flow begin to have a damaging impact on juvenile salmonids is difficult to define, but generally flow levels that promote upstream migration of adults are likely adequate to encourage downstream movement of smolts (Hendry *et al.* 2003).

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

It is anticipated that these climate change effects could significantly affect the functioning of the Atlantic salmon critical habitat. Increased temperatures will affect the timing of upstream and downstream migration and make some areas unsuitable as temporary holding and resting areas. Higher temperatures could also reduce the amount of time that conditions are appropriate for migration (<23°C), 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.

7. EFFECTS OF THE ACTION

This section of an Opinion assesses the direct and indirect effects of the proposed action on threatened and endangered species or critical habitat, together with the effects of other activities that are interrelated or interdependent (50 CFR 402.02). Indirect effects are those that are caused later in time, but are still reasonably certain to occur. Interrelated actions are those that are part of a larger action and depend upon the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). The trapping of Atlantic salmon adults and smolts by MDMR for scientific purposes at the Mattaceunk Project will continue to occur during the period of this consultation. This activity would not occur but for the continued operation of the fish passage facilities at the project. However, as this activity has already been authorized under a research and recovery blanket permit with USFWS (permit number 697823); its effects will not be addressed in this Opinion. We have not identified any other interrelated or interdependent actions.

The ISPP is valid for a six-year period and expires in 2018. Therefore, this Opinion analyzes the effects of interim operation of the Mattaceunk Project until 2018. In 2018, this Opinion will no longer be valid and consultation under Section 7 will need to be reinitiated by FERC in 2017.

7.1. Upstream Fish Passage

To complete their life cycle, pre-spawn Atlantic salmon in the Penobscot River require access to suitable spawning habitat. As significant suitable spawning habitat occurs in the upper areas of the Penobscot River, Atlantic salmon must be able to migrate successfully through the fishway at the Mattaceunk Project. Fishways, in general, collect motivated fish into human-made structures that allow them to proceed in their migration. These fish are necessarily crowded together into a narrow channel or trap, which exposes them to increased levels of injury and delay, as well as to stress from elevated water temperatures, energetic exhaustion and disease. Forcing fish to alter their migratory behavior and potentially exposing them to the corresponding stress and injury negatively affects 100% of the Atlantic salmon motivated to migrate past a hydroelectric project.

GLHA proposes to continue operating the existing upstream fishway at the Mattaceunk Project during the period of the ISPP. Additionally, GLHA proposes to refurbish the existing fishway which will likely enhance its performance in passing Atlantic salmon. As described in Section 2.0, the existing upstream fishway consists of a pool and weir design comprised of 36 pools with a drop of approximately 14 inches between pools. Fish are able to ascend the fishway by way of either submerged orifices or weir notches. A gravity-fed pipe provides auxiliary water (7 cfs) for additional attraction flow to the entrance pool. A fish trap is located at the upstream exit of the fishway, so that fish enter the trap for monitoring purposes through a funnel-like opening after negotiating the fishway. Daily monitoring data show a peak in upstream migration during July and in early September, with early June, August, and mid-late October showing minimal salmon upstream movement.

A series of upstream fish passage studies were conducted at the Mattaceunk Project from 1983 to 1986 associated with licensing efforts and fishway modifications. The modifications made prior to the 1986 migration season, along with the comprehensive upstream passage monitoring study conducted during the 1986 season, best reflect the fishway's effectiveness. The introduction of attraction water to the entrance pool via a cascading overflow in 1986 appeared to significantly increase the salmon passage rate (GNP 1986). The 1986 study evaluated upstream passage efficiency of adult Atlantic salmon using two methods; 1) compared the results of monitoring adult Atlantic salmon captured in the fishway in 1986 to prior years and supplemental sources of tagging efforts, and 2) evaluated fish passage behavior by tracking adult salmon with radio telemetry. The results of this study showed that the earlier fishway modifications improved the upstream passage efficiency of adult Atlantic salmon. An increase from 119 adults captured in 1985 to 472 in 1986 represented an approximate 400% increase, while the number of salmon released into the main stem above Veazie Dam increased by only 161%. The percentage of adult Atlantic salmon released into the main stem that were captured at the Mattaceunk Project increased from 5.5% in 1985 to 13.5% in 1986 (GNP 1986).

Radio-tagged and control adult Atlantic salmon were utilized to measure upstream passage efficiency at the Mattaceunk Project in 1986 (GNP 1986). The control fish were used to evaluate any effects from radio tagging on salmon behavior. Of 14 radio-tagged fish that reached the Mattaceunk Project, 10 were trapped in the fishway, representing a minimum efficiency of 71%. In addition, 16 of the 18 control salmon were captured in the trap. Conservatively assuming that the other two control salmon reached the Mattaceunk Project, the passage efficiency of the control salmon was 89%; however, efficiency may have been 100% for these control fish if the other two control salmon never reached the Mattaceunk Project (and one of the two control fish was known to have been caught by recreational fishing downstream of the dam). The study suggested there was strong evidence that the tags or tagging procedure had a negative effect on fish passage, including a significant number of tagged fish that dropped downstream immediately after tagging (GNP 1986).

Additional analysis of Atlantic salmon upstream migration and passage can be obtained from tagging efforts by MDMR, where 9 of 10 East Branch Penobscot origin salmon released at South Lincoln were captured in the Mattaceunk Project fish trap, an efficiency of 90%. It is not known if the missing salmon ever approached the Mattaceunk Project, so efficiency could have been as high 100% (GNP 1986). Based on the results of all data presented, the GNP 1986 study concluded that the upstream passage efficiencies observed at Mattaceunk were acceptable and no further fishway modifications were needed. Resource agencies agreed, and study efforts at the project were shifted to downstream passage of smolts and kelts after the 1986 study season.

The USGS, University of Maine, and others are engaged in an on-going upstream passage monitoring study at nine major dams in the Penobscot River watershed, including the Mattaceunk Project. The monitoring study uses Passive Integrated Transponder (PIT) tag and tracking technology to monitor upstream migrating adult salmon movement. GLHA has been cooperating with USGS and University of Maine on this study, and PIT tag detection arrays are deployed on the Mattaceunk Project upstream fishway. As of 2011, a total of 2,429 adult Atlantic salmon collected at the Veazie fish trap were fitted with PIT tags (Maine Cooperative Fish and Wildlife Research Unit and Department of Wildlife Ecology, University of Maine. 2011). In 2012, all eight PIT-tagged Atlantic salmon that were contacted at the Mattaceunk Project successfully passed upstream.

Based upon the above information, it appears that the existing upstream fishway at the Mattaceunk Project is effective at attracting and passing Atlantic salmon. As no upstream survival studies have been conducted at the project, we do not know the survival of Atlantic salmon that use the existing fishway. For purposes of this analysis, we assume that the minimum effectiveness of the existing fishway is at least 71% effective at passing Atlantic salmon at the Mattaceunk Project.

Adult salmon that are not passed at the Mattaceunk Project will either spawn in downstream areas, return to the ocean without spawning, or die in the river. Although no studies have looked directly at the fate of fish that fail to pass through upstream fish passage facilities on the Penobscot River, we convened an expert panel in 2010 to provide the best available information on the fate of these fish. The panel was comprised of state, federal, and private sector Atlantic salmon biologists and engineers with expertise in Atlantic salmon biology and behavior at fishways. The group estimated a baseline mortality rate of 1% for Atlantic salmon that fail to pass a fishway at a given dam on the Penobscot River (NMFS 2011, Appendix B). The expert panel concluded that adult Atlantic salmon that do not use the upstream fishway at the Mattaceunk Project will stray and successfully spawn in downstream areas particularly the Mattawamkeag River headwaters. Therefore, the best available information suggests that 1% of adult Atlantic salmon that do not use the fishway at Mattaceunk will die.

7.2. Downstream Fish Passage

Under the proposed action, the Mattaceunk Project would continue to affect downstream migrating Atlantic salmon smolts and kelts by: 1) injury and mortality associated with entrainment through project facilities, 2) delayed outmigration influencing outmigrating timing, 3) potential to increase predation on outmigrating juveniles in the project reservoir and tailrace, and 4) increasing stress levels, which leads to a subsequent decrease in saltwater tolerance. The project's reservoir would continue to affect the timing and behavior of outmigrating fish. GLHA's proposal to repair the existing downstream fishway will likely enhance its performance in passing Atlantic salmon smolts and kelts.

Downstream Smolt Passage

Since the mid 1980's, GLHA and its predecessors have been providing and studying downstream fish passage for Atlantic salmon and other fish species at the Mattaceunk Project. The installation and subsequent monitoring plan of downstream fish passage facilities at the Mattaceunk Project for anadromous fish was part of the FERC license condition (Article 404) issued for the Mattaceunk Project in 1988, with the design of these facilities and the monitoring plans conducted in consultation with the USFWS, Maine Atlantic Salmon Commission (MASC), MDMR, and NMFS, along with the final approval by the FERC. The permanent downstream fish passage facilities have been tested a number of times since 1993, with overall Atlantic salmon smolt passage efficiency results varying between 17% and 59% over seven years of study in the 1990s, as seen in Table 10 (Letter from GLHA to USFWS dated March 8, 2006). Passage efficiency of the downstream fishway for wild smolts ranged from 28% to 37% (GNP 1995, GNP 1997). The average time needed for hatchery smolts to pass the dam, after being detected in the forebay area, was 15.6 hours (range 0 to 72 hours), 39.2 hours (range 0 to 161 hours), 14.6 hours (range 0 to 59.4 hours) and 30 hours (range 0.2 to 226 hours) in four different study years (GNP 1995, GNP 1997, GNP 1998, GNP 1999). Most of these studies were conducted by project licensees and used radio telemetry methods.

In the spring of 2004, the downstream fish passage facilities were tested under "baseline" conditions with no strobe lights and typical turbine flow conditions, resulting in a passage efficiency of 41% (Letter from GLHA to USFWS dated March 8, 2006). The relatively high number of undetected fish was likely related to the number of tagged fish passing through the facility simultaneously, surpassing the ability of the monitoring system to detect multiple targets. Of the 29 study smolts contacted by telemetry during their passage, 12 passed through the downstream fish passage facilities resulting in the 41% efficiency. Given the irregular success of the strobe light system in directing smolts to the fishway, it is no longer in use.

GLHA coordinated with resource agencies and the University of Maine to expand on Penobscot River studies by including the Mattaceunk Project in the evaluation of Penobscot River downstream Atlantic salmon smolt migrations. These studies, conducted in 2010, 2011, and 2012 used acoustic telemetry to assess movement and survival rates of Atlantic salmon smolt migrating downstream through the Mattaceunk Project (USGS *unpublished data*). Wild Atlantic salmon collected at the Mattaceunk Project downstream fishway were used during 2010 and 2011 studies; in 2012, hatchery smolts were used. All test fish were released in Medway, Maine approximately 10 km upstream of the Project. Survival estimates were based on detection by acoustic arrays deployed throughout the river; however, the cause of any smolt mortalities is not known.

Table 10. Summary of Mattaceunk Project Downstream Bypass Passage Efficiency Studies for Atlantic Salmon Smolts (1987-2005).

Year	Result
1987	Upstream passage facility evaluated as a potential means of providing downstream passage and found to be ineffective for providing downstream passage of smolts
1988	A suction hose in turbine forebay #3 and a weir box upstream of unit #4 thermal break were tested – 3% smolt collection efficiency; strobe lights were found to be effective in turbine forebay #3 testing
1989	Suction hoses in turbine forebay #3 and #4 were tested with no strobe lights – 32% smolt collection efficiency
1990	Suction hoses in turbine forebay #3 and #4 were tested with strobe lights in turbine forebay #1 and #2 – 17% smolt collection efficiency
1991 and 1992	Log sluice was tested, while passing 140 cfs, and found to be ineffective for downstream passage
1993	Permanent downstream passage system was installed. The system was tested with strobe lights in turbine forebay #1 and #2, and 65% of the turbine flow through units #3 and #4 – 59% smolt collection efficiency
1994	System tested with strobe lights in turbine forebay #1 and #2, and 61% of the turbine flow through units #3 and #4 – 45% smolt collection efficiency
1995	System tested with Flash Technology strobe lights at full depth on units #1 and #2 and at lower depths on units #3 and #4, and 66% of turbine flow through units #3 and #4 – 52% smolt collection efficiency
1996	No studies due to high water
1997	System tested with strobe lights at full depth on units #1 and #2 and at lower depths on units #3 and #4, and 63% of turbine flow through units #3 and #4 – 41% smolt collection efficiency
1998	System tested with strobe lights at full depth on units #1 and #2 and at lower depths on units #3 and #4, and 48% of turbine flow through units #3 and #4 with flow reduced through turbine #3 and surface inlet #4 for testing – 22% smolt collection efficiency
1999	System tested with strobe lights at full depth on units #1 and #2, and 63% of turbine flow through units #3 and #4 – 17 % smolt collection efficiency
2000	No studies due to high water
2001	No studies due to turbine #2 being down. Flash Technology strobe light system was removed
2002	No studies due to turbine #2 being down
2003	No studies due to Great Northern Paper mills being down
2004	System tested with normal flows and no strobe lights – 41% smolt collection

Year	Result
	efficiency
2005	No studies due to restoration of generating station

A total of 74 wild smolts were collected and tagged and released in early May 2010. Mortality estimates through the 8 km reach containing the Mattaceunk Project was 0.04 (± 0.03 SE) (USGS *unpublished data*). Movement rates revealed that the average rate of smolts passing through the Mattaceunk Project area was 0.87 kilometers per hour (km/h), and 0.31 km/h through the headpond reaches (USGS *unpublished data*). The study was duplicated in 2011, but due to poor fish condition, low detection probabilities, smaller test fish, larger tags, lateness of the study, and different monitoring locations, the results were not comparable to the 2010 results. Significantly high mortality rates were observed at the release site and next downstream detection array, resulting in very low numbers of test smolts. The high release mortality (0.60 ± 0.06 SE) was suspected to be associated with unusually turbulent conditions in the fish trap from high river flows, resulting in added stress to the test smolts.

