United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer To: FirstLight Hydro Generating Company — March 1, 2013
Turners Falls Hydroelectric Project, FERC No. 1889
Northfield Mountain Pumped Storage Project, FERC No. 2485
Connecticut River
COMMENTS ON PRE-APPLICATION DOCUMENT
STUDY REQUESTS
SCOPING DOCUMENT 1

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E., Room 1A
Washington, DC 20426

Dear Secretary Bose:

This responds to the Pre-Application Document (PAD) for the Turners Falls Hydroelectric Project and the Northfield Mountain Pumped Storage Project (NMPS), located on the Connecticut River in Franklin County, Massachusetts; Windham County, Vermont; and Cheshire County, New Hampshire. The PAD is being provided in preparation of an application for a new federal license for the projects. We offer the following comments based on the PAD (submitted to us by FirstLight Power Resources [FirstLight] on October 30, 2012) and information we obtained at the site visit held on October 4, 2012, the joint agency meeting held on October 5, 2012, and the Federal Energy Regulatory Commission (Commission) scoping meetings held on January 30-31, 2013.

PRE-APPLICATION DOCUMENT

PROPOSAL

Turners Falls Project

The Turners Falls Project consists of two dams separated by an island that impound 2,110 acres of water at the normal pool elevation of 185.0 feet mean sea level (msl). The Montague Dam is 630 feet long and has four bascule gates. The Gill Dam is 493 feet long and consists of three tainter gates. Adjacent to the dam is a gatehouse that leads to a 2.1-mile-long canal. The canal provides water to a number of users, including the Turners Falls Project's Station No. 1 and

Cabot Station hydropower generating facilities. The canal has a capacity of approximately 18,000 cfs and a target elevation of 173.5 feet msl.

Station No. 1 is located at the end of a short side canal that branches off the main power canal 0.9 miles downstream of the canal gatehouse. The powerhouse intake is covered with trashracks that have clear spacing of 2.625 inches and an approach velocity of 1.2 feet per second. Behind the racks are four penstocks that feed water to seven horizontal Francis turbines. Five of the seven turbines are currently operable. The combined nameplate capacity is 5.693 MW and the total hydraulic capacity of the project is 2,210 cfs.

The Cabot Station is located at the end of the main power canal. The intake to the powerhouse is covered with trashracks that have 1-inch-clear spacing on the upper 11 feet and 5-inch-clear spacing on the bottom 20 feet. The average approach velocity at the maximum hydraulic capacity of 13,728 cfs is approximately 2.0 feet per second. Behind the racks, six penstocks feed water to six vertical Francis turbines. The total nameplate capacity of the station is 62.016 MW, with each turbine having a maximum hydraulic capacity of 2,288 cfs.

The Turners Falls Project bypasses 2.7 miles of the Connecticut River. The project is required to release 200 cfs to the bypass beginning May 1. When FirstLight is notified that the fish passage season has begun, the bypassed reach flow release is increased to 400 cfs until July 15 (or until the fishways are closed), when it is reduced to 120 cfs until river temperature drops below 7°C. No minimum flow to the bypassed reach is required from the time when the river temperature drops to 7°C through April 30.

The project is operated as a peaking facility when flows are within the hydraulic capacity of the two stations, with allowable headpond fluctuations of up to nine feet (from elevation 176.0 feet msl to 185.0 feet msl). Station No. 1 typically only operates during low flow periods or when flows exceed the hydraulic capacity of Cabot Station. The project is required to release a minimum below-project flow of 1,433 cfs, or inflow (whichever is less).

FirstLight operates both upstream and downstream fish passage facilities at the project. These facilities include an upstream anadromous fish ladder at the spillway, another fish ladder adjacent to the Cabot Station powerhouse that conveys fish to the canal, a third fishway at the canal gatehouse that conveys fish from the canal and spillway fishways to the headpond, and a downstream fish bypass in the Cabot Station forebay.

Northfield Mountain Pumped Storage Project

NMPS consists of an intake located along the banks of the Connecticut River (which acts as the lower reservoir), a powerhouse, a pressure shaft, and a 286-acre upper reservoir. The powerhouse contains four reversible pump/turbines that have a total nameplate capacity of 1,119.2 MW. The project pumps at a maximum hydraulic capacity of 15,200 cfs and generates at a capacity of 20,000 cfs. The intake to the lower reservoir is covered with trashracks that have 6-inch-clear spacing and an approach velocity of 3.5 feet per second.

NMPS operates as a peaking facility, typically pumping at night when power prices are low and generating during peak power periods during the day. The upper reservoir is allowed to fluctuate 62.5 feet (from elevation 1,000.5 feet msl down to elevation 938 feet msl). During the spring, the project limits pumping operation to three pumps and deploys a seasonal barrier net to minimize entrainment of Atlantic salmon (*Salmo salar*) smolts.

Average annual generation for the Turners Falls Project was 320,140 MWh for the period 2000 to 2010, and for the NMPS Project was 1,143,038 MWh for the period 2000 to 2009.

FirstLight is considering a number of potential modifications as part of the subject relicensing proceedings, including: (1) upgrading Station No. 1 with new or rehabilitated turbines; (2) closing Station No. 1 and adding capacity at Cabot Station similar to Station No. 1's capacity; (3) utilizing Cabot Station's full hydraulic capacity; (4) utilizing more storage in the NMPS upper reservoir; and (5) increasing the unit and station capacity at NMPS.

In the PAD, FirstLight has proposed no additional protection, mitigation and enhancement (PME) measures.

COMMENTS

3.2 Project Facilities

FirstLight provided a detailed description of the project facilities associated with the three stations (Station No. 1, Cabot Station, and NMPS); however, several important pieces of information are missing:

- the minimum hydraulic capacities, runner diameters and speeds of the turbines at Station No. 1 and Cabot Station; and
- the "lower reservoir" pool elevation that was used to calculate the approach velocity at the NMPS intake trashrack.

