

3.3.20 Entrainment of American Shad Ichthyoplankton at the Northfield Mountain Pumped Storage Project.

General Description of Proposed Study

The purpose of this study is to quantify entrainment of American shad ichthyoplankton at the Northfield Mountain Pumped Storage Project (Northfield Mountain Project).

On February 21, 2014, the Federal Energy Regulatory Commission (FERC) issued its second Study Plan Determination Letter (SPDL). On March 13, 2014, the United States Fish and Wildlife Service (USFWS) filed a notice of study dispute relating to the SPDL's determination not to require FirstLight to conduct ichthyoplankton sampling in the vicinity of the Northfield Mountain Project intake (tailrace) to quantitatively determine the level of entrainment of early life stages of American shad. Following the USFWS's letter, the following activities occurred relative to the study dispute:

- On March 26, 2014, a conference call was held with FirstLight, USFWS and FERC to discuss the notice of study dispute.
- On March 28, 2014, FirstLight filed with FERC information relative to Northfield Mountain Project Pumping.
- On March 31, 2014 FERC issued a Notice of Dispute Resolution Panel Meeting and Technical Conference.
- On April 1, 2014, a conference call was held with FirstLight, USFWS and FERC to further discuss the study dispute.
- On April 3, 2014, FirstLight filed with FERC two reports from the 1990s relevant to the Study Dispute Panel's consideration of the dispute.
- On April 7, 2014, FirstLight filed with FERC "Comments and Information of FirstLight Hydro Generating Company Regarding Notice of Study Dispute" relating to USFWS's exercise of Federal Power Act section 18 authority as it pertains to the study dispute.
- On April 8, 2014, the Study Dispute Panel held its meeting at the Northfield Mountain Project Visitors Center.
- On April 8, 2014, following the study dispute panel meeting, a meeting was held with FirstLight, USFWS and FERC to discuss the possibility of a mutually agreeable solution that would alleviate the need for a Director's determination on the study dispute.
- On April 14, 2014, FirstLight filed with FERC drawings and photographs of the Northfield Mountain Project relevant to study methodology discussed by FirstLight, USFWS, and FERC.
- On April 15, 2014, FirstLight filed with FERC Dye testing information conducted at the Northfield Mountain Project.
- On April 22, 2014, a conference call was held with FirstLight, USFWS and FERC to further discuss a mutually agreeable study plan.
- On May 1, 2014, the USFWS filed a Response to the FirstLight's April 7, 2014 filing.
- On May 2, 2014, the USFWS filed with FERC a conceptual framework for assessing ichthyoplankton entrainment at the Northfield Mountain Project. In addition, in a separate May

2, 2014 letter to FERC, USFWS stated that if FERC accepts the proposed study plan framework and requires FirstLight to conduct the study, USFWS will consider the dispute resolved.

- On May 2, 2014, FirstLight filed with FERC a letter supporting USFWS's proposed study.
- On May 2, 2014, FERC suspended the Dispute Resolution Panel.

Study Goals and Objectives (18 CFR § 5.11(d)(1))

Goal: Quantify entrainment of American shad ichthyoplankton into the Northfield Mountain Project during pump-back operation in a manner that will allow evaluation of temporal differences in larval density throughout the pumping cycle and the effects of the number of units pumping on entrainment rate.

Study Objectives:

- Calculate the number of American shad eggs and larvae entrained at the Northfield Mountain Project;
- Estimate the loss of adult and juvenile shad equivalents based on shad egg and larvae entrainment at the Northfield Mountain Project;
- Compare entrainment rates with one through four units pumping; and
- Determine the temporal distribution of entrainment within the prevailing pumping period.

Resource Management Goals of Agencies/Tribes with Jurisdiction over Resource (18 CFR § 5.11(d)(2))

The Connecticut River Atlantic Salmon Commission (CRASC) developed A *Management Plan for American Shad in the Connecticut River* in 1992. Management objectives in the plan that relate to the requested study include: (1) achieving and sustaining an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually and (2) maximizing outmigrant survival for juvenile shad.