In 2012, USGS tagged 85 hatchery-reared smolts and released them in Medway. Mortality estimates through the 8 km reach containing the Mattaceunk Project was 0.12 (± 0.04 SE). The average (±SE) movement rate of Atlantic salmon smolts was 1.97 km/h (±0.21 km/h) through downstream reference reaches, 0.33 km/h (±0.04 km/h) through the Mattaceunk Project, and was 0.39 (±0.03) through the headpond. Study results suggest there is higher mortality and slower migration rates through the Mattaceunk Project and headpond when compared to mortality and migration speed through the downstream reaches. It should be noted that mortality was also observed in a majority of the reaches without dams during the studies conducted from 2010 to 2012 (USGS *unpublished data*).

In 2012, Alden Research Laboratory, Inc. modeled expected smolt survival rates at a variety of hydroelectric projects on the Penobscot River, including the Mattaceunk Project (Alden Lab 2012). At the Mattaceunk Project, Alden estimated a mean total project survival rate of 86% for smolts based upon expected passage through turbines, spill, and downstream fishways Alden Lab's analysis accounted for both immediate and delayed mortality associated with dam passage.

GLHA also conducted an assessment of Atlantic salmon smolt survival in the BA submitted to FERC. The analysis estimated whole station survival using a standard desktop methodology for estimating turbine survival. Immediate smolt survival through the turbines was estimated by the following two separate methodologies: (1) empirical estimates compiled in the scientific literature (EPRI Turbine Passage Survival Database) and (2) the Advanced Hydro Turbine model (Franke *et al.* 1997). The estimates of whole station survival derived by GLHA assumed a median May flow at the project with proportional smolt passage via turbine entrainment, spillage, and the downstream fish passage facility (Figure 11). The EPRI technique resulted in a mean turbine survival rate of 94.6%, while the Advanced Hydro Turbine model resulted in a mean turbine survival rate of 95.9%. Mean survival over the spillway was estimated to be 97.1% based on field trials conducted at five hydroelectric projects (Normandeau Associates, Inc. 2011). Survival through the downstream bypass/fishway was assumed to be 100% based on intended design for successful passage through agency consultation.

A desktop analysis provides an estimate of immediate survival and does not assess potential impacts resulting from migratory delays, non-lethal injuries, or latent death. Therefore, actual survival of smolts is likely less than reported in the FERC's BA. The potential for delays in the timely passage of smolts encountering the Mattaceunk Project is evident based upon the results of radio telemetry studies. While these delays can lead to direct mortality of Atlantic salmon from increased predation (Blackwell *et al.* 1998), migratory delays can also reduce overall physiological health or physiological preparedness for seawater entry and oceanic migration (Budy *et al.* 2002). Various researchers have identified a "smolt window" or period of time in which smolts must reach estuarine waters or suffer irreversible effects (McCormick *et al.* 1999). Late migrants lose physiological smolt characteristics due to high water temperatures during spring migration (McCormick *et al.* 1999). Similarly, artificially induced delays in migration from dams can result in a progressive misalignment of physiological adaptation of smolts to seawater entry, smolt migration rates, and suitable environmental conditions and cues for migration. If so, then these delays may reduce smolt survival (McCormick *et al.* 1999).

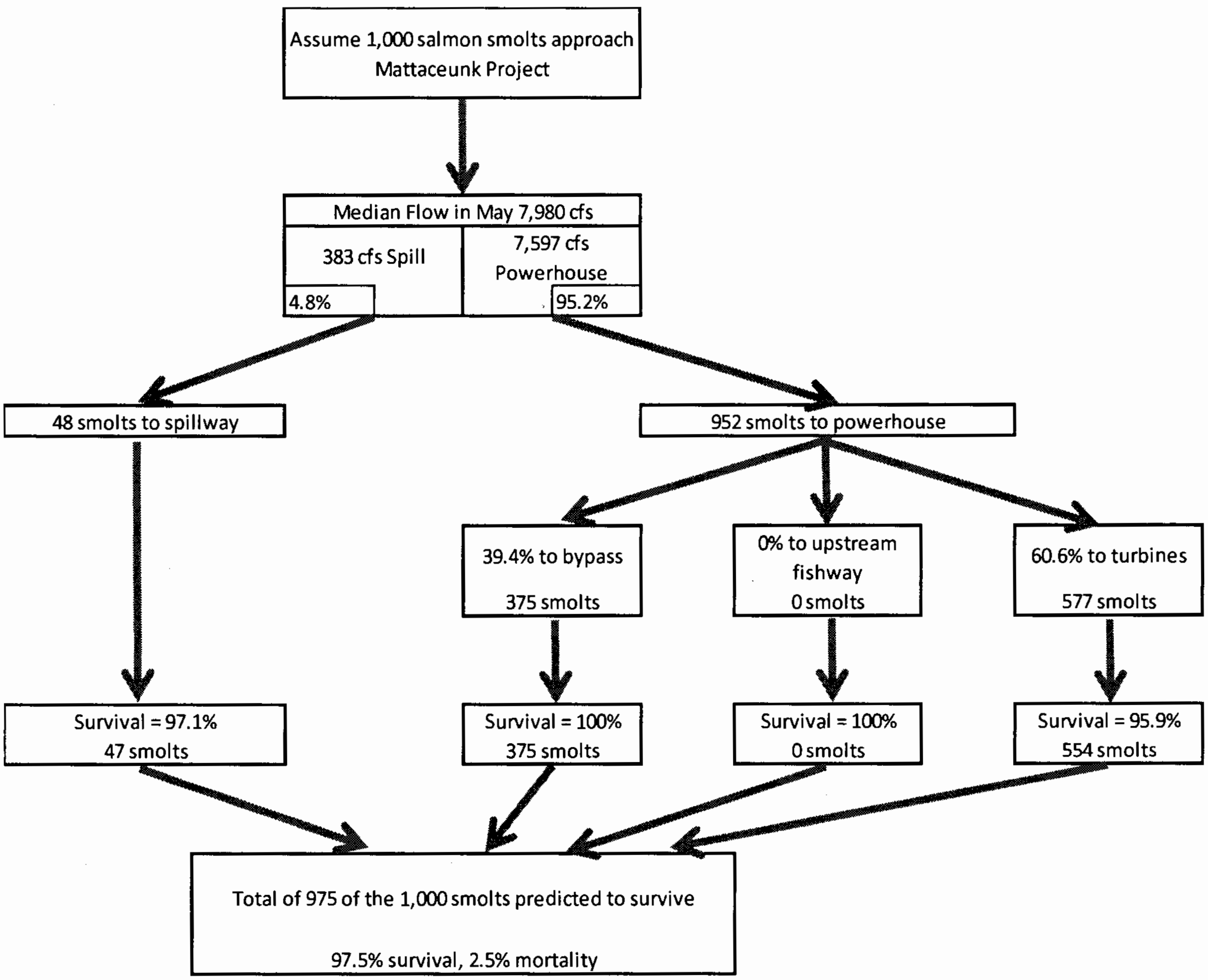

Figure 11. Example calculation of smolt survival for downstream passage at the Mattaceunk Project during May median flow using the modeled turbine survival rate.

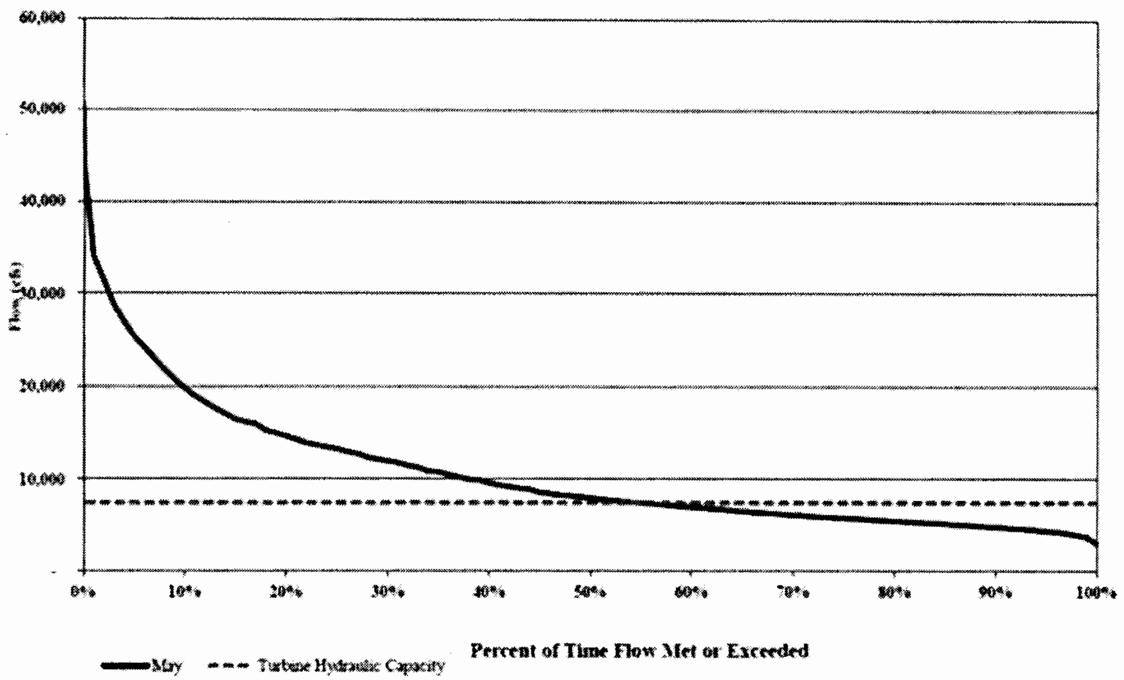

Figure 9. May flow exceedance, Mattaceunk Project USGS Gages 01046500, 01047000, 01048000, and 01049000.

Based upon the above information, we believe survival studies conducted by USGS in 2010 and 2012 provide the best available information concerning Atlantic salmon smolt survival at the Mattaceunk Project. In 2010, survival of smolts through the project area was 96%; in 2012 survival was 88%.

Downstream Kelt Passage

Downstream passage success of kelts at the Mattaceunk Project was studied extensively from 1987 to 1998. During this period, over 200 kelts were radio tagged and released into the river upstream of the project. Throughout the study period, the configuration of the downstream fishway was modified to enhance its collection efficiency. Mobile and stationary monitoring after release demonstrated the kelts tended to move downstream during high flows (GNP 1987; GNP 1988; GNP 1989; GNP 1990; GNP 1991; GNP 1993; GNP 1994; GNP 1995; GNP 1998). Although kelts tended to move downstream with high flows in early spring, most of the study fish were hatchery kelts that were tagged and released in the spring, thus fall movement was not assessed in some of these studies. Overall, the routes of passage for kelts at the Mattaceunk Project were evenly distributed between the turbines, spillage, and the downstream fishway. In the final year of study (1998), the downstream fishway achieved an effectiveness of 75% for kelts. The studies were not designed to quantify survival of kelts passing the Mattaceunk Project.

Current MDMR research tracking tagged adult Atlantic salmon in the Penobscot River basin has shown that adults can drop downstream quickly past many dams. Researchers noted that, "the presence of dams did not appear to impede downstream movement of motivated salmon, and some fish passed seven dams in as many days." In 2010, eight fish that migrated downstream of

Veazie Dam were recaptured 17 days after being released in the Piscataquis River, and "appeared in excellent condition and showed no adverse effects from passing downstream over multiple (seven) dams" (Spencer *et al.* 2010, 2011). It should be noted that spillage was occurring at most of the seven dams during the 2010 study.

While no kelt survival data is available for the Mattaceunk Project, Alden Research Laboratory, Inc. modeled expected kelt survival rates at a variety of hydroelectric projects on the Penobscot River, including the Mattaceunk Project (Alden Lab 2012). For the Mattaceunk Project, Alden estimated mean total project survival rates between 75.8% and 82.7% based upon expected passage through turbines, spill, and downstream fishways during the months of April, May, or November. Alden Lab's analysis accounted for both immediate and delayed mortality associated with dam passage. Absent site-specific empirical data at the Mattaceunk Project, we consider the Alden Research Lab model estimates to be the best available information concerning kelt survival at the project.

7.3. Critical Habitat

The Mattaceunk Project operates as a run-of-river facility to protect fish and wildlife resources. The Mattaceunk Project tailrace is connected to the mainstem of the river (no bypass). 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 (FERC 2005), including Atlantic salmon. Additionally, run-of-river flow requirements below the Mattaceunk Project are maintained per the FERC license, and fish passage operation flow protocols have been established in consultation with USFWS, NMFS, and MDMR. Maintaining upstream and downstream passage at the project improves migration habitat for Atlantic salmon. Table 11 below summarizes the condition of essential features of Atlantic salmon critical habitat following implementation of the ISPP at the Mattaceunk Project.

Table 11. Atlantic salmon critical habitat essential features following implementation of the ISPP at the Mattaceunk Project.