4.3.1.3 Overview of Water-Related Project Features

FirstLight discusses the gages that are installed at the Turners Falls and NMPS projects to monitor water level, discharges, generation and pumping conditions. The PAD provides monthly and annual summaries of these data. Unfortunately, monthly data do not provide the level of detail necessary to understand fully how these peaking projects operate individually and together; therefore, we are requesting that FirstLight provide hourly data (water surface elevations, dam discharge, generation, and pumping data) from both projects (three stations) for the past five years.

FirstLight states that it maintains hourly data on daily log sheets. This statement should be clarified; are data manually recorded, or does each gage electronically record hourly readings?

In the PAD, FirstLight states that generation can only take place at NMPS if releases can be stored in the Turners Falls impoundment without increasing the headpond elevation above

allowable levels. While this statement might technically be accurate, there are other ways to maintain the elevation of the Turners Falls pool within allowable levels (e.g., opening a bascule gate). This statement should be clarified to address whether the bascule or tainter gates are ever opened to accommodate NMPS generation. If so, under what operation conditions of the Turners Falls Project has this occurred and is that operation proposed to continue?

4.3.1.6 2012 Water Level Monitoring Baseline Study

FirstLight undertook a water level monitoring effort in 2012, in consultation with state and federal resource agencies. Water level recorders were installed at various locations within the Turners Falls Project (i.e., the impoundment, bypass reach, and downstream of the Cabot Station tailrace). The recorders were deployed from April through early August. Appendix E of the PAD provides figures depicting the water level data. The results are helpful in understanding how water levels vary on a daily basis within different project areas. However, including additional information relevant to a particular location would provide even more insight (e.g., overlaying gate discharge and Station No. 1 generation data on the bypass reach graphs; overlaying Cabot Station and/or Station No. 1 generation data on the below-Cabot graphs, etc.).

4.3.2. Water Quality

The Turners Falls Project lies within three state boundaries: Vermont, New Hampshire, and Massachusetts. All three states classify the Connecticut River in the vicinity of the Turners Falls Project as Class B (although the criteria to meet Class B standards vary by state).

Impairments

Vermont lists the stretch of the Connecticut River from downstream of Vernon Dam to the state line as impaired due to flow alteration, with aquatic life support use impacted by fluctuating flows due to hydropower production. Likewise, New Hampshire lists the same stretch of river as impaired, with aquatic life use impacted by aluminum, copper, and low pH. Massachusetts lists the Connecticut River as impaired, with specific causes linked to specific locations as follows:

Location	Cause
State line to the Route 10 bridge	Other flow regime alterations; alteration in stream-side or littoral vegetative covers
Route 10 bridge down to the Turners Falls Dam	Alteration in stream-side or littoral vegetative covers; non-native aquatic plants
Downstream of Turners Falls Dam to confluence with Deerfield River	Suspended solids; low flow alterations; other flow regime alterations
From confluence with Deerfield River downstream to the Holyoke Dam	*E. coli* bacteria

Existing Data

The PAD provides a summary of existing water quality data. While a number of monitoring efforts have taken place and include sample sites within the project boundary, none of those studies were designed to comprehensively investigate whether all relevant project areas currently meet Class B standards:

- the Massachusetts Department of Environmental Protection's Connecticut River watershed assessment monitoring occurred in 2003, only had two stations located within the project area (both upstream of the Turners Falls dam), and only collected five to six samples from late April to early October;

- the Connecticut River Watershed Council's volunteer monitoring program only had one sample site within the project area (at Barton's Cove in the Turners Falls headpond), and while those data are more recent, only three samples were collected in 2007, and only six samples in 2008 (over the course of three to four months each year); and

- the U.S. Geological Survey's long-term water quality monitoring station, located downstream of the Cabot Station tailrace, stopped taking samples in 2007, only collected information roughly once per month, and sampled dissolved oxygen even less frequently.

No directed, site-specific surveys have been conducted to determine whether waters within the project area meet state standards. This information gap needs to be filled so resource agencies can properly evaluate and determine the potential impact of project operations on water quality. In the PAD, FirstLight proposes to conduct a water quality study during the summer period. The U.S. Fish and Wildlife Service (Service) supports FirstLight conducting water quality monitoring to verify compliance with state standards and herein submits a request for such a study.

4.4 Fish and Aquatic Resources

Resident Fish

In the PAD, FirstLight summarizes data from resident fish surveys conducted by the State of Massachusetts Division of Fisheries and Game (MA DFG, now the Division of Fisheries and Wildlife) in the early-to-mid-1970s, as well as a limited 2008 sampling effort by Midwest Biodiversity Institute (MBI) (Yoder *et al.* 2009). The MA DFG sampled eight stations within the Turners Falls pool every two weeks from April through October. MBI took a single sample at four sites within the Turners Falls pool during late September/early October.

Based on the very old MA DFG data and the limited sampling by MBI, 16 fish species were collected within the project area. However, we are aware that resident species such as northern pike (*Esox lucius*), tessellated darter (*Etheostoma olmstedi*), burbot (*Lota lota*), eastern silvery minnow (*Hybognathus regius*), and channel catfish (*Ictalurus punctatus*) also inhabit project waters (Ken Sprankle, USFWS, and Jessie Leddick, MADFW, personal communication). It is unknown how many other species may inhabit or utilize aquatic habitats in the project area, potentially including species of greatest conservation need.

The Turners Falls impoundment and below-dam riverine reach contain a diversity of habitat. Existing studies are of limited value due to being outdated, of too short duration, or gear-restricted (i.e., both studies only used electrofishing to sample fish), and thus do not provide a thorough understanding of the fish assemblages inhabiting the Turners Falls pool and riverine reach below the dam. This information is needed in order to determine whether project operations (at Turners Falls and NMPS) are impacting the health of the fish community within the project area. FirstLight has not proposed any studies to address this deficiency; therefore, the Service is herein submitting a request for such a study.