In addition, the Atlantic States Marine Fisheries Commission's Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (ASMFC 2010) has a stated objective of maximizing the number of juvenile recruits emigrating from freshwater stock complexes.

Existing Information and Need for Additional Information (18 CFR § 5.11(d)(3))

Prior entrainment studies conducted at the Northfield Mountain Project include an entrainment study targeting egg, larval and juvenile American shad in 1992 (LMS, 1993). The studies were conducted to evaluate the impacts of the Project operation on American shad in the Connecticut River. Specific methods used in these studies included entrainment netting, and mark/recapture to investigate the probability of entrainment.

Results demonstrated seasonally-influenced entrainment rates of pre-juvenile life stages of American shad. The LMS (1993) study also suggested the possibility of a temporal component regarding rates of entrainment; however the study methodology was not designed to produce reliable inferences regarding sub-daily variations in entrainment rates. Additionally, the LMS (1993) study made certain assumptions that may have resulted in higher than actual entrainment rates (e.g., shad eggs and larvae in the river channel are evenly mixed throughout the water column and the Northfield Mountain Project intakes draw water evenly from the water column). A study that would directly sample the intake water, rather than the

river channel, multiple times during a pumping cycle could be used to evaluate varying entrainment rates on a sub-daily basis.

Other data sources filed with FERC during the study dispute period in 2014 include:

- March 28 filing: Northfield Mountain Project Pumping Information for May, June and July during the years 1991-1993 and 2011-2013, and hourly pumping records for the same period.
- April 3 filing: This included the following two reports:
 - “Northfield Mountain Pumped Storage Project 1990 Field Sampling Program.” The draft report, dated February 1991, was prepared by Harza Engineering Company for Northeast Utilities Service Company.
 - “Impact of the Northfield Mountain Pumped Storage Facility on Atlantic Salmon and American Shad.” The draft report, dated March 1993, was prepared by Lawler, Matusky & Skelly Engineers for Northeast Utilities Service Company.
- April 14 filing: Drawings and photographs of the Northfield Mountain Project.
- April 15 filing: Analysis of Dye Dispersion into Branches of the Northfield Mountain Project.

Project Nexus (18 CFR § 5.11(d)(4))

Factors that influence entrainment at hydroelectric projects include the size and depth of the intakes, the hydraulic capacity and configuration of the turbines, the velocity of water as it enters the intake relative to fish swim speeds, the location of the intake relative to fish habitat, and the characteristics of fish species present in the study area.

American shad broadcast spawn in congregations and fertilized eggs drift downstream until hatching. Shad are known to spawn upstream and downstream of the Northfield Mountain Project. Because early life stages of shad are non- or barely-motile, they are unable to avoid project intakes, and thus may be susceptible to entrainment.

The economic feasibility of pumped storage projects is highly dependent upon the daily timing of operations. Therefore, an entrainment study that allows for a more comprehensive evaluation of temporal variations of shad larval/egg entrainment within pumping cycles may be useful to better understand if and how operations of the project may affect shad larval/egg entrainment rates.

Methodology (18 CFR § 5.11(b)(1), (d)(5)-(6))

Sampling of ichthyoplankton entrainment at Northfield Mountain Project would be implemented by sampling water within the cooling water system of the Northfield Mountain Project as described below. The sampling of power plant cooling water intakes is an accepted sampling approach, to determine entrainment rates of ichthyoplankton.

Task 1. Entrainment Sampling

Sampling Frequency

The cooling water system inside the Northfield Mountain powerhouse will be sampled in the period of May 15 through July 31, 2015. Sampling will begin once 5,000 shad have passed through the Turners Falls Gatehouse fishway. Sampling will cease when American shad eggs and larvae are no longer found in the samples collected from the cooling water system. Once per week samples will be collected every 2 hours during a pumping cycle. Sample collection will be initiated 30 minutes after the pumping cycle begins to ensure the water is well mixed. At a minimum, one sample will be collected each during the following intervals: 1am to 4am; 5am to 8am.