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

7.4. Effects of Roller Gate and Fishway Repairs

As discussed in Section 2, GHLA intends to perform maintenance at the Mattaceunk Project in the summer of 2013 which will require a large scale drawdown (20-25 feet) of the project impoundment. The focus of this maintenance will be dam safety maintenance and repairs to the roller gate section of the dam that were recommended by the Part 12D dam safety inspection report. Once the impoundment is drawn down, work on the roller gate will proceed in the dry. In addition to these required repairs, GLHA also intends to take advantage of the drawdown to perform additional maintenance and repairs at the upstream and downstream fishways as described in Section 2. GHLA proposes to conduct the work during the low flow period of July through August 2013 to protect aquatic resources. In addition, crews will survey the impoundment to relocate any stranded fish to reduce injury and mortality.

The primary effects to listed Atlantic salmon during the maintenance work will result from a disruption in upstream migrations in the action area during the period of work (July through August). Since work will occur in the dry, we do not anticipate reduce water quality during the work. In fact, a lowered headpond will resemble natural riverine conditions However, during a reduced headpond elevation, the upstream fishway at the project cannot function; therefore, GLHA will close the upstream fishway during the summer maintenance drawdown to allow fishway repairs to be performed. The average number of upstream migrating salmon that use the upstream fishway is highly variable (see Section 5), however, summer low flow periods in the Penobscot River coincide with reduced movements of adult Atlantic salmon due to increased ambient water temperatures. Salmon are known to seek cool water refuge areas during this time period, and then resume their upstream migration when river water temperatures cool in the fall. The number of Atlantic salmon using the Mattaceunk fishway has been shown to be lowest in August. Further, suitable habitat for upstream migrating salmon is available downstream of the project, particularly in the Mattawamkeag River, a tributary which enters the Penobscot River approximately 4.3 miles downstream the project (Figure 7). The Mattawamkeag River is known to be readily utilized by upstream migrating salmon that reach the river section below the Mattaceunk Project.

We also note that removal of Veazie Dam will occur during the summer of 2013. During removal activities at Veazie, upstream passage for Atlantic salmon will be curtailed for 4-6 weeks. Prior to dam removal activities at the Veazie Dam, the MDMR will transport most if not all adult Atlantic salmon captured at the Veazie fishway to the Green Lake National Fish Hatchery (GLNFH) for use as broodstock. Thus, it is anticipated that few, if any, returning salmon will be released to upstream riverine areas including the Mattaceunk Project in the summer of 2013. Beneficial effects to Atlantic salmon migrations are expected are a result of repairs to upstream and downstream fishways at the project.

7.5. Monitoring and Evaluation

In order to determine the upstream and downstream survival of Atlantic salmon passing the Mattaceunk Project, GLHA proposes to conduct survival studies for Atlantic salmon adults and smolts at the project during the period of the ISPP. The downstream smolt survival studies will involve obtaining Atlantic salmon smolts from GLNFH, surgically implanting radio transmitter tags, and then conducting paired releases in groups up and downriver of the Mattaceunk 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. GHLA will monitor and evaluate the effectiveness and survival of the fish passage facilities for up to three years at the project. It is expected that 150 smolts will be used per year, for a total of 600 smolts. In addition, it is anticipated that three years of upstream studies consisting of radio telemetry studies using a sample size of 20 adult salmon each year will be conducted during the interim period covered under the ISPP. Kelt studies were not proposed as part of the ISPP but will occur as part of the final SPP that will become part of the new license for the project.

Tagging

Techniques such as PIT tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. Radio telemetry will be used as the primary technique for the proposed studies. There are two techniques used to implant fish with radio tags and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways. This is the technique that GLHA proposes to use on adult Atlantic salmon for the upstream passage studies.

The second method for implanting radio tags is to surgically place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible (Chisholm and Hubert 1985, Mellas and Haynes 1985). This is the technique that GLHA proposes to use on Atlantic salmon smolts for the downstream passage studies.

Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982, Matthews and Reavis 1990, Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance.

All fish used in the proposed 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 a 100% of the fish that are handled and tagged will suffer injury.

All 600 Atlantic salmon smolts used in the downstream survival study will be harassed and injured. In addition, 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 were subject to delayed mortality. Over the same timeframe, we surgically implanted tags into wild juvenile Atlantic salmon prior to their release into the Narraguagus River. Of the 679 fish tagged, 13, or 1.9%, died during surgery (NMFS, unpublished data). It is likely there were delayed mortalities as a result of the surgeries, but this could not be quantified because fish were not held for an

extended period. In a study assessing tagging mortality in hatchery reared yearling Chinook salmon, Hockersmith *et al.* (2000) determined that 1.8% (20 out of 1,133) died after having radio tags surgically implanted. Given this range of mortality rates, it is anticipated that no more than 2% of Atlantic salmon smolts (or 6 individuals) will be killed due to handling and tagging during the proposed downstream monitoring over three years of study.
All adult salmon used in the downstream passage studies will be harassed and injured due to handling and tagging. However, long term effects of handling and tagging on adult salmon appear to be negligible. Bridger and Booth (2003) indicate that implanting tags 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 the study conducted by Hockersmith *et al.* (2000), it was determined that 0.3% (3 out of 1,078) of yearling Chinook salmon died after being implanted with a PIT tag. 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 (pre spawn and kelts) being used in the passage studies at the Mattaceunk Project. Given the small number of adult Atlantic salmon being tagged (no more than 60 fish over three years) and that adult salmon are less likely than yearling Chinook salmon to be significantly injured by PIT 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.

8. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR §402.02 as those effects of future state or private activities that are reasonably certain to occur within the action area of the Federal action subject to consultation. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA. 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.

In December 1999, the State of Maine adopted regulations prohibiting all angling for sea-run salmon statewide. A limited catch-and-release fall fishery (September 15 to October 15) for Atlantic salmon in the Penobscot River was authorized by the MASC for 2007. The fishery was closed prior to the 2009 season. Despite strict state and federal regulations, both juvenile and adult Atlantic salmon remain vulnerable to injury and mortality due to incidental capture by recreational anglers and incidental catch in commercial fisheries. The best available information indicates that Atlantic salmon are still incidentally caught by recreational anglers. Evidence suggests that Atlantic salmon are also targeted by poachers (NMFS 2005). 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, paper production facilities, stormwater runoff from development, groundwater discharge, and industrial development. Atlantic salmon are vulnerable to impacts from pollution and are likely to continue to be impacted by water quality impairments in the Penobscot River and its tributaries.

Impacts to listed salmon 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.

9. INTEGRATION AND SYNTHESIS OF EFFECTS

In the discussion below, we consider whether the effects of the proposed action reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of the GOM DPS of Atlantic salmon in the wild by reducing the reproduction, numbers, or distribution. The purpose of this analysis is to determine whether the proposed action, in the context established by the status of the species, environmental baseline, and cumulative effects, would jeopardize the continued existence of the GOM DPS of Atlantic salmon. In addition, the analysis will determine whether the proposed action will adversely modify designated critical habitat for Atlantic salmon.

In the NMFS/USFWS Section 7 Handbook, for the purposes of determining jeopardy, survival is defined as, "the species' persistence as listed or as a recovery unit, beyond the conditions leading to its endangerment, with sufficient resilience to allow for the potential recovery from endangerment. Said in another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter."

Recovery is defined as, "Improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in Section 4(a)(1) of the Act." Below, we summarize the status of the species and consider whether the proposed action will result in reductions in reproduction, numbers or distribution of the species and then consider whether any reductions in reproduction, numbers or distribution resulting from the proposed action would reduce appreciably the likelihood of both the survival and recovery of the species, as those terms are defined for purposes of the Federal Endangered Species Act.

We have determined that the proposed action will result in harm and harassment of Atlantic salmon in the action area. While lethal injuries and/or mortalities will be reduced by operation of existing upstream and downstream passage facilities and repairs and improvements to these facilities, it is anticipated that some level of take will continue during the term of the ISPP.

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 either stable or declining over the past several decades. The proportion of fish that are of natural origin is extremely low (approximately 6% over the last ten years) and is continuing to decline. The conservation hatchery program 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.

We recognize that the proposed ISPP will lead to an improvement in upstream and downstream passage for Atlantic salmon from current conditions. However, the project will continue to affect the abundance, reproduction and distribution of salmon in the Penobscot 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 these fish will be injured as a result of the studies and some will be killed. Operation of the Mattaceunk Project will also affect the migration PCE of Atlantic salmon critical habitat, primarily as a result of maintaining the project impoundment which affects water quality, substrate, cover and shelter and safe passage.

Summary of Upstream Passage Effects

During the term of the proposed ISPP, adult salmon will continue to be passed upstream of the Mattaceunk Project using the existing fishway. During this period, we anticipate that 1% of adult Atlantic salmon in the action area that fail to pass the Mattaceunk Project will not survive due to fish passage inefficiencies.

Summary of Downstream Passage Effects

A portion of Atlantic salmon smolts and kelts will be injured or killed while passing downstream at the Mattaceunk Project. Based upon information in FERC's BA, it is estimated that survival of smolts would range from 88 - 96% (empirical data) and 86% to 94.6% (desktop analysis). To be conservative, we assume the lower, empirical survival rate (88%) occurs at the project. Downstream survival of kelts at the project is estimated to be approximately 75.8% and 82.7% based upon Alden modeling. To be conservative, we assume the lower, empirical survival rate (75.8%) for kelts occurs at the project. Under the terms of the ISPP, this level of take is expected to occur only until 2018.

Summary of Maintenance Activities Effects

GHLA intends to perform maintenance at the Mattaceunk Project in the summer 2013 which will require a large scale drawdown (20-25 feet) of the project impoundment. It is anticipated that few, if any, returning salmon will be released to upstream riverine areas including the Mattaceunk Project in the summer of 2013. Therefore, we do not anticipate any take of Atlantic salmon as a result of maintenance activities at the project during the summer of 2013.

9.1. Survival and Recovery Analysis

Jeopardy is defined by USFWS and NMFS (1998) as "an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." Therefore, to determine if the proposed action will jeopardize the GOM DPS of Atlantic salmon, an analysis of the effects on survival and recovery must be conducted. The ISPP and this Opinion are valid for a six-year period and expire in 2018. Therefore, the following section analyzes whether interim operation of the project will jeopardize the GOM DPS of Atlantic salmon during this six-year period. In 2018, this Opinion will no longer be valid and consultation under section 7 will need to be reinitiated by FERC.

Survival Analysis

The first step in conducting this analysis is to assess the effects of the proposed project on the survival of the species. Survival can be defined as the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring, which exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter (USFWS and NMFS 1998).

While implementing the proposed ISPP will result in the loss of Atlantic salmon smolts and kelts, the relatively short time frame of the action (6 years) will greatly reduce the potential of the project to affect the long-term survival potential of the species. Almost all production of Atlantic salmon in the Penobscot River is the result of fry and smolt stocking in the river. The number of smolts produced upstream of the project is presently unknown. Based upon past fry stocking upstream of the Mattaceunk Project (average of 671,850 fry per year), estimated fry to smolt survival in the Penobscot River (5.2%; NEFSC 2012), and an 88% survival rate for smolts passing the project, we calculate that approximately 4,192 smolts will be delayed, injured, or killed annually during the period of the ISPP. We note that not all of smolts produced in the East Branch of the Penobscot River will reach the Mattaceunk Project due to predation and other natural mortality; thus, the number of smolts actually killed at the project annually is likely less than we predict.

Based upon the current median marine survival rate of 0.4% (NMFS 2012), the operation of the Mattaceunk Project under this production and survival scenario could conceptually cause a reduction in adult returns to the Penobscot of 17 adults when compared to a no project scenario. We would expect this level of mortality to be reduced once the final SPP is implemented using data collected as part of the ISPP process. We did not attempt to quantify the effects of lost kelts on adult production in the Penobscot River due to the low proportion of repeat spawners in the GOM DPS.

GLHA's proposed ISPP is expected to benefit the distribution of the species by improving upstream and downstream passage at the project. Improved upstream passage will improve reproduction of the species. Improvements to the downstream passage facility at the project are expected to increase the number of smolts surviving in the Penobscot River which will lead to increased number of adults returning to the river. We also expect current stocking practices to continue in the East Branch of the Penobscot River during the ISPP period which will also help insure the survival of Atlantic salmon in the Penobscot River. Therefore, we have determined that this relatively small loss of adults over a six-year period under the proposed action will not appreciably reduce the likelihood that Atlantic salmon will survive in the wild.

Recovery Analysis

The second step in conducting this analysis is to assess the effects of the proposed project on the recovery of the species. Recovery is defined as the improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the ESA (USFWS and NMFS 1998). As with the survival analysis, there are three criteria that are evaluated under the recovery analysis; reproduction, numbers and distribution. In the recovery analysis, the same measures are used to evaluate these criteria as are used in the survival analysis. However, unlike with survival, the recovery analysis requires an adjustment to the existing freshwater and marine survival rates to allow for a population that has a positive growth rate. The recovery condition includes existing dam passage rates, but does not include hatchery supplementation as it is assumed that in a recovered population, stocking will not be necessary to sustain a viable population.

In certain instances an action may not appreciably reduce the likelihood of a species survival (persistence) but may affect its likelihood of recovery or the rate at which recovery is expected to occur. As explained above, we have determined that the proposed action will not appreciably reduce the likelihood that Atlantic salmon will survive in the wild. Here, we consider the potential for the action to reduce the likelihood of recovery. As noted above, recovery is defined as the improvement in status such that listing is no longer appropriate.