Headpond Fluctuations

The Turners Falls Project operates in a peaking mode. In the PAD, FirstLight states that while it is allowed to fluctuate the impoundment up to nine feet, it typically operates over a much narrower range. However, given that FirstLight is not proposing to formalize those operating ranges, it still could utilize the full drawdown levels. Regardless, even at the narrower operating bands, there is the potential for the project to dewater littoral areas important to shallow water nesting species.

The PAD contains no site-specific information on littoral spawners residing within the impoundment, or potential impacts of project operations on those species. This information gap needs to be filled so that the agencies can determine appropriate recommendations relative to headpond fluctuation restrictions. The Service herein provides such a request.

In addition to potentially impacting littoral spawners, daily drawdowns also may impact species that move from mainstem habitat into tributaries to spawn or fulfill other life history requirements. The PAD provides no information regarding how far upstream the influence of the impoundment extends into tributaries entering the mainstem. It is possible that when the headpond is at the lower end of its operating range, the mouths of tributaries could become perched, creating a barrier to upstream movement. This issue needs to be investigated so that agencies can use the results to develop recommendations regarding future project operations. The Service herein submits a request to address this issue.

Migratory Fish Species

American shad

FirstLight provides detailed descriptions of the life histories, restoration efforts, and passage status of migratory fish species known to occur within the project area. The Service offers one point of clarification with respect to American shad (*Alosa sapidissima*). In the PAD, FirstLight states that the seaward migration out of the Connecticut River begins in September; however, results of a study conducted by O'Donnell and Letcher (2008) examining juvenile shad early life history and migration upstream and downstream of the Turners Falls Dam suggest that outmigration begins in the month of August.

American shad are known to spawn downstream from the Turners Falls Project. Layzer (1974) identified six spawning sites from an area below the mouth of the Deerfield River (river mile 191.9) to river mile 161.7 below the Mill River in Hatfield, Massachusetts. Kuzmeskus (1977) verified 16 different spawning sites ranging from downstream of the Cabot tailrace to just upstream of the Holyoke dam (river mile 87.1). The only parameter that all spawning sites had in common was current (Kuzmeskus 1977). The Service is not aware of any more recent studies that document whether these 16 sites are still viable spawning locations for shad. We are not aware of any studies that have determined American shad spawning habitat or spawning sites upstream of the Turners Falls Dam, although juvenile shad have been collected within the Turners Falls pool, which suggests that spawning is occurring.

Peaking releases from Cabot Station produce rapid flow changes, and operations at Turners Falls and NMPS result in fluctuations of the Turners Falls pool. Both peaking releases and pond fluctuations affect physical parameters (i.e., water depth and velocity) that are important for shad spawning success. The Service is not aware of any studies being conducted specifically designed to determine if project operations at Turners Falls and NMPS affect American shad spawning behavior, habitat use, and egg deposition.

Fish Passage

The PAD provides an overview of the fish passage facilities that exist at both projects, when they began operating, and studies that have been conducted to determine their effectiveness at passing target species. We would like to offer some points of clarification. First, the Applicant states that the log sluice at Cabot Station is operated for American eels (*Anguilla rostrata*). While the sluice is operated during the eel outmigration period, the downstream bypass facility was not designed with eels in mind, and studies conducted by Alex Haro of the U.S. Geological Survey's Conte Anadromous Fish Research Center indicate that the bypass is not effective in preventing entrainment of eels at the intake (although an unknown proportion of silver phase eels do use the bypass).

Second, FirstLight states that effectiveness studies conducted in the 1990s estimated that 90 percent of the juvenile clupeids exited via the log sluice. The Service has reviewed the 1991 study conducted by Harza Engineering Company and RMC Environmental Services (full citation contained in Appendix G of the PAD) and the results clearly state that an estimated 58 percent of the juvenile clupeids approaching Cabot Station were bypassed via the log sluice.

Third, FirstLight cites two entrainment studies at NMPS involving intake netting of juvenile shad in the upper reservoir; however, both of the studies referenced relate to studies of Atlantic salmon smolts.

Canal Drawdown

FirstLight provides no information on the annual canal drawdown. Each year, the power canal is dewatered in September for over a one-week period to perform facility maintenance, inspections, and repairs. Historically, the canal drawdown occurred in July, but approximately five years ago, it was moved to September, where it has occurred annually since then (with the exception of

2010 when no drawdown took place). The agencies were informed in a letter by FirstLight that the shift to September was at the request of the Independent System Operator–New England to avoid peak load months of June through August.

Moving the drawdown event to September presents a number of concerns to the Service. First, the drawdown now coincides with the juvenile shad and adult eel outmigration period. Once the canal is drawn down to below the invert of the downstream bypass facility, the only way for fish to move out of the canal is through the intake and turbines. The fate of migrants that do not leave the canal is unknown, but they are certainly at risk for desiccation and predation.

Second, the canal contains substantial amounts of rearing habitat for sea lamprey (*Petromyzon marinus*) ammocoetes. The ammocoetes reside in the soft substrate materials located in much of the downstream end of the canal (Dr. Boyd Kynard, BK-Riverfish, LLC, personal communication). The number of ammocoetes that have died during recent drawdowns has been estimated qualitatively at tens of thousands (Matt O'Donnell, USGS Conte Lab, personal communication).

Third, the canal provides habitat for resident fishes, herptiles, and benthic invertebrates such as freshwater mussels. While a mussel survey conducted in 2011 by BioDrawversity (PAD, page 4-151) found no state listed or federally threatened or endangered mussel species, the eastern floater (*Pyganodon cataracta*) was found in the canal. All of these inhabitants potentially are impacted by the drawdown.

FirstLight is not proposing to conduct any studies relative to the canal drawdown. The Service believes the potential impacts to resources resulting from the canal drawdown warrants evaluation, and herein submits a study request intended to fill this information gap.