In addition, pumpback operations will be manipulated to specifically sample entrainment with 1, 2, 3, and if possible, 4 pumps running. Four pumping scenarios will be sampled as follows:

- Scenario 1: 1 pump operational (Unit 2)
- Scenario 2: 2 pumps operational (Unit 2 and one other)
- Scenario 3: 3 pumps operational (Unit 2 and two others)
- Scenario 4: All 4 pumps operational¹

This sampling will occur during four pumping cycles spread over the expected peak of egg and larval density (May 23 through July 5); if possible, multiple scenarios will be sampled within one or more of the four cycles. Sampling will be randomized or scheduled if possible such that scenarios are not run in a sequence of an increasing or decreasing number of pumps. In addition, if any daytime pumping or uncommon nighttime pumping hours scheduled to occur during the sampling period to the extent possible given pumping scheduling decision lead time, samples will be collected during these times.

System Design and Collection Method

Entrainment sampling will be accomplished by tapping off of existing piping that supplies cooling water from the Connecticut River to the station. The goal is to sample a minimum of 150 gpm (gallons per minute) of flow. PVC and rubber piping, a digital flow meter, a 1,000-liter plastic tank, and a 0.333 mm mesh plankton net will be utilized to construct the sampling system. The objective will be to filter approximately 100-200 cubic meters of intake water for each sample. Intake cooling water will be diverted through a four-inch diameter flexible hose to an entrainment sampling tank. An inline Signet® digital flow meter will be mounted in the hose to record the volume of water sampled. The hose's discharge will be directed into a conical 0.333 mm mesh plankton net suspended in a 1,000 liter plastic tank. The plastic tank is designed with an overflow system. The objective is to filter at least 100 cubic meters of intake water per sample. Once sufficient volume is obtained, the net will be removed from the sampling tank and its contents will be rinsed down into the cod-end collection jar with fresh water. The sample jar will be removed from the plankton net and the contents preserved with a 10% formalin solution. All jars will be appropriately labeled and transported back to Kleinschmidt's sorting facility for sorting, enumerating and organism identification. At the beginning of each entrainment sampling event, the following water quality information will be measured and recorded: temperature, dissolved oxygen, pH, and conductivity. In addition, data on Northfield Mountain Project operations including which unit and the number of units operating, unit output and the Turners Falls Impoundment elevation at the Northfield Mountain Project tailrace will be recorded.

Sample Validation

To validate that larval densities in the cooling water pipe are representative of densities in the intake tunnel, a paired sampling of both cooling water pipe and the intake/tailrace channel will be collected at the start of the study. Ichthyoplankton samples will be collected in the intake/tailrace channel with weighted 60-cm diameter paired bongo nets with 0.333 mm mesh deployed from a boat. The bongo nets will be towed in a straight line starting at the intake tailrace at mid-depth for approximately six minutes or until at least 100 cubic meters of river water is sampled. General Oceanics flowmeters will be suspended in the center of each net to measure the volume of river water filtered during each tow. Once the target volume is obtained, the nets will be hauled onto the boat and the contents from one net from each tow will

¹ A potential Unit 1 outage, which is anticipated, may prevent Scenario 4 from occurring, in which case, an analytical analysis of entrainment rates with 4 pumps operating will be performed provided sample scenarios 1-3 indicated a linear relationship of the entrainment rates between those sampling scenarios.

be rinsed down with water into the cod-end collection jars. The samples will be preserved with a 10% formalin solution in appropriately labeled jars and transported back to the sorting room for analysis. A minimum of three replicate samples will be collected at each of the two locations. Densities of American shad eggs and larvae in the two sets of samples will be compared. If differences are found, a correction coefficient for entrainment calculations will be developed. Alternatively existing computational fluid dynamic modeling results may be used to validate that larval densities in cooling water pipe are representative of densities in the intake tunnel. As part of the 2D Northfield tailrace modeling study, velocity profiles at three transects across the tailrace under 2 and 4 pump operations have been collected and may be used for sample validation analysis.