Section 4(a)(1) of the ESA requires listing of a species if it is in danger of extinction throughout all or a significant portion of its range (i.e., "endangered"), or likely to become in danger of extinction throughout all or a significant portion of its range in the foreseeable future (i.e., "threatened") because of any of the following five listing factors: (1) The present or threatened destruction, modification, or curtailment of its habitat or range, (2) overutilization for commercial, recreational, scientific, or educational purposes, (3) disease or predation, (4) the inadequacy of existing regulatory mechanisms, (5) other natural or manmade factors affecting its continued existence.

At existing freshwater and marine survival rates (the medians have been estimated by NMFS as 1.1% and 0.4%, respectively), it is unlikely that Atlantic salmon will be able to achieve recovery. A significant increase in either one of these parameters (or a lesser increase in both) will be necessary to overcome the significant obstacles to recovery. We have created a conceptual model to indicate how marine and freshwater survival rates would need to change in order to recover Atlantic salmon (NMFS 2010). In Figure 12, the red dot represents current marine and freshwater survival rates; the blue 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 blue line, the population is growing, and, thus, trending towards recovery (lambda greater than one). The red lines indicate the rates of freshwater survival that have been historically observed (Legault 2004). This model indicates that there are many potential routes to recovery; for example, recovery could be achieved by significantly increasing the existing marine survival rate while holding freshwater survival at existing levels, or, conversely, by significantly increasing freshwater survival while holding marine survival at today's levels. Conceptually, however, the figure makes clear that an increase in both freshwater and marine survival will lead to the shortest and, therefore, most realistic, path to achieving a self-sustaining population that is trending towards recovery.

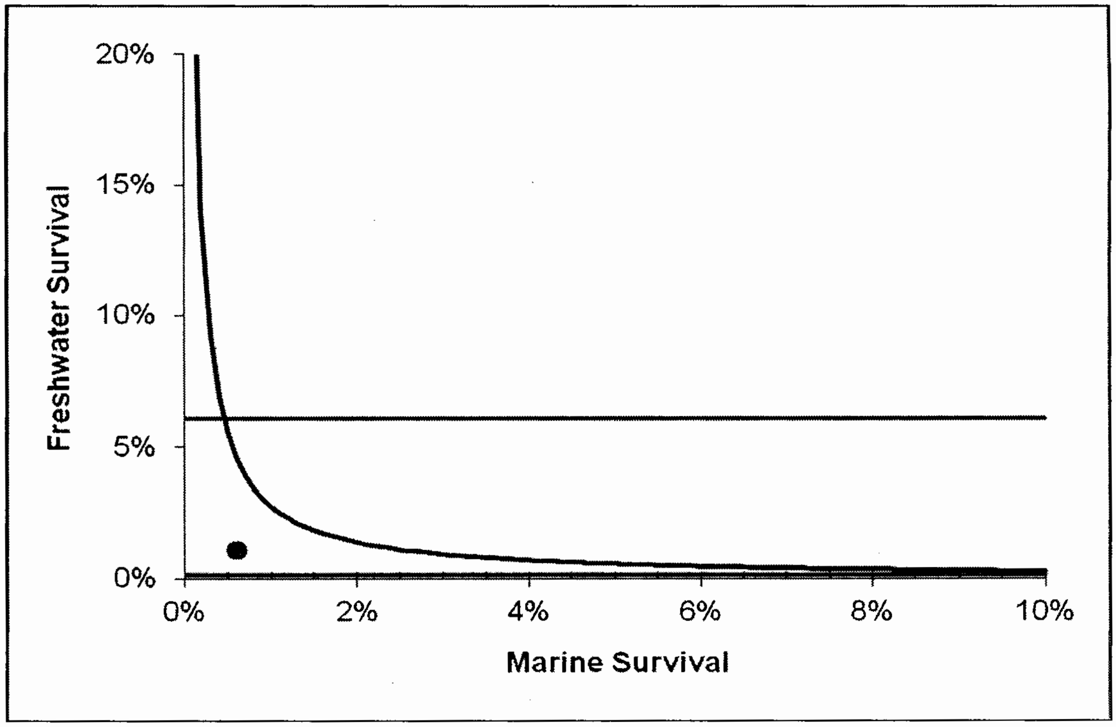

Figure 12. NMFS (2010) conceptual model depicting marine and freshwater survival relative to recovery of the GOM DPS of Atlantic salmon (Note: The red dot represents current conditions, the blue line represents recovery, and the red lines are the historic maximum and minimum freshwater survival).

In order to assess the effect that the proposed project would have on recovery, marine and freshwater survival rates need to be increased to a point that will allow for the recovery of the species. To do this, assumptions need to be made about what constitutes a realistic increase that these parameters. In the mid-1980's to early 1990's there was a 50% to 70% decline in Atlantic salmon marine survival rates. This event is referred to as the regime shift (Chaput et al. 2005); the causes for this shift are unknown at this time (Windsor et al. 2012). Based on the smolt to adult return rate for wild fish in the Narraguagus River, USFWS (2012) estimated that the pre-regime shift marine survival rate ranged between 0.9% and 5.2%, with an average of 3.0%. A four-fold increase in the current median marine survival rate (from 0.4% to 1.7%) will allow for a rate that is within the range estimated to have existed prior to the regime shift.

Freshwater survival rates have historically ranged between 0.1% and 6.0%, with an average of 1.5% (Legault 2004). A two fold increase in the existing median freshwater survival rate (from 1.1% to 2.2%) creates a condition that is above the historical mean, but is within the range that has been observed and, when coupled with improved marine survival, will allow for a modest positive growth rate in the Atlantic salmon population.

While implementing the proposed ISPP will result in the loss of Atlantic salmon smolts and kelts, the relatively short time frame of the action (6 years) will greatly reduce the potential of the project to affect the long-term recovery potential of the species. In addition, the proposed ISPP will benefit the distribution of the species by improving upstream passage at the project. Therefore, we have determined that the proposed action will not appreciably reduce the likelihood that Atlantic salmon will recover in the wild.

9.2. Summary of Effects to Atlantic Salmon

In this section, we summarize the effects of the proposed action on the GOM DPS of Atlantic salmon in conjunction with the environmental baseline. Based on the information provided above, the proposed action will not appreciably reduce the likelihood of survival for Atlantic salmon in the wild (i.e., it will not decrease the likelihood that the species will continue to persist into the future with sufficient resilience to allow for the potential recovery from endangerment). While juvenile and adult Atlantic salmon mortality associated with dam passage at the Mattaceunk Project will continue to have an adverse effect on Atlantic salmon in the Penobscot River for a relatively short period (6 years), we believe that the loss will not be sufficient to appreciably diminish the species ability to achieve recovery. As such, there is not likely to be an appreciable reduction in the likelihood of survival and recovery in the wild of the Penobscot River population or the species as a whole.

The proposed action will not affect Atlantic salmon in a way that prevents the species from having a sufficient population, represented by all necessary age classes, genetic heterogeneity, and number of sexually mature individuals producing viable offspring and it will not result in effects to the environment which would prevent Atlantic salmon from completing their entire life cycle, including reproduction, sustenance, and shelter. The above analysis predicts that the proposed project will lead to an improvement in the reproduction and distribution of Atlantic salmon. This is the case because Atlantic salmon survival is expected to improve a result of repairs and improvements to passage facilities.

Despite the threats faced by individual Atlantic salmon inside and outside of the action area, the proposed action will not increase the vulnerability of individual Atlantic salmon to these additional threats and exposure to ongoing threats will not increase susceptibility to effects related to the proposed action. While we are not able to predict with precision how climate change will impact Atlantic salmon in the action area or how the species will adapt to climate change-related environmental impacts, no additional effects related to climate change to Atlantic salmon in the action area are anticipated over the life of the proposed action (6 years). We have considered the effects of the proposed action in light of cumulative effects explained above, including climate change, and haveconcluded that even in light of the ongoing impacts of these activities and conditions, the conclusions reached above do not change.

10. CONCLUSION

After reviewing the best available information on the status of endangered and threatened species under our jurisdiction, the environmental baseline for the action area, the effects of the action, and the cumulative effects, it is our biological opinion that the proposed action may adversely affect but is not likely to jeopardize the continued existence of 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.

11. INCIDENTAL TAKE STATEMENT

Section 9(a)(1) of the ESA prohibits any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of endangered species without a specific permit or exemption. NMFS interprets the term ''harm'' as an act which actually kills or injures fish or wildlife. It is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing behavioral patterns such as spawning, rearing, feeding, and migrating (50 CFR §222.102; NMFS 1999b). The term "harass" has not been defined by NMFS; however, it is commonly understood to mean to annoy or bother. In addition, legislative history helps elucidate Congress' intent that harassment would occur where annoyance adversely affects the ability of individuals of the species to carry out biological functions or behaviors: "[take] includes harassment, whether intentional or not. This would allow, for example, the Secretary to regulate or prohibit the activities of birdwatchers where the effect of those activities might disturb the birds and make it difficult for them to hatch or raise their young" (HR Rep. 93-412, 1973). Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity by a Federal agency or applicant (50 CFR §402.02). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the ESA, provided that such taking is in compliance with the terms and conditions of the incidental take statement.

An incidental take statement specifies the amount or extent of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary and appropriate to minimize and/or monitor incidental take and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. The measures described in this section are nondiscretionary. If the FERC fails to include these conditions in the license articles or GLHA fails to assume and carry out the terms and conditions of this incidental take statement, the protective coverage of section 7(a)(2) may lapse. To monitor the effect of incidental take, the FERC must require GLHA to report the progress of the action and its effect on each listed species to NMFS, as specified in this incidental take statement (50 CFR §402.14(i)(3)).

11.1. Amount or Extent of Take

The following sections describe the amount or extent of take that we expect would result based on the anticipated effects of the proposed action. If the proposed action results in take of a greater amount or extent than that described above, the FERC would need to reinitiate consultation. The exempted take includes only take incidental to the proposed action. The incidental take provided by this Opinion is valid for only a six-year period 2018. In 2018, this Opinion will no longer be valid, therefore consultation under section 7 will need to be reinitiated by FERC or us in 2017.

Hydroelectric Operations

Continued operation of the Mattaceunk Project for the term of the ISPP (6 years) will result in: 1) trapping of 100% of Atlantic salmon that enter the existing upstream fishway; 2) the harassment of up to 28.7% of pre-spawn adult Atlantic salmon due to upstream passage inefficiencies; 3) the death of up to 0.3% (1% of the 29% that fail to pass) of pre-spawn adult Atlantic salmon that did not use the fishway due to upstream passage inefficiencies; 4) the delay, injury, or death of up to 12% of the total number of smolts in the project area; and 5) the delay, injury, or death of up to 24.2% of all kelts in the project area. Under the terms of the ISPP, this level of take is expected to occur only until 2018.

We anticipate that initial studies at the Mattaceunk Project may indicate higher levels of take than specified above. Using an adaptive management framework, the Licensee will be required to modify operations or configurations to improve survival should the extent of take be exceeded in any year. The intent of the Licensee's ISPP is to allow time to monitor and improve conditions for Atlantic salmon at the project for a period of six years. Therefore, we will consider the average of 3 years of upstream and downstream studies to determine compliance with our level of incidental take.

Roller Gate and Fishway Repairs

We do not anticipate any take of Atlantic salmon during maintenance activities at the Mattaceunk Project during the summer of 2013.

Fish Passage Monitoring

To assess the present levels of smolt survival at the Mattaceunk Project, GLHA proposes to obtain 200 hatchery smolts from the GLNFH annually for three years. These fish would be tagged or held for observation which would likely lead to injury or delays in migration. The result of the studies will be used by GLHA and us to determine whether additional protection measures are needed at the project during preparation of the final SPP. As such, the level of take associated with conduct of the survival studies will be 600 Atlantic salmon smolts during the term of the ISPP.

GLHA also proposes to conduct upstream adult Atlantic salmon passage studies for up to three years. Although a study plan has not been submitted yet, it is assumed that it will involve the radio tagging of not more than 20 adults annually for a maximum of three years. These fish will all be subject to injury due to handling and tagging. As three years of study may be necessary to obtain sufficient data, it is expected that not more than 60 adults could be injured due to passage monitoring over the six year term of the ISPP. The result of the studies will be used by GLHA and us to determine whether additional protection measures are needed at the project during preparation of the final SPP. As such, the level of take associated with conduct of the survival studies will be 60 Atlantic salmon adults during the term of the ISPP.

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 Opinion, we determined that this level of anticipated take is not likely to result in jeopardy to the species.

11.2. 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 at the Mattaceunk Project. Please note that these reasonable and prudent measures and terms and conditions are in addition to the measures contained in the FERC's March 14, 2013 BA and ISPP that GLHA has committed to implement and FERC is proposing to incorporate into the project license. As these 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. Therefore, FERC should require that GLHA complete the following measures:

1. FERC must ensure, through enforceable conditions of the Project license, that the licensee conduct all in-water and near-water construction activities in a manner that

minimizes incidental take of ESA-listed or proposed species and conserves the aquatic resources on which ESA-listed species depend.

2. FERC must ensure, through enforceable conditions of the Project licenses, that the licensee measure and monitor the provisions contained in the February 28, 2013 Interim Species Protection Plan (SPP) in a way that is adequately protective of listed Atlantic salmon.
3. FERC must ensure, through enforceable conditions of the project licenses, that GLHA complete an annual monitoring and reporting program to confirm that GLHA is minimizing incidental take and reporting to NMFS any project-related observations of dead or injured salmon made by GLHA.