Climate Change

The Turners Falls Project has a very long impoundment capable of storing a large volume of water, as does the Northfield Mountain upper reservoir. The Turners Falls pool effectively has converted a large portion of the Connecticut River into an in-river "lake." Because water velocities slow in these impounded sections of river, it allows for increased thermal loading and resultant higher water surface temperatures than in free-flowing sections of river. The PAD provides a summary of existing water quality data compiled by FirstLight, including water temperature data obtained from the Service. The PAD also notes a 1991 study by the former licensee that modeled thermal effects of pumping to the upper reservoir. That model reported a maximum temperature difference attributable to NMPS operation of 0.21°C in the Turners Falls reach of the Connecticut River in low flow (4,000 cfs) simulation.

The most recent climate change prediction models specific to the Northeast forecast warmer air temperatures, more frequent high precipitation events, more heat waves, and an increase in the incidence of short-term droughts (Karl *et al.* 2009). The increase in air temperature will increase thermal loading into the impoundment and upper reservoir, which will then be discharged downstream of the dam.

The PAD contains no information relative to climate change and how climate change predictions may impact future operation of the hydroelectric plants, nor of how the projects either mitigate for or exacerbate predicted climate change impacts to freshwater ecosystems. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations with respect to the Service's management goals and objectives, including those identified in its draft Climate Adaptation Strategy document (Anonymous 2012).

4.6 Wetland, Riparian, and Littoral Habitat

Wetland Habitat

The PAD provides a general description of invasive plant species within the Turners Falls pool. FirstLight identifies common reed (*Phragmites australis*) and Japanese knotweed (*Fallopia japonica*) as occurring in the impoundment, but the Service is aware that Eurasian watermilfoil (*Myriophyllum spicatum*) and water chestnut (*Trapa natans*) also are found within the Turners Falls pool. In fact, the abundance of water chestnut is increasing; in 2012, FirstLight and the Conte National Fish and Wildlife Refuge (Conte Refuge) removed over 3,500 pounds of water chestnut from the river immediately upstream from the dam (which, unfortunately, was not the entire population; thus, the plants that remained likely produced a seedbank that now will pose a reinfestation and expansion risk for the next 12 years).

With respect to invasive species, FirstLight should be aware that in the Connecticut River watershed, six Cooperative Invasive Species Management Area (CISMA) partnerships of varying scales are working on invasive species projects, including public outreach, inventory and on-the-ground invasive plant control. In addition, a full Connecticut River watershed-wide initiative networks these CISMAs as well as additional state and regional partners to prioritize invasive plant control actions and to plan and implement early detection and rapid response to new invaders to the watershed.

Wetland, Riparian and Littoral Vegetation and Wildlife

The PAD provides no site-specific vegetation or wildlife information. Baseline information on wildlife and botanical resources is needed in order for the agencies to determine if project operations may be impacting wetland, riparian or littoral species and their habitats.

FirstLight is proposing to conduct a baseline inventory of terrestrial wildlife and botanical resources in the Turners Falls impoundment, the bypass reach, and below Cabot Station. The Service supports FirstLight conducting a wildlife and botanical resources inventory and herein submits a request for such a study that also includes an assessment of the impacts of project-induced water level fluctuations on wetlands, and littoral and riparian vegetation and wildlife.

4.7 Critical Habitat and Threatened and Endangered Species

Puritan Tiger Beetle (*Cicindela puritan)*

The Puritan tiger beetle is listed as threatened, and inhabits Rainbow Beach, a point bar located within the Connecticut River in Northampton, Massachusetts. Within the Massachusetts section of the river, Rainbow Beach is the only known suitable habitat for the Puritan tiger beetle. The water levels at Rainbow Beach, which is within the Holyoke Project (FERC No. 2004), while controlled to some extent by the presence of Holyoke Dam and the operation of the Holyoke Project, are also impacted by the peaking generation operations of the Turners Falls Project. Given that the Holyoke Project is licensed as a run-of-river facility, and due to unique channel restrictions in the Holyoke impoundment, peaking flow releases from Cabot Station result in increased water levels at Rainbow Beach, which may lead to the periodic inundation of occupied Puritan tiger beetle habitat.

How the operations of the Turners Falls and Holyoke projects interact, and what operational changes to the Turners Falls Project can be implemented to reduce water level fluctuations at Rainbow Beach, need to be evaluated to ensure that relicensing of the Turners Falls Project does not result in adversely affecting the Puritan tiger beetle, which includes harm resulting from habitat modification or degradation. The Service is providing herein a modeling study request that includes this evaluation. If the results of that study indicate that water levels associated with the relicensing may affect the Puritan tiger beetle or its habitat, further consultation with this office under the Endangered Species Act is recommended.

5.2 Potential Studies and Information Gathering

Water Resources

FirstLight proposes to develop a calibrated operations model that would simulate existing operations of the Turners Falls Project and NMPS, and allow for evaluation of potential modifications to the projects (e.g., upgrade or decommission Station No. 1, upgrade Cabot Station, increase storage at NMPS, etc.), as well as assess alternative operations.

While FirstLight would use the model to understand how any changes would impact generation at the stations, the Service supports this study because it will allow the agencies to understand what, if any, limitations there may be to changing project operations to benefit natural resources within and beyond the project areas. The Service herein submits a request for such a study.

Water Quality

As noted above, the Service supports FirstLight conducting a water quality monitoring study and is submitting a request to that effect.

Fish and Aquatic Resources

Downstream Passage at Turners Falls

FirstLight proposes to evaluate the need for potential improvements to existing downstream fish passage and protection measures for American shad and American eel at the Turners Falls Project by utilizing information from previously conducted studies and ongoing studies. To date, the studies that have been conducted indicate that the downstream bypass is not effective for juvenile shad or American eel. No studies have been undertaken to evaluate the effectiveness of the existing downstream bypass for post-spawned adult shad.

The Service believes that new studies need to be conducted to fully understand how post-spawned adult shad, juvenile shad, and silver phase eels move through the lower Turners Falls pool, Turners Falls canal system, intakes and bypass. In addition, turbine and gate discharge mortality studies are needed for all of these species/life stages and should be used in conjunction with the results of the passage routing studies to calculate total through-project survival rates. The Service herein provides study requests in order to address these information needs.