Task 2. Sample Processing

Ichthyoplankton samples will be sorted with the aid of a dissecting microscope. Larvae and eggs will be removed from the samples, identified to the lowest practical taxonomic category, and enumerated. Larvae and eggs of blueback herring, and American shad in the Connecticut River are not easily distinguishable. However alewives are not found in this area of the Connecticut River, and blueback herring numbers are very low, therefore any herring eggs or larvae will be identified as American shad.

A quality control program designed to ensure that the Average Outgoing Quality Limit for ichthyoplankton sorting and identification is greater than 90% will be followed. To accomplish this, one ichthyoplankton sample from each series of ten samples processed by a single individual will be randomly selected to be re-sorted. No one will be allowed to perform a QA/QC on his or her own samples. The person checking the sample (the QA/QC-er) will re-process the sample to determine what percentage of both larvae and eggs was missed, if any. If the percentage missed in either category is equal to or greater than 10 percent, the following QA/QC procedure will be followed until a "passing" QA/QC was obtained: Starting with samples sorted prior to the failed QA/QC, samples were re-sorted in sequential order, working back, until a 'passing' QA/QC is obtained (i.e., Number found by QA/QC-er is less than 10% of total eggs or larvae in the sample). The process will be repeated with subsequently sorted samples, sequentially until a passing QA/QC is obtained. Any larvae or eggs found during the QA/QC process will be added to the totals on the corresponding data sheet and included in the entrainment estimates.

All sorting and field data will be entered into a Microsoft Access database. All data entered will be verified for accuracy against the original data sheets prior to commencement of analyses, which are described below.

Task 3. Ichthyoplankton Data Analysis Methods

Entrainment Estimates

Entrainment of American shad eggs and larvae will be estimated based on the extrapolation of raw counts using a volumetric ratio and summing of weekly estimates derived from samples. The daily cooling water volume will be calculated based on daily average flow rates obtained from Northfield Mountain Project personnel. An estimate for each day not sampled will be calculated by multiplying the average entrainment density (number of larvae/eggs per m³ of cooling water) for the sampled night by the volume of cooling water used on each day not sampled. All daily estimates will then be summed to generate a total for the larvae and eggs of each species entrained.

Equivalent Adult Estimates

The numbers of entrained fish larvae and eggs will be converted into adult equivalents to determine population impact. Adult equivalent losses (AELs) are estimates of the number of entrained organisms removed from the population that otherwise would have survived to some future age, or age of equivalence. To estimate AELs, the estimates of American shad larvae and eggs are multiplied by the survival fraction at a given lifestage:

$$AEL = \sum_{j=1}^n S_{i,A} N_i$$

where:

N_i = number of fishes lost at stage i ; and

$S_{i,A}$ = fraction of fishes expected to survive from stage i to the stage of equivalence.

Survival rates of early lifestages are often expressed on a lifestage-specific basis so that the fraction surviving from any particular lifestage to adulthood is expressed as the product of survival fractions for all lifestages through which a fish must pass before reaching adulthood (j_{max} = the stage immediately prior to the age of equivalence):

$$S_{i,A} = \prod_{j=i}^{j_{max}} S_j$$

Survival fraction data for all lifestages of American shad entrained will be compiled from EPA (2004).

Ichthyoplankton Densities

Egg and larval sample densities will be determined by dividing the number of American shad eggs and larvae by life stage (egg, yolk-sac larvae, post yolk-sac larvae) in each sample by the sample volume. The densities will then be standardized to the number of larvae per 500 m³. Densities by life stage will be analyzed by date and time.

Level of Effort and Cost (18 CFR § 5.11(d)(6))

The cost for this study would be \$60,000 to \$70,000. Costs will be related to equipment, sampling and processing of the ichthyoplankton samples, analysis of data, and production of a final report.

Literature Cited

- Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). Washington, D.C.
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DRAFT - FOR CONSULTATION