11.3. Terms and Conditions

In order to be exempt from prohibitions of section 9 of the ESA, FERC and GLHA 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.

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

    a. Hold a pre-construction meeting with the contractor(s) to review all procedures and requirements for avoiding and minimizing impacts to Atlantic salmon and to emphasize the importance of these measures for protecting salmon.

    b. Timing of in-water work: Work below the bankfull elevation should occur outside of the smolt outmigration period (April 1 to June 15) or within a dewatered cofferdam. The licensee must notify NMFS one week before in-water work begins.

    a. Use Best Management Practices that will minimize concrete products (dust, chips, larger chunks) mobilized by construction activities from entering flowing or standing waters. Best practicable efforts shall be made to collect and remove all concrete products prior to rewatering of construction areas.

    b. Employ erosion control and sediment containment devices at the construction site. During construction, all erosion control and sediment containment devices shall be inspected weekly, at a minimum, to ensure that they are working adequately. Any erosion control or sediment containment inadequacies will be immediately addressed until the disturbance is minimized.

    c. Provide erosion control and sediment containment materials (e.g., silt fence, straw bales, aggregate) in excess of those installed, so they are readily available on site for immediate use during emergency erosion control needs.

    d. Ensure that vehicles operated within 150 feet (46 m) of the construction site waterways will be free of fluid leaks. Daily examination of vehicles for fluid leaks is required during periods operated within or above the waterway.

e. During construction activities, ensure that BMPs are implemented to prevent pollutants of any kind (sewage, waste spoils, petroleum products, etc.) from contacting water bodies or their substrate.

f. In any areas used for staging, access roads, or storage, be prepared to evacuate all materials, equipment, and fuel if flooding of the area is expected to occur within 24 hours.

g. Perform vehicle maintenance, refueling of vehicles, and storage of fuel at least 150 feet (46 m) from the waterway, provided, however, that cranes and other semi-mobile equipment may be refueled in place.

h. At the end of each work shift, vehicles will not be stored within, or over, the waterway.

i. Prior to operating within the waterway, all equipment will be cleaned of external oil, grease, dirt, or caked mud. Any washing of equipment shall be conducted in a location that shall not contribute untreated wastewater to any flowing stream or drainage area.

j. Use temporary erosion and sediment controls on all exposed slopes during any hiatus in work exceeding seven days.

k. Place material removed during excavation only in locations where it cannot enter sensitive aquatic resources.

l. Minimize alteration or disturbance of the streambanks and existing riparian vegetation to the greatest extent possible.

m. Remove undesired vegetation and root nodes by mechanical means only. No herbicide application shall occur.

n. Mark and identify clearing limits. Construction activity or movement of equipment into existing vegetated areas shall not begin until clearing limits are marked.

o. Retain all existing vegetation within 150 feet (46 m) of the edge of the bank to the greatest extent practicable.

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

a. Prepare in consultation with NMFS a plan to study the passage and survival of Atlantic salmon smolts, adults, and kelts at the Mattaceunk Project.

b. Require the Licensee develop in consultation with NMFS a project-specific adaptive management plan to address any upstream or downstream passage deficiencies at the project.

c. Require GLHA to consult with NMFS regarding the improvements to upstream and downstream fishways at the Mattaceunk Project. Require the Licensee seek comments from NMFS on any fish passage design plans at the 30%, 60%, and 90% design phase. Also, allow NMFS to inspect fishways at the projects at least annually.

d. Notify NMFS of any changes in operation including maintenance activities at the project during the term of the ISPP. Also, allow NMFS to inspect fishways at the projects at least annually.

e. Require GLHA to inspect the upstream and downstream fish passage facilities daily during from April 1 to November 30, annually. Submit summary reports to NMFS weekly during the fish passage season.

3. To implement reasonable and prudent measure #3, FERC must require GLHA to do the following:

a. Contact NMFS within 24 hours of any interactions that GLHA observes with Atlantic salmon, including non-lethal and lethal takes (Jeff Murphy: by email (Jeff.Murphy@noaa.gov) or phone (207) 866- 7379 and the Section 7 Coordinator (incidental.take@noaa.gov)

b. 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.

c. Prepare in consultation with NMFS a plan to study the survival of migrating adults at the Mattaceunk Project.

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 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. 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 each of these RPMs and Terms and Conditions are necessary and appropriate to minimize or monitor the level of incidental take associated with the proposed action and how they represent only a minor change to the action as proposed by the FERC.
RPM #1, as well as Term and Condition #1 are necessary and appropriate as they will require the licensee and their contractors to use best management practices and best available technology for construction. This will ensure that effects to listed Atlantic salmon are minimized to the extent practical. These procedures represent only a minor change to the proposed action as following these procedures should not increase the cost of the project or result in any delays or reduction of efficiency of the project.

RPM #2 as well as Term and Condition #2 are necessary and appropriate as they describe how the licensee will be required to measure and monitor the success of the proposed ISPP. These procedures represent only a minor change to the proposed action as following these procedures should not increase the cost of the project or result in any delays or reduction of efficiency of the project.

RPM #3 as well as Term and Condition #2 are necessary and appropriate to ensure the proper documentation of any interactions with listed species as well as requiring that these interactions are reported to NMFS in a timely manner with all of the necessary information. This is essential for monitoring the level of incidental take associated with the proposed action. This RPM and the Terms and Conditions represent only a minor change as compliance will not result in any increased cost, delay of the project or decrease in the efficiency of the project.

12. 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. NMFS has 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, NMFS recommends that FERC implement the following conservation measure.

1. If any lethal take occurs, FERC and/or GLHA should arrange for contaminant analysis of the specimen. If this recommendation is to be implemented, the fish should be frozen and NMFS should be contacted immediately to provide instructions on shipping and preparation.

2. FERC should require all licensees in the GOM DPS to provide safe and effective upstream and downstream fish passage to protect listed Atlantic salmon and other diadromous fish species. This can be accomplished through station shutdowns during the smolt passage season (April to June) and kelt passage season (October to December and April to June) or the installation of highly effective fishways.

3. FERC should require all licensees in the GOM DPS to document the effectiveness of station shutdowns or fishways in protecting listed Atlantic salmon.

4. FERC should require all licensees in the GOM DPS to operate their hydroelectric facilities to protect listed Atlantic salmon. This can be accomplished by requiring these facilities to operate in a run-of-river mode to simulate a natural stream hydrograph.

13. REINITIATION NOTICE

This concludes formal consultation concerning FERC's proposal to amend the license for the Mattaceunk Project to incorporate the provisions of the proposed ISPP. 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. In 2018, this Opinion will no longer be valid and consultation under Section 7 will need to be reinitiated by FERC or us in 2017.

14. LITERATURE CITED

Abbott, A., Maine Atlantic Salmon Habitat Atlas: Penobscot River. Gulf of Maine Coastal Program, U.S. Fish and Wildlife Service and Maine Atlantic Salmon Commission, April 2006.

Alaska Department of Fish and Game (ADFG). 1991. Blasting standards for the protection of fish. 35 pp.

Alden Research Laboratory, Inc. 2012. Atlantic Salmon Survival Estimates At Mainstem Hydroelectric Projects on the Penobscot River. Draft Phase 3 Final Report. Prepared by S. Amaral, C.Fay, G. Hecker and N. Perkins. 556 pps.

Allen, K.R. 1940. Studies on the biology of the early stages of the salmon (*Salmo salar*): growth in the river Eden. J. Animal Ecol. 9(1):1-23.

Arkoosh, M. R., E. Casillas, E. Clemons, A. N. Kagley, R. Olson, P. Reno, and J. E. Stein. 1998a. Effect of pollution on fish diseases: potential impacts on salmonid populations. Journal of Aquatic Animal Health 10:182-190.

Arkoosh, M. R., E. Casillas, P. Huffman, E. Clemons, J. Evered, J. E. Stein, and U. Varanasi. 1998b. Increased susceptibility of juvenile Chinook salmon from a contaminated estuary to *Vibrio anguillarum*. Transactions of the American Fisheries Society 127: 360-374.

ASMFC. 2009. Greene, K. E., J. L. Zimmerman, R. W. Laney, and J. C. Thomas-Blate. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations for conservation, and research needs. Atlantic States Marine Fisheries Commission Habitat Management Series No. 9, Washington, D.C.

Atlantic Salmon Recovery Team (ASRT). 2010. Atlantic salmon recovery framework. Draft. 2010. http://www.nero.noaa.gov/prot_res/altsalmon/FrameworkWorkingDraft081110-1.pdf

Atlas of Maine. 2009. Atlantic salmon habitat and dams in Maine. Online URL: http://virwarc0.colby.edu/aom09_07/. Accessed June 2011. Colby College.

Aquatic Science Associates, Inc. 2011. Downstream fish passage evaluation for Atlantic salmon smolts 2010. Prepared for Black Bear Hydro Partners, LLC. Milford, Maine. February 2011.

Bakshtansky, E.L., V.D. Nesterov and M.N. Nekludov. 1982. Change in the behaviour of Atlantic salmon (*Salmo salar*) smolts in the process of downstream migration. ICES, 16 pages.

Bakshtansky, E. L., I.A. Barybina, and V.D. Nesterov. 1976. Changes in the intensity of downstream migration of Atlantic salmon smolts according to abiotic conditions. ICES Anadromous and Catadromous Fish Committee C.M.1976/M:4.

Bangor Pacific Hydro Associates (BPHA). 1993a. 1992 Evaluation of Downstream Fish Passage Facilities at the West Enfield Hydroelectric Project. FERC #2600-029. Bangor-Pacific Hydro Associates. Bangor, ME. 11 pp. and appendices.

Bangor Pacific Hydro Associates (BPHA). 1993b. 1993 Evaluation of downstream fish passage facilities at the West Enfield Hydroelectric Project. Bangor Maine. 20 pages with appendices.

Bangor Pacific Hydro Associates (BPHA). 1994. 1994 Evaluation of Downstream Fish Passage Facilities at the West Enfield Hydroelectric Project. FERC #2600-029. Bangor-Pacific Hydro Associates. Bangor, ME. 18 pp. and appendices.

Barr, L.M. 1962. A life history of the chain pickerel, *Esox niger Lesueur*, in Beddington Lake, Maine. M.S. Thesis University of Maine, Orono, ME: 88 pp.

Bates, B.C., Z.W. Kundzewicz, S. Wu, and J.P. Palutikof (Eds.). 2008. Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change (IPCC), IPCC Secretariat, Geneva 1-210.

Battin, J., M. Wiley, M. Ruckelshaus, R. Palmer, E. Korb, K.Bartz, and H. Imaki. 2007. Project impacts of climate change on habitat restoration. Proceedings of the National Academy of Sciences 104, no. 16: 6720-6725.

Baum, E.T. 1997. Maine Atlantic salmon - a national treasure. Atlantic Salmon Unlimited, Hermon, Maine.

Baum, E.T. and A. L. Meister. 1971. Fecundity of Atlantic salmon (*Salmo salar*) from two Maine rivers. J. Fish. Res. Bd. Can. 28(5):7640767.

Beland, K.F., R.M. Jordan and A.L. Meister. 1982. Water depth and velocity preferences of spawning Atlantic salmon in Maine Rivers. North American Journal of Fisheries Management 2:11-13.

Beland and Gorsky. 2003. Penobscot River Adult Atlantic Salmon Migration Study. 2002 Progress Report. Maine Atlantic Salmon Commission. Bangor, ME. 11 pp.

Beland, K. F. and D. Gorsky. 2004. Penobscot River Adult Atlantic Salmon Migration Study: 2002-2003 Progress Report. Maine Atlantic Salmon Commission. Bangor, ME. 16 pp.

Bell, M. C. 1991. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U. S. Army Corps of Engineers. North Pacific Division.

Berg, L., and T.G. Northcote. 1985. Changes in territorial, gill-flaring, and feeding behavior in juvenile coho salmon (Oncorhynuchus kisutch) following short-term pulses of suspended sediment. Can. J. Aquat. Sci. 42(8): 1410-1417

Beaugrand, G. and P. Reid. 2003. Long-term changes in phytoplankton, zooplankton, and salmon related to climate. Global Change Biology 9: 801-817.

Bigelow, H.B. and W.C. Schroeder. 1953. Fishes of the Gulf of Maine. Fishery Bulletin 74. Fishery Bulletin of the Fish and wildlife service, vol. 53. http://www.gma.org/fogm/

Birtwell, I.K, G. Hartman, B. Anderson, D.J. McLeay and J.G. Malik. 1984. A brief investigation of Arctic grayling (Thymallus arcticus) and aquatic invertebrates in the Minto Creek drainage, Mayo, Yukon Territory Can. Tech. Rept. Fish. Aquat. Sci. 1287.

Bjornn, T.C. and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in Meehan, W.R (ed.). 1991. Influences of forest and rangeland management of salmonid fishes and their habitats. Am. Fish. Soc. Special Publication 19. Bethesda, MD.

Black Bear Hydro Partners LLC. 2012. Draft Biological Assessment for Atlantic salmon, shortnose sturgeon, and Atlantic Sturgeon. Black Bear Hydro Projects - Orono Project, FERC No. 2710, Stillwater Project, FERC No. 2712, Milford Project, FERC No. 2534, West Enfield Project, FERC No. 2600, and Medway Project, FERC No. 2666. Prepared - March 2012.