Upstream Passage at Turners Falls

FirstLight proposes to evaluate the need for potential improvements to existing upstream fish passage facilities for American shad and American eel at the Turners Falls Project by utilizing information from previously conducted studies and ongoing studies. To date, the studies that have been conducted indicate that the Cabot fish ladder is not effective for passing American shad. No studies have been undertaken to evaluate the effectiveness of the existing fish ladders for juvenile American eels.

Relative to American eels, the Service believes that new studies are needed to determine where juvenile eels concentrate in relation to various project features, so that eel-specific upstream passage facilities can be sited properly. Previous studies have identified a number of problems with respect to American shad at the Cabot ladder and gatehouse fishway entrances, and the Service believes that a comprehensive radiotelemetry study is needed to understand the relationship between project operations, including spill flows, and shad movement through the Connecticut River, including attraction to and passage through these three ladders. Additionally, a study to define the relationship of the complex hydraulic conditions at the spillway fishway entrance and the gatehouse fishway entrances is needed in order to evaluate data on fish behavior and passage at those locations. Therefore, the Service is providing herein study requests to address these information needs.

Passage Past NMPS

FirstLight proposes no studies to address false attraction and entrainment at the NMPS facility. Previously conducted studies documented entrainment of juvenile shad. No studies have been undertaken to determine annual entrainment of resident fishes or entrainment of silver phase eels during outmigration.

Operations at NMPS have the potential to significantly impact movement of migratory fishes past the project and recruitment of migratory and resident riverine fishes within the impoundment. The extent of NMPS' influence on fish movement and entrainment needs to be determined. The adult shad radiotelemetry study referred to above should allow for evaluation of false attraction and entrainment of adult American shad. Separate studies are needed to assess entrainment of other species and life stages (including ichthyoplankton). In addition, hydraulic modeling of the NMPS intake area and the main river channel near the project are needed to understand the flow fields and intake/discharge velocities at the project that influence entrainment and passage past the project. Therefore, the Service is providing herein study requests to address these information needs.

Effects of Project Operations on Shortnose Sturgeon

FirstLight proposes to assess effects of discharges from Cabot Station and Station No. 1 on shortnose sturgeon (*Acipencer brevirostrum*) spawning. The Service agrees that station generation, as well as other project operations, including generation flows, spill flows, canal trash sluice discharges, and downstream passage sluice discharges have the potential to impact sturgeon spawning and egg incubation; therefore, we are providing study requests in order to address these information needs.

Instream Flows in the Turners Falls Bypass and Below Cabot Station

FirstLight is proposing to assess the effects of discharges from Cabot Station on zone of passage and habitat. The methodology outlined in the PAD to conduct a mesohabitat survey and then determine what level of additional studies, if any, are necessary, is inadequate. The bypass reach is 2.7 miles long and contains diverse habitat, including important spawning habitat for the federally endangered shortnose sturgeon. There are 10 miles of free-flowing river downstream of the Cabot Station that also contain a diversity of habitat, including important spawning and rearing habitat for migratory fish species such as American shad.

No studies have been conducted to assess the adequacy of the existing bypass flow protocol, or to evaluate the effect of peaking operations on instream and littoral habitat in the reach of river downstream of the Cabot tailrace. The Service herein submits study requests intended to address these information gaps.

Terrestrial Wildlife and Botanical Resources
Wetland, Riparian, and Littoral Habitat
Critical Habitat and Threatened and Endangered Species

FirstLight proposes to conduct a baseline inventory of botanical resources in the Turners Falls impoundment, bypass reach, and below Cabot Station. The inventory would include documenting wildlife and vegetative resources (including rare, threatened, endangered, and invasive species) in littoral, riparian, wetland and upland habitats. As noted above, the Service supports this study and is submitting a request to that effect.

5.3 Comprehensive Waterway and Resource Management Plans

In the PAD, FirstLight identifies 18 federal plans recognized by the Commission as Comprehensive Waterway Development Plans. In addition to those plans, the Service hereby submits the following plan to the Commission for consideration in determining whether it qualifies as a comprehensive plan pursuant to Section 10(a)(2)(A) of the Federal Power Act (Attachment A):

Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

If the Commission determines that the plan identified above does not qualify as a comprehensive plan, we request that it be considered as a relevant resource management plan.

ADDITIONAL INFORMATION

The following information is needed:

- the minimum hydraulic capacities, runner diameters and speeds of the turbines at Station No. 1 and Cabot Station;
- the "lower reservoir" pool elevation that was used to calculate the approach velocity at the NMPS intake trashrack;
- a more thorough description of how project operations are monitored and recorded;
- the linear length of the Turners Falls impoundment so that the agencies can determine the distance of free-flowing river downstream of the Vernon Dam;[1]
- hourly data (water surface elevations, dam discharge, generation, and pumping data) from both projects (three stations) in spreadsheet format for the past five years; and
- updates to the figures in Appendix E of the PAD to include additional information relevant to a particular location (e.g., overlay gate discharge and Station No. 1 generation data on the bypass reach graphs; overlay Cabot Station and/or Station No. 1 generation data on the below-Cabot graphs, etc.).

RECOMMENDED STUDIES

The Applicant already has undertaken a mussel survey and water level monitoring effort. In addition, FirstLight is proposing to conduct a number of studies, including water quality monitoring, an instream flow assessment, and a baseline wildlife and botanical resources inventory. Enclosed please find our formal study requests (Attachment B) in the format required pursuant to 18 CFR §4.38(b)(5).

[1] The Service is aware that FirstLight has collected data that indicate the Turners Falls pool does not extend up to the base of the Vernon Dam (as originally thought).

SCOPING DOCUMENT 1

3.6.3 Project Decommissioning

The Commission proposes to eliminate this alternative from detailed study in the environmental analysis, because no party has suggested project decommissioning would be appropriate in this case. The Commission asserts that there would be significant costs involved with decommissioning the project, including lost energy production.

We recommend that the Commission include project decommissioning in the environmental analysis. We note that while no party has suggested this alternative, up to this point in the Integrated Licensing Process, there has been no formal opportunity to provide such a recommendation. Further, the Commission has supplied no supporting information to justify the contention of significant decommissioning costs (which could run the gamut from "locking the door" to full dam removal at the Turners Falls Project, and from sealing the intake to draining and filling the upper reservoir at NMPS); and given the substantial increase in the numbers of proposed renewable energy projects, it is possible that there may be no net loss of energy production when viewed on a regional basis. Also, we are requesting a number of studies to understand the impacts of the NMPS project. Study results could identify impacts that either cannot be mitigated or would be prohibitively expensive to mitigate. In light of that possibility, decommissioning of the NMPS project should be retained as a potential alternative that the Commission may need to address.

4.1.2 Geographic Scope

The Service recommends that the geographic scope of the Commission's environmental analysis of the impacts to cumulatively affected fishery, water quantity and water quality resources extend from the upstream extent of the Wilder Project impoundment, downstream to Long Island Sound. For terrestrial resource issues, the geographic scope should be from the upstream extent of the Turners Falls Project impoundment to the upstream extent of the Holyoke headpond (i.e., the "impact" zone of the current peaking operation). For threatened and endangered species, the geographic scope should be from the Turners Falls Dam to the Holyoke Dam.

4.3.3 Aquatic Resources

Effects of project facilities and operations on fish migration should be analyzed cumulatively as well as for individual projects.

Effects of entrainment should not be limited to fish populations, but should include impacts to food web interactions and overall ecosystem productivity.

The annual drawdown of the Turners Falls canal should be included as an issue to analyze (i.e., effects of the canal drawdown on migratory and resident fish, herptiles and benthic invertebrates).

4.3.5 Threatened and Endangered Species

The federally threatened puritan tiger beetle (*Cicindela puritan*) should be included as a species to be analyzed. While the tiger beetle does not occur within the Turners Falls project boundary, flow releases from the project do affect water surface elevations, which in turn affect the beetle's habitat on Rainbow Beach in Northampton, Massachusetts.

Thank you for this opportunity to comment. If you have any questions regarding these comments, please contact John Warner of this office at (603) 223-2541.

Sincerely yours,

Thomas R. Chapman
Supervisor
New England Field Office

Attachments

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cc: FERC, Secretary (w/att)
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ATTACHMENT A

Comprehensive Waterway Development Plans

Atlantic States Marine Fisheries Commission

ADDENDUM II TO THE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL

ASMFC Vision Statement:
Healthy, self-sustaining populations for all Atlantic coast fish species or successful restoration well in progress by the year 2015.

Approved October 23, 2008

INTRODUCTION

The Atlantic States Marine Fisheries Commission's American Eel Management Board initiated the development of Addendum II in January 2007 to propose measures that would facilitate escapement of silver eels during or just prior to their spawning migration as a means to improve American eel recruitment and abundance. Although the available data for American eel in the U.S. have not been sufficient to perform a reliable quantitative assessment of the population size or fishing mortality rates (ASMFC 2001, 2006), there has been evidence that the stock has declined and is at or near low levels (ASMFC 2000, 2001, 2006; USFWS 2007). The Management Board asked the Technical Committee (TC) and Advisory Panel (AP) to consider closed seasons, gear restrictions, size limits or a combination of these measures to reduce the harvest of emigrating eels. The public comment draft of Addendum II proposed these management measures, as well as recommendations for increased protection of American eels during their upstream and downstream migration.

This Addendum recommends stronger regulatory language to improve upstream and downstream passage of American eel to state and federal regulatory agencies. As such, there is no implementation schedule and there are no new compliance requirements. Member states are still required to submit annual compliance reports by September 1. This Addendum does not alter any other provisions from the Interstate Fishery Management Plan (FMP) and makes no changes to Addendum I to the FMP.

Background

The American eel occupies fresh, brackish, and coastal waters along the Atlantic from the southern tip of Greenland to northeastern South America. The species is catadromous, spending the majority of life in freshwater, but migrating to the Sargasso Sea to spawn. Newly hatched eels drift on oceans currents, eventually entering nearshore areas where they migrate up-river. Therefore, a comprehensive eel management plan and comprehensive set of regulations must consider the various unique life stages and the diverse habitats used, in addition to society's interest and use of this resource.

American eel (*Anguilla rostrata*) occupy a significant and unique niche in the Atlantic coastal reaches and its tributaries. Historically, American eel were very abundant in East Coast streams, comprising more than 25 percent of the total fish biomass. Eel abundance declined from historic levels but remained relatively stable until the 1970s. More recently, fishermen, resource managers, and scientists postulated a further decline in abundance based on harvest information and limited assessment data. This resulted in the development of the Atlantic States Marine Fisheries Commission FMP for American Eel. The goals of the FMP are:

1. Protect and enhance the abundance of American eel in inland and territorial waters of the Atlantic States and jurisdictions and contribute to the viability of the American eel spawning population; and
2. Provide for sustainable commercial, subsistence, and recreational fisheries by preventing overharvest of any eel life stage.

In support of these goals, the following objectives were included in the FMP:

- Improve knowledge of eel utilization at all life stages through mandatory reporting of harvest and effort by commercial fishers and dealers, and enhanced recreational fisheries monitoring.
- Increase understanding of factors affecting eel population dynamics and life history through increased research and monitoring.
- Protect and enhance American eel abundance in all watersheds where eel now occur.
- Where practical, restore American eel to those waters where they had historical abundance but may now be absent by providing access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel.
- Investigate the abundance level of eel at the various life stages, necessary to provide adequate forage for natural predators and support ecosystem health and food chain structure.