Blackwell, B.F. 1996. Ecology of double-crested cormorants using the Penobscot River and Bay Maine. Doctoral dissertation, University of Maine.

Blackwell, B.F. and W.B. Krohn. 1997. Spring foraging distribution and habitat selection by double-crested cormorants on the Penobscot River, Maine, USA. Colonial Waterbirds 20(1): 66-76.

Blackwell, B.F., W.B. Krohn, N.R. Dube, and A.J. Godin. 1997. Spring prey use by doublecrested cormorants on the Penobscot River, Maine, USA. Colonial Waterbirds 20(1): 77-

Blackwell, B. F. and F. Juanes. 1998. Predation on Atlantic salmon smolts by striped bass after dam passage. North American Journal of Fisheries Management 18: 936-939.

Bley, P.W. 1987. Age, growth, and mortality of juvenile Atlantic salmon in streams: a review. Biological Report 87(4). U.S. Fish and Wildlife Service, Washington, D.C.

Bley, P.W. and J.R. Moring. 1988. Freshwater and ocean survival of Atlantic salmon and steelhead: a synopsis. Biological Report 88(9). Maine Cooperative Fish and Wildlife Research Unit, Orono.

Bourgeois, C. E. and M. F. O'Connell, 1986. Observations on the seaward migration of Atlantic salmon (*Salmo salar L.*) smolts through a large lake as determined by radio telemetry and Carlin tagging. Canadian Journal of Zoology 66: 685-691.

BPHA (Bangor-Pacific Hydro Associates). 1993. 1993 Evaluation of Downstream Fish Passage

Facilities at the West Enfield Hydroelectric Project. FERC #2600-029. Bangor-Pacific Hydro Associates. Bangor, ME. 20 pp. and appendices.

BPHA (Bangor-Pacific Hydro Associates) . 1994. 1994 Evaluation of Downstream Fish Passage Facilities at the West Enfield Hydroelectric Project. FERC #2600-029. Bangor-Pacific Hydro Associates. Bangor, ME. 18 pp. and appendices.

Breau, C., L. Weir and J. Grant. 2007. Individual variability in activity patterns of juvenile Atlantic salmon (Salmo salar) in Catamaran Brook, New Brunswick. Canadian Journal of Fisheries and Aquatic Science 64: 486-494.

Bridger, C.J. and R.K. Booth. 2003. The Effects of Biotelemetry Transmitter Presence and Attachment Procedures on Fish Physiology and Behavior. Reviews in Fisheries Science, 11(1): 13–34

Budy, P., G. P. Thiede, N. Bouwes, C. E. Petrosky, and H. Schaller. 2002. Evidence linking delayed mortality of Snake River salmon to their earlier hydrosystem experience. North American Journal of Fisheries Management 22: 35-51.

Chaput, G., Legault, C. M., Reddin, D. G., Caron, F., and Amiro, P. G. 2005. Provision of catch advice taking account of non-stationarity in productivity of Atlantic salmon (Salmo salar L.) in the Northwest Atlantic. e ICES Journal of Marine Science, 62: 131e143.

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American fisheries Society 114:766-767.

Clews, E., I. Durance, I.P. Vaughan and S.J. Ormerod. Juvenile salmonid populations in a temperate river system track synoptic trends in climate. Global Change Biology 16 (2010): 3271-3283.

Cooper, K.R. 1989. Effects of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans on Aquatic Organisms. Aquatic Sciences. 1(2): 227-242.

Crouse, D. T., L. B. Crowder, and H. Caswell. 1987. A stage-based population model for loggerhead sea turtles and implications for conservation. Ecology 68:1412–1423.

Crouse, D. T. 1999. The consequences of delayed maturity in a human dominated world. Pages 95–202 in J. A. Musick, editor. Life in the slow lane: ecology and conservation of long-lived marine animals. American Fisheries Society, Symposium 23, Bethesda, Maryland.

Crowder, L. B., D. T. Crouse, S. S. Heppell, and T. H. Martin. 1994. Predicting the impact Of turtle excluder devices on loggerhead sea turtle populations. Ecological Applications 4: 437–445.

Cunjak, R. A. 1988. Behavior and microhabitat of young Atlantic salmon (*Salmo sala*r) during winter. Can. J. Fish. Aquat. Sci. 45(12): 2156-2160.

Danie, D.S., J.G. Trial, and J.G. Stanley. 1984. Species profiles: life histories and environmental requirements of coastal fish and invertebrates (North Atlantic) – Atlantic salmon. U.S. Fish Wildl. Serv. FW/OBS-82/11.22. U.S. Army Corps of Engineers, TR EL-82-4. 19 pp.

Dempson, J.B., M.F. O'Connell, and M. Shears. 1996. Relative production of Atlantic salmon from fluvial and lacustrine habitats estimated from analyses of scale characteristics. J. Fish Biol.48: 329-341

deGaudemar B, Beall E. 1998. Effects of overripening on spawning behaviour and reproductive success of Atlantic salmon females spawning in a controlled flow channel. J Fish Biol 53:434-446.

DeVore, P. W., L. T. Brooke, and W. A. Swenson. 1980. The effects of red clay turbidity and sedimentation on aquatic life in the Nemadji River System. Impact of nonpoint pollution control on western Lake Superior. EPA Report 905/9-79-002-B. U.S. Environmental Protection Agency, Washington, D.C.

Drinkwater, K., A. Belgrano, A. Borja, A. Conversi, M. Edwards, C. Greene, G. Ottersen, A. Pershing and H. Walker. 2003. The Response of Marine Ecosystems to Climate Variability Associated with the North Atlantic Oscillation. Geophysical Monograph 134: 211-234.

Dube, N. R. 1988. Penobscot River 1987 radio telemetry investigations. Maine Atlantic Sea-Run Salmon Commission. Bangor, ME. 22 pp. and appendices.

Dube, N.R., R. Dill, R.C. Spencer, M.N. Simpson, O.N. Cox, P.J. Ruhsznis, K.A. Dunham, and K. Gallant. 2011. Penobscot River 2010 Annual Report. Maine Department of Marine Resources. June 2011.

Dutil, J.-D. and J.-M. Coutu. 1988. Early marine life of Atlantic salmon, *Salmo salar*, postsmolts in the northern Gulf of St. Lawrence. Fish. Bull. 86(2):197-211.

Elliott, J.M. 1991. Tolerance and resistance to thermal stress in juvenile Atlantic salmon, *Salmo salar*. Fresh. Biol. 25:61-70.

Elliot, S., T. Coe, J. Helfield and R. Naiman. 1998. Spatial variation in environmental characteristics of Atlantic salmon (Salmo salar) rivers. Canadian Journal of Fisheries and Aquatic Sciences 55, suppl. 1: 267-280.

Electric Power Research Institute (EPRI). 1997a. Turbine entrainment and survival database – field tests. Prepared by Alden Research Laboratory, Inc., Holden, Massachusetts. EPRI Report No. TR-108630. October 1997.

Electric Power Research Institute (EPRI). 1997b. Guidelines for hydro turbine fish entrainment and survival studies. Prepared by Alden Research Laboratory, Inc., Holden, Massachusetts. EPRI Report No. TR-107299. July 1997.

Erkinaro, J., Yu Shustov, and E. Niemelä. 1995. Enhanced growth and feeding rate in Atlantic salmon parr occupying a lacustrine habitat in the river Utsjoki, northern Scandinavia. J. Fish Bio. 47(6): 1096-1098.

Erkinaro, J., E. Niemelä, A. Saari, Y. Shustov, and L. Jøgensen. 1998. Timing of habitat shift by Atlantic salmon parr from fluvial to lacustrine habitat: analysis of age distribution, growth, and scale characteristics. Can. J. Fish. Aquat. Sci. 55: 2266-2273.

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

FERC (Federal Energy Regulatory Commission). 1996. Final Environmental Impact Statement, Ripogenus and Penobscot Mills. Office of Hydropower Licensing. Washington, D.C.

FERC. 1997. Final Environmental Impact Statement Lower Penobscot River Basin Maine. Washington, DC.

FERC. 1988. License order for Great Northern Paper Mattaceunk Project. 44 FERC ¶62,368, Great Northern Paper Company, Project No. 2520-000 - Maine, Federal Energy Regulatory Commission, (Sep. 30, 1988).

FERC. 1997. Final Environmental Impact Statement - Lower Penobscot River Basin, Maine (Basin Mills, Stillwater, and Milford Hydroelectric Projects - FERC Nos. 10981, 2712, and 2534, respectively). FERC, Washington, D.C.

Fisheries Hydroacoustic Working Group (FHWG). 2008. Agreement in principle for interim criteria for injury to fish from pile driving activities. Memorandum signed June 12, 2008.

Food and Agriculture Organization of the United Nations (FAO). 2012. Species Fact Sheets, Salmo salar. FAO Fisheries and Aquaculture Department. http://www.fao.org/fishery/species/2929/en (Accessed June 18, 2012).

Foster, N.W. and C.G. Atkins. 1869. Second report of the Commissioners of Fisheries of the state of Maine 1868. Owen and Nash, Printers to the State, Augusta, ME.

Friedland, K.D., D.G. Redding, and J.F. Kocik. 1993. Marine survival of N. American and European Atlantic salmon: effects of growth and environment. ICES J. of Marine Sci. 50: 481- 492.

Friedland, K. 1998. Ocean climate influences on critical Atlantic salmon (Salmo salar) life history events. Canadian Journal of Fisheries and Aquatic Sciences 55, suppl. 1: 119-130.

Friedland, K.D., J.-D. Dutil, and T. Sadusky. 1999. Growth patterns in postsmolts and the nature of the marine juvenile nursery for Atlantic salmon, *Salmo salar*. Fish. Bull. 97: 472-481.

Friedland, K.D., D.G. Reddin, and M. Castonguay. 2003. Ocean thermal conditions in the post-smolt nursery of North American Atlantic salmon. ICES Journal of Marine Scienc. 60: 343-355.

Gibson, R.J. 1993. The Atlantic salmon in freshwater: spawning, rearing, and production. Reviews in Fish Biology and Fisheries. 3(1):39-73.

Glebe, B. D. & Leggett, W. C. 1981. Temporal, intra-population differences in energy allocation and use by American shad (Alosa sapidissima) during the spawning migration. Canadian Journal of Fisheries and Aquatic Sciences 38, 795–805.

GNP (Great Northern Paper, Inc). 1989. 1989 Report on downstream passage of Atlantic salmon smolts and kelts at The Mattaceunk Project. Mattaceunk Project - FERC No. 2520. Great Northern Paper, Inc. Millinocket, ME.

GNP (Great Northern Paper, Inc). 1995. 1995 Report on the effectiveness of the permanent downstream passage system for Atlantic salmon at The Mattaceunk Project. Mattaceunk Project - FERC No. 2520. Great Northern Paper, Inc. Millinocket, ME. 93 pp.

GNP (Great Northern Paper, Inc). 1997. 1997 Report on the effectiveness of the permanent downstream passage system for Atlantic salmon at The Mattaceunk Project. Mattaceunk Project - FERC No. 2520. Great Northern Paper, Inc. Millinocket, ME. 61 pp. and appendices.

GNP (Great Northern Paper, Inc). 1998. 1998 Report on the effectiveness of the permanent downstream passage system for Atlantic salmon at The Mattaceunk Project. Mattaceunk Project - FERC No. 2520. Great Northern Paper, Inc. Millinocket, ME. 36 pp. and appendices.

GNP (Great Northern Paper, Inc). 1999. 1999 Report on the effectiveness of the permanent downstream passage system for Atlantic salmon at The Mattaceunk Project. Mattaceunk Project - FERC No. 2520. Great Northern Paper, Inc. Millinocket, ME.

Gorsky, D. 2005. Site fidelity and the influence of environmental variables on migratory movements of adult Atlantic salmon (Salmo salar) in the Penobscot River basin, Maine. Master's thesis. University of Maine, Orono.

Greene CH, Pershing AJ, Cronin TM and Ceci N. 2008. Arctic climate change and its impacts on the ecology of the North Atlantic. Ecology 89:S24-S38

Gustafson-Greenwood, K. I., and J. R. Moring. 1991. Gravel compaction and permeabilities in redds of Atlantic salmon, *Salmo salar* L. Aquaculture and Fisheries Management 22:537-540.

Gustafson-Marjanan, K. I., and H. B. Dowse. 1983. Seasonal and diel patterns of emergence from the redd of Atlantic salmon (*Salmo salar*) fry. Can. J. Fish.Aquat. Sci. 40: 813-817.

Haeseker, S. L., J. A. McCann, J. Tuomikoski, B. Chockley. 2012. Assessing Freshwater and Marine Environmental Influences on Life-Stage-Specific Survival Rates of Snake river Spring-Summer Chinook Salmon and Steelhead. Transactions of the American Fisheries Society 141:121-138.

Haines, T. A. 1992. New England's rivers and Atlantic salmon. Pages 131-139 in R. H. Stroud (ed.) Stemming the tide of coastal fish habitat loss. National Coalition for Marine Conservation, Savannah, Georgia.

Hall, S. D. and S. L. Shepard. 1990. Report for 1989 Evaluation Studies of Upstream and Downstream Facilities at the West Enfield Project. FERC #2600-010. Bangor Hydro-

Electric Company. 17 pp. and appendices.

Halvorsen, M. & Svenning, M.-A. 2000. Growth of Atlantic salmon parr in fluvial and lacustrine habitats. J. Fish Biol. 57**:** 145–160.