Status of the Stock

Current stock status (i.e., overfished or not overfished) for American eel is poorly understood due to limited and non-uniform stock assessment efforts and protocols across the species' range. No range-wide estimate of abundance exists and reliable indices of abundance of this species are scarce. Information on demographic structure is lacking and difficult to determine because the American eel is a single population (termed *panmixia*) with individuals randomly spread over an extremely large and diverse geographic range, with growth rates and sex ratios environmentally dependent. At present, limited data (fishery-dependent and independent) from indirect measurements (harvest by various gear types and locations) and localized direct stock assessment information are collected.

In 2003, declarations from the International Eel Symposium (AFS 2003, Quebec City, Quebec, Canada) and the Great Lakes Fishery Commission (GLFC) highlighted concerns regarding the health of American eel stock. Canada has recently applied the "Special Concern" designation to American eel. Available data attributes the population drop to decreasing recruitment combined with localized declines in abundance. This information is cause for concern and represents an opportunity for cooperation with other entities such as the GLFC to preserve the American eel stock.

The most recent peer reviewed stock assessment was presented to the Commission's American Eel Management Board in February 2006. The stock assessment did not meet some of the terms of reference according to the Terms of Reference and Advisory Report to the American Eel Stock Assessment Peer Review (ASMFC 2006). In May 2006, the Board tasked the American Eel Stock Assessment Subcommittee (SASC) with following up on specific recommendations in the peer review report to improve the 2005 stock assessment. The SASC follow-up to the Terms of Reference and Advisory Report to the American Eel Stock Assessment Peer Review was presented to the Board in October 2006. This report was inconclusive regarding the status of the stock. In their follow-up report, the SASC created a coastwide index for American eel using yellow eel indices that are monitored along the Atlantic Coast, both in the United States and Canada, and combing them with General Linear

Modeling (GLM). The SASC's report included a suggestion that the coastwide yellow eel GLM index could be used as a management trigger and would be a means to monitor coastwide, yet act locally.

In reaction to the extreme declines in eel abundance the Saint Lawrence River-Lake Ontario portion of the species' range, the Commission requested in 2004 that the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) conduct a status review of American eel. In February 2007, the USFWS announced the completion of a Status Review for American eel. The report concluded that protecting eel as an endangered or threatened species is not warranted. The USFWS did note that while the species' overall population is not in danger of extinction or likely to become so in the foreseeable future, the eel population has "been extirpated from some portions of its historical freshwater habitat over the last 100 years…[and the species abundance has declined] likely as a result of harvest or turbine mortality, or a combination of factors" (50 CFR Part 17).

Following the 2005 stock assessment, Terms of Reference and Advisory Report to the American Eel Stock Assessment Peer Review, and Stock Assessment Subcommittee's 2006 report, the Board initiated this Addendum to consider management options to halt the current decline in yellow eel abundance.

Status of the Fishery

American eel currently support important commercial fisheries throughout their range. Fisheries are executed in rivers, estuaries, and ocean. Commercial glass eel harvest is legal in Maine and South Carolina, although reported landings are minimal in South Carolina. Yellow and silver eel fisheries exist in all states and jurisdictions with the exception of Pennsylvania and the District of Columbia. South Carolina and Georgia recorded no commercial yellow or silver eel landings in 2007.

Commercial

Commercial landings decreased from a high of 1.8 million pounds in 1985 to a low of 641,000 pounds in 2002. Landings of yellow and silver eel in 2007 totaled 834,500 pounds.[1] New Jersey and Delaware each reported landings over 100,000 pounds of eel and Maryland reported landings over 300,000 pounds in 2007. Combined, these three states accounted for 73% of the coastwide commercial landings. Massachusetts, Pennsylvania, Georgia, Florida, and the District of Columbia were granted *de minimis* status for the 2007 commercial fishing year. De *minimis* is approved if a member states' commercial landings of yellow and silver eel for the previous year is less than 1% of the coastwide landings for the same year. Additionally, member states must request *de minimis* status.

Recreational

Few recreational anglers directly target eel and most landings are incidental when anglers are fishing for other species. Eel are often purchased by recreational fishermen for use as bait for larger sport fish such as striped bass, and some recreational fishermen may catch their own eel to utilize as bait. The NMFS Marine Recreational Fisheries Statistics Survey (MRFSS)

[1] Harvest data for 2007 comes from the 2008 State Compliance Reports. The landings are preliminary and some are incomplete.

shows a declining trend in the catch of eel during the latter part of the 1990s. According to MRFSS[2], 2007 recreational total catch was 140,372 fish, which represents a 63% increase in number of fish from 2006 (86,024 fish). About 59% of the eel caught were released alive by the anglers. MRFSS 2007 total recreational harvest was 57,986 fish.

For current commercial and recreational regulations for American eel by state, please see Appendix I.

STATEMENT OF THE PROBLEM

While the status of the American eel stock is uncertain, the latest stock assessment information indicates that the abundance of yellow eel (a juvenile life stage) has declined in the last two decades and the stock is at or near low levels. Further, relative abundance is likely to continue to decline unless mortality decreases and recruitment increases. The American Eel Management Board directed the American Eel Plan Development Team (PDT) to develop potential management measures for American eel that would facilitate an increase in the number of adult American eel (also known as silver eel) that are able to move from fresh and estuarine water to the ocean—also known as out-migrate—and spawn. The recommended management measures included gear and size restrictions, seasonal closures, and a recommendation to protect the upstream and downstream migration of American eel.

The Board initiated this Addendum based on a concern for the American eel population and sought public comment on measures that would facilitate escapement of silver eel on their spawning migration with the intent of halting any further declines in juvenile recruitment and eel abundance. The Board chose not to implement any additional restrictions on the fishery at this time and requested that a new stock assessment be initiated to better understand the stock status. The primary objective of this document is to recommend stronger regulatory language to improve upstream and downstream passage of American eel to state and federal regulatory agencies.