Heggenes, J. 1990. Habitat utilization and preferences in juvenile Atlantic salmon (*Salmo salar*) in streams. Regulated Rivers: Research and Management 5(4): 341-354.

Hendry, K., D. Cragg-Hine, M. O'Grady, H. Sambrook, and A. Stephen. 2003. Management of habitat for rehabilitation and enhancement of salmonid stocks. Fisheries Research 62: 171-192.

Herbert, D. W., and J. C. Merkens. 1961. The effect of suspended mineral solids on the survival of trout. International Journal of Air and Water Pollution 5: 46-55.

Hiscock, M. J., D. A. Scruton, J. A. Brown, and C. J. Pennell. 2002. Diel activity pattern of juvenile Atlantic salmon (*Salmo salar*) in early and late winter. Hydrobiologia 483: 161-165.

Hoar W.S. 1988. The physiology of smolting salmon. Pages 275–343 in W.S. Hoar and D.J. Randall (eds.), *Fish Physiology XIB*, Academic Press, New York.

Hockersmith, E.E., W.D. Muir, S.G. Smith, B.P. Sandford, N. Adams, J.M. Plumb, R.W. Perry and D.W. Rondorf. 2000. Comparative Performance of Sham Radio-Tagged and PIT-Tagged Juvenile Salmon. Prepared for the Army Corps of Engineers. Walla Walla District. 36 pgs.

Holbrook, C.M. 2007 Behavior and survival of migrating Atlantic salmon (Salmo salar) in the Penobscot River and estuary, Maine: Acoustic telemetry studies of smolts and adults. Thesis. University of Maine.

Holbrook, C.M., J. Zydlewski, D. Gorsky, S.L. Shepard, M.T. Kinnison. 2009. Movements of prespawn adult Atlantic salmon near hydroelectric dams in the lower Penobscot River, Maine. North American Journal of Fisheries Management 29: 495-505.

Holbrook, C.M., M.T. Kinnison, J. Zydlewski. 2011. Survival of migrating Atlantic salmon smolts through the Penobscot River, Maine: A prerestoration assessment. Transactions of The American Fisheries Society 140: 1255-1268.

Holland, B. F., Jr. and G. F. Yelverton. 1973. Distribution and biological studies of anadromous fishes offshore North Carolina. North Carolina Department of Natural and Economic Resources SSR 24, 132 pages.

Houston, R., K. Chadbourne, S. Lary, and B. Charry. 2007. Geographic distribution of diadromous fish in Maine. U.S. Fish and Wildlife Service, Gulf of Maine Coastal Program, Falmouth, Maine. http://www.fws.gov/r5gomp/gom/bd/diadfish.html

Hulme, P.E. 2005. Adapting to climate change: is there scope for ecological management in the face of global threat? Journal of Applied Ecology 43: 617-627.

Hutchings, J.A. 1986. Lakeward migrations by juvenile Atlantic salmon, *Salmo salar*. Can. J. Fish. Aquat. Sci. 43(4): 732-741.

Hyvarinen, P., P. Suuronen and T. Laaksonen. 2006. Short-term movement of wild and reared Atlantic salmon smolts in brackish water estuary – preliminary study. Fish. Mgmt. Eco. 13(6): 399 –401.

Independent Scientific Advisory Board for the Northwest Power and Conservation Council (ISAB). 2007. Latent Mortality Report: Review of hypotheses and causative factors contributing to latent mortality and their likely relevance to the "Below Bonneville" component of the COMPASS model. *Independent Scientific Advisory Board,* April 6, 2007 (revised June 11, 2007) ISAB 2007-1.

IPCC (Intergovernmental Panel on Climate Change) 2007. Fourth Assessment Report. Valencia, Spain.

Jackson, D. A. 2002. Ecological Effects of Micropterus Introductions: The Dark Side of Black Bass. In Black Bass: Ecology, Conservation, and Management. American Fisheries Society Symposium No. 31:221-232.

Jordan, R.M. and K.F. Beland. 1981. Atlantic salmon spawning and evaluation of natural spawning success. Atlantic Sea Run Salmon Commission. Augusta, ME. 26 pp.

Juanes, F., S. Gephard and K. Beland. Long-term changes in migration timing of adult Atlantic salmon (Salmo salar) at the southern edge of the species distribution. Canadian Journal of Fisheries and Aquatic Sciences 61 (2004): 2392-2400.

Kalleberg, H. 1958. Observations in a stream tank of territoriality and competition in juvenile salmon and trout (*Salmo salar* L. and *S. trutta* L.). Report/Institute of Fresh-Water Research, Drottningholm 39:55-98.

Karl, T., J. Melillo and T. Peterson (Eds.) Global Climate Change Impacts in the United States. 2009. U.S. Global Change Research Program (USGCRP), Cambridge University Press.

Kennebec River Resource Management Plan. 1993. Kennebec River resource management plan: balancing hydropower generation and other uses. Final Report to the Maine State Planning Office, Augusta, ME. 196 pp.

Klemetsen, A., P.A. Amundsen, J.B. Dempson, B. Jonsson, N. Jonsson, M.F. O'Connell, and E. Mortensen. 2003. Atlantic salmon *Salmon salar* (L.), brown trout *Salmo trutta* (L.) and Arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. Ecology of Freshwater Fish 12(1):1-59.

Lacroix, G.L. and McCurdy, P. 1996. Migratory behavior of post-smolt Atlantic salmon during initial stages of seaward migration. J. Fish Biol. 49, 1086-1101.

Lacroix, G. L, McCurdy, P., Knox, D. 2004. Migration of Atlantic salmon post smolts in relation tohabitat use in a coastal system. Trans. Am. Fish. Soc. 133(6): pp. 1455-1471.

Lacroix, G. L. and D. Knox. 2005. Distribution of Atlantic salmon (*Salmo salar*) postsmolts of different origins in the Bay of Fundy and Gulf of Maine and evaluation of factors affecting migration, growth and survival. Can. J. Fish. Aquat. Sci. 62(6): 1363- 1376.

Larinier, M. 2000. Dams and fish migration. World Commission on Dams Environmental Issues, Dams and Fish Migration, Final Draft. 30 pp.

Legault, C.M. 2004. Population viability analysis of Atlantic salmon in Maine, USA. Transactions of the American Fisheries Society, 134: 549-562.

Lehodey, P., J. Alheit, M. Barange, T. Baumgartner, G. Beaugrand, K. Drinkwater, J.M. Fromentin, S.R. Hare, G. Ottersen, R.I. Perry, et al. "Climate Variability, Fish, and Fisheries." American Meteorological Society 19 (2006): 5009-5030.

Lévesque F., R. Le Jeune, and G. Shooner. 1985. Synthesis of knowledge on Atlantic salmon (Salmo salar) at the stage post-spawning time. Canadian Manuscript Report of Fisheries and Aquatic Sciences 1827: 34.

Lichter, J., H. Caron, T.S. Pasakarnis, S.L. Rodgers, T.S. Squiers Jr., and C.S. Todd. 2006. The ecological collapse and partial recovery of a freshwater tidal ecosystem. Northeastern Naturalist 13:153–178.

Lloyd, D. S. 1987. Turbidity as a water quality standard for salmonid habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7:18-33.

Lundqvist, H. 1980. Influence of photoperiod on growth of Baltic salmon parr (*Salmo salar* L.) with specific reference to the effect of precocious sexual maturation. Can. J. Zool. 58(5):940-944.

Maine Department of Environmental Protection. 2012. Penobscot River Phosphorus Waste Load Allocation Ambient Monitoring Plan Report – 2011. Prepared by Robert Mohlar, P.E., Bureau of Land and Water, Division of Environmental Assessment. May 2012.

Maine Department of Environmental Protection. 2011. Penobscot River Phosphorus Waste Load Allocation 2011 - Ambient Monitoring Plan. Prepared by Robert Mohlar, P.E., Bureau of Land and Water, Division of Environmental Assessment. May 2011.

Maine Department of Inland Fisheries and Wildlife (MDIFW). 2002. Fishes of Maine. Augusta, ME. 38 pp.

Maine Department of Marine Resources (MDMR). 2007. Atlantic salmon freshwater assessments and research. Semi-annual project report. NOAA grant NA06MNF4720078. May 1, 2007 – Oct. 30, 2007. Bangor, ME. Nov. 2007. 153 pp.

Maine Department of Marine Resources (MDMR). 2008. Atlantic salmon freshwater assessments and research. Semi-annual project report. NOAA grant

NA06MNF4720078. May 1, 2008 – Oct. 30, 2008. Bangor, ME. Nov. 2007. 96 pp.

Maine Department of Marine Resources (MDMR). 2009. Penobscot River 2008 Annual Report.

Maine Department of Marine Resources (MDMR) and Maine Department of Inland Fisheries and Wildlife (MDIFW). 2009. Operational Plan for the Restoration of Diadromous Fishes to the Penobscot River. Prepared for the Atlantic Salmon Commission (ASC). April 10, 2009 draft. 293 pp.

Maine Department of Marine Resources (MDMR). 2010. Penobscot River 2009 Annual Report.

Maine Department of Marine Resources (MDMR). 2011. Penobscot River 2010 Annual Report.

Maine Department of Marine Resources (MDMR). 2012. Penobscot River 2011 Annual Report.

Maine DMR. 2010. Final Report to NMFS Protected Resources Office for Award Number NA07NMF4720053.

Maine DMR. 2011. Salmon Trap Count Statistics – Adult Atlantic Salmon Trap Catch Summary. Online [URL]: http://www.maine.gov/dmr/searunfish/salmontraps.shtml. Accessed June 15, 2011.

Maine DMR. 2012. Salmon Trap Count Statistics – Adult Atlantic Salmon Trap Catch Summary. Online [URL]: http://www.maine.gov/dmr/searunfish/salmontraps.shtml. Accessed January 25, 2013.

Marschall, E.A., T.P. Quinn, D.A. Roff, J. A. Hutchings, N.B. Metcalfe, T.A. Bakke, R.L.Saunders and N.LeRoy Poff. 1998. A Framework for understanding Atlantic salmon (*Salmo salar*) life history. Can. J. Fish. Aquat. Sci. 55(Suppl. 1): 48-58.

Matthews, K.R. and R.H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium 7:168-172.

McLeay, D.J., G.L. Ennis, I.K. Birtwell, and G.F. Hartman. 1984. Effects on Arctic grayling (Thymallus arcticus) of prolonged exposure to Yukon placer mining sediment: a laboratory study. Yukon River Basin Study. Canadian Technical Report of Fisheries and Aquatic Sciences 1241.

McLeay, D.J., I.K. Birtwell, G.F. Hartman, and G.L. Ennis. 1987. Responses of Arctic grayling, Thymallus arcticus, to acute and prolonged exposure to Yukon placer mining sediment. Can. J. Fish. Aquat. Sci. 44: 658–673.

McCormick, S.F. and R.L. Saunders. 1987. Preparatory physiological adaptation for marine life of salmonids: osmoregulation, growth, and metabolism. Common strategies of anadromous and catadromous fishes. Proceedings of an International Symposium held in Boston, MA, USA, March 9-13, 1986. American Fisheries Society. 1:211-229.

McCormick S.D., L.P. Hansen, T. Quinn, and R. Saunders. 1998. Movement, migration, and smolting of Atlantic salmon (*Salmo salar*). Can. J. Fish. Aquat. Sci. **55**(Suppl. 1): 77-92.

McCormick, S. D., R. A. Cunjak, B. Dempson, M. F. O'Dea, and J. B. Carey. 1999. Temperature-related loss of smolt characteristics in Atlantic salmon (*Salmo salar*) in the wild. Canadian Journal of Fisheries and Aquatic Sciences 56(9): 1649-1658.

McLaughlin, E. and A. Knight. 1987. Habitat criteria for Atlantic salmon. Special Report, U.S. Fish and Wildlife Service, Laconia, New Hampshire. 18 pp.

Meister, A.L. 1958. The Atlantic salmon (*Salmo salar*) of Cove Brook, Winterport, Maine. M.S. Thesis. University of Maine. Orono, ME. 151 pp.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (Salmo gairdneri) and white perch (Morone americana): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Mesa, M.G. 1994. Effects of multiple acute stressors on the predator avoidance ability and physiology of juvenile chinook salmon. Transactions of the American Fisheries Society 123(5): 786-793. *Cited in* 74 FR 29362.

Moring, J.R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium 7:109-116.

Murdoch, P. S., J. S. Baron, and T. L. Miller. 2000. Potential effects of climate change on surface-water quality in North America. JAWRA Journal of the American Water Resources Association, 36: 347–366

National Assessment Synthesis Team (NAST). 2008. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, US Global Change Research Program, Washington DC, http://www.usgcrp.gov/usgcrp/Library/nationalassessment/1IntroA.pdf

National Marine Fisheries Service (NMFS). 2005. Salmon at the River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon. NOAA Technical Memorandum NMFS-NWFSC-68. 279pp.

National Marine Fisheries Service (NMFS). 2009a. Endangered and threatened species; designation of critical habitat for Atlantic salmon Gulf of Maine distinct population segment. Federal Register 74 (117): 29300-29341.

National Marine Fisheries Service (NMFS). 2009b. Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment. Northeast Regional Office 1 Blackburn Drive Gloucester, MA. 100 pgs.

National Marine Fisheries Service (NMFS). 2011. Atlantic Salmon Fate and Straying at Upstream Fish Passage Facilities on the Penobscot River. Summary of an expert panel convened on December 8, 2010 at the Maine Field Station of the Northeast Regional Office.

National Marine Fisheries Service (NMFS). 2012. Dam Impact Assessment Model. Lab Reference Document. Northeast Fisheries Science Center, Woods Hole, MA.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2005. Recovery plan for the Gulf of Maine distinct population segment of the Atlantic salmon (*Salmo salar*). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 2009. Endangered and threatened species; Determination of endangered status for the Gulf of Maine distinct population segment of Atlantic salmon. Federal Register 74 (117):29344-29387.

National Marine Fisheries Service (NMFS). 2008. Endangered Species Act Section 7 formal consultation regarding proposed funding of fisheries sampling in the Penobscot River, Maine, to be funded by NMFS. Gloucester, MA. Biological Opinion, September 4.

National Marine Fisheries Service. 2009a. Endangered Species Act Section 7 formal consultation regarding surrender of licenses for the Veazie, Great Works and Howland Projects, Nos. 2403, 2312, 2721. F/NER/2009/01515. NMFS - Gloucester, MA. December 23.

National Science and Technology Council (NSTC). 2008. Scientific Assessment of the Effects of Global Change on the United States. A report of the Committee on Environment and Natural Resources, Washington, DC.

Newcombe, C.P. and T.O.T. Jensen. 1996. Channel Suspended Sediment and Fisheries: A synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16(4): 693-716

Newcombe, C.P., and D.D. MacDonald. 1991. Effects of suspended sediments on aquatic ecosystems. N. Am. J. Fish. Manage. 11:72–82.

Nielsen, L.A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. Bethesda, Maryland 1992, 208p.

Normandeau Associates, Inc. 2011. A review of the Weston Project on the Kennebec River, Maine on Atlantic salmon (*Salmo salar*) smolts and kelt downstream passage and adult upstream passage. Prepared for FPL Energy Maine Hydro, Hallowell, ME. April 2011.

O'Connell, M.F. and E.G.M. Ash. 1993. Smolt size in relation to age at first maturity of Atlantic salmon (*Salmo salar*): the role of lacustrine habitat. J. Fish Biol. 42(4):551-569.

Palmer M.A., C.A. Reidy, C. Nilsson, M. Florke, J. Alcamo, P.S. Lake, and N. Bond. 2008. Climate change and the world's river basins: anticipating management options. Frontiers in Ecology and the Environment 6:81-89.

Pepper, V.A. 1976. Lacustrine nursery areas for Atlantic salmon in Insular Newfoundland. Fishereis and Marine Service Technical Report 671. 61 pp.

Pepper, V.A., N.P. Oliver, and R. Blunden. 1984. Lake surveys and biological potential for natural lacustrine rearing of juvenile Atlatnic salmon (*Salmo salar*) in Newfoundland. Canadian Technical Report of Fisheries and Aquatic Sciences 1295. 72 pp.

Ramstad, K.M. and C.A. Woody. 2003. Radio Tag Retention and Tag-Related Mortality among Adult Sockeye Salmon. North American Journal of Fisheries Management 23:978–982

Randall, R.G. 1982. Emergence, population densities, and growth of salmon and trout fry in two New Brunswick streams. Can. J. Zool. 60(10):2239-2244.

Reddin, D.G. 1985. Atlantic salmon (*Salmo salar*) on and east of the Grand Bank. J. Northwest Atl. Fish. Soc. 6(2):157-164.

Reddin, D.G. 1988. *Ocean* life of Atlantic salmon *(Salmo salar L.)* in the Northwest Atlantic. pp. 483 – 511. in D. Mills and D. Piggins [eds.] *Atlantic Salmon: Planning for the Future.* Proceedings of the 3rd International Atlantic Salmon symposium.

Reddin, D.G and K.D. Friedland. 1993. Marine environmental factors influencing the movement and survival of Atlantic salmon. 4th Int. Atlantic Salmon Symposium. St. Andrews, N.B. Canada.

Reddin, D.G. and W.M. Shearer. 1987. Sea-surface temperature and distribution of Atlantic salmon in the Northwest Atlantic Ocean. Am. Fish. Soc. Symp.

Reddin, D.G and P.B. Short. 1991. Postsmolt Atlantic salmon (*Salmo salar*) in the Labrador Sea. Can. J. Fish Aquat. Sci.. 48: 2-6.

Reddin, D.J., D.E. Stansbury, and P.B. Short. 1988. Continent of origin of Atlantic salmon (*Salmo salar* L.) caught at West Greenland. Journal du Conseil International pour l'Eploration de la Mer, 44: 180-8.

Redding, J.M., C.B. Shreck, and F.H. Everest. 1987. Physiological effects on coho salmon and steelhead of exposure to suspended solids. Transactions of the. American Fisheries Society 116: 737–744.

Rechisky, E.Ll, D.W. Welch, A.D. Porter, M.C. Jacobs-Scott, P.M. Winchell, and J.L. McKern. 2012. Estuarine and early-marine survival of transported and in-river migrant Snake River spring Chinook salmon smolts. Scientific Reports 2. Article number: 448.

Riley, W.D., D.L. Maxwell, M.G. Pawson, and M.J. Ives. 2009. The effects of low summer flow on wild salmon (Salmo salar), trout (Salmo trutta), and grayling (Thymallus thymallus) in a small stream. Freshwater Biology 54: 2581-2599.

Ritter, J.A. 1989. Marine migration and natural mortality of North American Atlantic salmon *(Salmo salarL.)*. Can. MS Rep. Fish. Aquat. Sci.. No. 2041. 136 p.

Rosenthal, H., and D.F. Alderdice. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. Journal of the Fisheries Research Board of Canada 33:2047-2065.

Ruggles, C.P. 1980. A review of downstream migration of Atlantic salmon. Canadian Technical Report of Fisheries and Aquatic Sciences. Freshwater and Anadromous Division.

Scannell, P. O. 1988. Effects of elevated sediment levels from placer mining on survival and Behavior of immature arctic grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Schaffer, W.M. and P.F. Elson. 1975. The adaptive significance of variations in life history among local populations of Atlantic salmon in North America. Ecology 56:577-590.

Schaller, H. A. and C. E. Petrosky. 2007. Assessing hydrosystem influence on delayed mortality of Snake River Stream-Type Chinook salmon. North American Journal of Fisheries Management 27:810–824.

Schilt, C.R. 2007. Developing fish passage and protection at hydropower dams. Applied Animal Behaviour Science 104: 295–325.

Scott, W.B. and E.J. Crossman. 1973. Atlantic salmon. Pages 192-197 in Freshwater Fishes of Canada (Bulletin 184). Department of Fisheries and Oceans, Scientific Information and Publications Branch, Ottawa.

Scott, W. B., and M. G. Scott. 1988. Atlantic fishes of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 219:1–731.

Servizi, J.A., and D.W. Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon, Oncorhynchus kisutch. Canadian Journal of Fisheries and Aquatic. Sciences. 48: 493–497.

Shelton, R.G.J., J.C. Holst, W.R. Turrell, J.C. MacLean, I.S. McLaren. 1997. Young Salmon at Sea. <u>In</u> Managing Wild Atlantic Salmon: New Challenges – New Techniques. Whoriskey, F.G and K.E.Whelan. (eds.). Proceedings of the Fifth Int. Atlantic Salmon Symposium, Galway, Ireland.

Shepard, S. L. 1989a. 1988 Progress Report of Atlantic Salmon Kelt Radio Telemetry Investigations in the Lower Penobscot River. Bangor Hydro-Electric Company. 30 pp.

Shepard, S. L. 1989b. Adult Atlantic Salmon Radio Telemetry Studies in the Lower Penobscot River. Bangor Hydro-Electric Company. 32 pp. and appendices.

Shepard, S. L. 1991. Report on Radio Telemetry Investigations of Atlantic Salmon Smolt Migration in the Penobscot River. Bangor Hydro-Electric Company. 38 pp. and appendices.

Shepard, S.L., and S.D. Hall. 1991. Adult Atlantic Salmon Telemetry Studies in the Penobscot River. Final Report. Bangor Hydro-Electric Company. 80 pp.

Shepard, S. L. 1993. Survival and Timing of Atlantic Salmon Smolts Passing the West Enfield Hydroelectric Project. Bangor-Pacific Hydro Associates. 27 pp.

Shepard, S. L. 1995. Atlantic Salmon Spawning Migrations in the Penobscot River, Maine: Fishways, Flows and High Temperatures. M.S. Thesis. University of Maine. Orono, ME. 112 pp.

Shepard, S.L. 1989.1989 Progress report – Adult Atlantic salmon radio telemetry studies in the lower Penobscot River. Bangor Hydro-Electric Company. Bangor, Maine. 34 pp with appendices.

Shepard, S.L. 1988. Bangor Hydro-Electric Company ASAL modeling of Penobscot River Atlantic salmon. Bangor Hydro-Electric Company. Bangor, Maine. 56 pp with appendices.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and Coho salmon. Transactions of the American Fisheries Society. 113: 142-150.

Sindermann, C.J. 1994. Quantitative effects of pollution on marine and anadromous fish populations.

Spence, B.. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis OR. (Available from the National Marine Fisheries Service, Portland, Oregon.)

Spidle, A.P., S.T. Kalinowski, B., A. Lubinski, D.L. Perkins, K.F. Beland, J.F. Kocik, and T.L. King. 2003. Population structure of Atlantic salmon in Maine with references to populations from Atlantic Canada. Trans. Am. Fish. Soc. 132:196-209.

Sullins, T.A. 1996. The Endangered Species Act.

Technical Advisory Committee. 1995. A Review of Atlantic Salmon and Brook Trout Management Conflicts on the East Branch Penobscot River. Prepared by the T.A.C. East Branch Fry Stocking Group.

Technical Advisory Committee. 1996. 1995 Progress Report Atlantic Salmon and Brook Trout Management Activities East Branch Penobscot River. Prepared by the T.A.C. East Branch Fry Stocking Group.

Technical Advisory Committee. 1997. 1996 Progress Report Atlantic Salmon and Brook Trout Management Activities East Branch Penobscot River. Prepared by the T.A.C. East Branch Fry Stocking Group.

Technical Advisory Committee. 2000. Atlantic Salmon and Brook Trout Management Activities East Branch Penobscot River. Interim Activity and Data Report. Prepared by the T.A.C. East Branch Fry Stocking Group.

Swansburg, E., G. Chaput, D. Moore, D. Caissie, and N. El-Jabi. 2002. Size variability of juvenile Atlantic salmon: links to environment conditions. J. Fish Biol. 61: 661-683.

USACOE (United States Army Corps of Engineers). 1990. Penobscot River Basin Study.

USACOE New England Division. Waltham, MA. 48 pp. and appendices.

U.S. Atlantic Salmon Assessment Committee (USASAC). Annual reports between 2001 and 2012. Annual Report of the U.S. Atlantic Salmon Assessment Committee.

US EPA (United States Environmental Protection Agency). 2003. National Coastal Condition Report IIL EPA/842-R-08-002 . 329 pp.

U.S. Department of the Interior. 1973 . Threatened Wildlife of the United States. Resource Publication 114, March 1973.

U.S. Fish and Wildlife Service. 2012. Technical Memorandum: Assumptions Used and Verification Process for the Development of the Black Bear Hydro Species Projection Plan. Maine Field Office, Orono, Maine. 66 pgs.

Van den Ende, O. 1993. Predation on Atlantic salmon smolts (*Salmo salar*) by smallmouth bass (*Micropterus dolomeiu*) and chain pickerel (*Esox niger*) in the Penobscot River, Maine. M.S. Thesis. University of Maine. Orono, ME. 95 pp.

Varanasi, U. 1992. Chemical contaminants and their effects on living marine resources. pp. 59-71. in: R. H. Stroud (ed.) Stemming the Tide of Coastqal Fish Habitat Loss. Proceedings of the Symposium on Conservation of Fish Habitat, Baltimore, Maryland. Marine Recreational Fisheries Number 14. National Coalition for Marine Conservation, Inc., Savannah Georgia.

Vladykov, V.D., and J.R. Greeley. 1963. Order Acipenseroidei. Pages 24-60 *in* Fishes of the western North Atlantic. Part III. Memoirs of the Sears Foundation for Marine Research 1.

Whalen, K. G., D. L. Parish, and M. E. Mather. 1999. Effect of ice formation on selection habitats and winter distribution of post-young-of-the-year Atlantic salmon parr. Can. J. Fish. Aquat. Sci. 56(1): 87-96.

White, H.C. 1942. Atlantic salmon redds and artificial spawning beds. J. Fish. Res. Bd. Can. 6:37-44.

Windsor, M. L., P. Hutchinson, L.P. Hansen and D. G. Reddin. 2012. Atlantic salmon at sea: Findings from recent research and their implications for management. NASCO document CNL(12)60. Edinburgh, UK. 20pp.

Wood, H., J. Spicer and S. Widdicombe. 2008. Ocean acidification may increase calcification rates, but at a cost. Proceedings of the Royal Society: Biological Sciences 275, no. 1644: 1767-1773.

Wright, J., J. Sweka, A. Abbott, and T. Trinko. 2008. GIS-Based Atlantic Salmon Habitat Model. *Appendix C in*: NMFS (National Marine Fisheries Service). 2008. Biological valuation of Atlantic salmon habitat within the Gulf of Maine Distinct Population Segment. NOAA National Marine Fisheries Service, Northeast Regional Office, Gloucester, MA.