PROPOSED MANAGEMENT OPTIONS from the PUBLIC COMMENT DRAFT of ADDENDUM II

Gear restrictions, size limits, and seasonal closures employed individually or in combination can protect out-migrating silver eels by allowing more silver eel to reach the Sargasso Sea and spawn. American eel larvae and glass eel recruit to estuaries and freshwater at random; it is predicted that increased escapement from any part of the species' range has the potential to benefit the species throughout the entire range. While operating under the theory that allowing more silver eel to escape will result in increased juvenile recruitment, the PDT recognizes that several factors can influence the amount of silver eels that are allowed to out-migrate, including:

1. The time duration in which silver eel out-migrate;

[2] MRFSS Data for American Eel are unreliable. 2007 Proportional Standard Error (PSE) values for recreational harvest in Massachusetts, Rhode Island, New Jersey, Delaware, Virginia, and South Carolina are 100, 84.3, 70.2, 100.4, 100 and 100 respectively.

2. The portion of the out-migration period that is covered by the closed season;
3. The maximum size eel that gear can catch;
4. The maximum size eel that harvesters are allowed to possess.

The Board chose to delay action on commercial fishery management measures in order to incorporate the results of the upcoming stock assessment, which will present new and updated information on American eel stock status, including the long-term young-of-the-year index being conducted by the states. In addition, the Board received substantial public comment and advice from its Advisory Panel that further restrictions on American eel harvest would significantly impact fishermen. The states will revisit management measures upon completion of the American eel stock assessment.

RECOMMENDATIONS FOR IMPROVING UPSTREAM AND DOWN STREAM PASSAGE OF AMERICAN EEL

There are multiple factors that influence the American eel population across its range, as well as factors that influence their local abundance. Such factors include barriers to upstream and downstream migration, loss of habitat, and natural oceanographic conditions. On the Atlantic and Gulf coasts, 33,663 dams potentially hinder American eel movement. Of these dams, 1,511 (4.5 percent) are for hydropower (50 CFR Part 17).

Recommendations for Federal Energy Regulatory Commission Relicensing
The Commission recognizes that many factors influence the American eel population, including harvest, barriers to migration, habitat loss, and natural climatic variation. The Commission's authority, through its member states, is limited to controlling commercial and recreational fishing activity; however, to further promote the rebuilding of the American eel population, the Commission strongly encourages member states and jurisdictions, as well as the U.S. Fish and Wildlife Service, to consider and mitigate, if possible, other factors that limit eel survival. Specifically, the Commission requests that member states and jurisdictions request special consideration for American eel in the Federal Energy Regulatory Commission relicensing process. This consideration should include, but not be limited to, improving upstream passage and downstream passage, and collecting data on both means of passage.

Recommendations for Improving American Eel Passage at Non-Federally Licensed Dams
Of the 33,663 dams located on the Atlantic and Gulf Coasts that potentially hinder American eel movement, 95% are not licensed by the federal government. Therefore, the states should strive to remove these obstructions where feasible. If removal is not feasible, then upstream and downstream passage should be improved to provide access to inland waters for glass eel, elvers, and yellow eel and adequate escapement to the ocean for pre-spawning adult eel consistent with the goal of the FMP.

APPENDIX I

Table A1. Commercial Regulations by State*

State	Size Limit	License/Permit	Other
ME		· Harvester and dealer license · Dealer reporting	· Seasonal closures · Gear restrictions
NH	6"	· Commercial saltwater license · Coastal harvest permit · Monthly trip level catch & effort reporting of harvest	· 50/day for bait · Gear restrictions in freshwater
MA	6"	· Commercial permit with annual catch report requirement · Registration and reporting for all eel buyers	· Nets, pots, spears, and angling only · Mesh restrictions · Coastal towns may have additional requirements
RI	6"	· Commercial fishing license required for the sale of American eel · Quarterly reporting	
CT	6"	· Commercial license with dealer reporting	· Gear restrictions
NY	6"	· Commercial harvester and dealer license and harvester reporting	· Gear restrictions
NJ	6"	· License required · Monthly reporting for eel pot license	· Gear restrictions
PA		· No commercial fishery	
DE	6"	· License required · Monthly reporting with catch and effort	· Commercial fishing in tidal waters only
MD	6"	· Licensed required with monthly reporting.	· Prohibited in non-tidal waters · Gear restrictions · Commercial crabbers 50 eel pots/day max no harvest limit
DC		· No commercial fishery	
PRFC	6"	· Eel license · Harvester weekly reporting w/daily effort	· Gear restrictions
VA	6"	· License with two-year delayed entry system · Mandatory monthly reporting (at trip level)	· Mesh size restrictions on eel pots
NC	6"	· Standard Commercial Fishing License for all commercial fishing	· Mesh size restrictions on eel pots · Bait limit of 50 eels/day
SC		· Permits by gear and area fished · Mandatory monthly reporting · License for all commercial fishing and sale	· Various gear restrictions
GA	6"	· Personal commercial fishing license and commercial fishing boat license · Harvester/dealer reporting required	· Gear restrictions on traps and pots
FL		· Commercial fishing license · Mandatory permit for all commercial eel harvesters · Mandatory trip and monthly sales summary reporting for permittees	· Gear restrictions

* For specifics on licenses, gear restrictions, and area restrictions, please contact the individual state.

Table A2. Recreational Regulations by State*

State	Size Limit	Possession Limit	Other
ME	6"	50 eels/person/day	· Gear restrictions · License requirement and seasonal closures (inland waters only)
NH	6"	50 eels/person/day	· Coastal harvest permit needed if taking eels other than by angling · Gear restrictions in freshwater.
MA	6"	50 eels/person/day	· Nets, pots, spears, and angling only · Mesh restrictions · Coastal towns may have additional requirements
RI	6"	50 eels/person/day	
CT	6"	50 eels/person/day	
NY	6"	50 eels/person/day	· Additional length restrictions in specific inland waters
NJ	6"	50 eels/person/day	
PA	6"	50 eels/person/day	· Gear restrictions
DE	6"	50 eels/person/day	· Two pot limit/person
MD	6"	No possession limit in tidal areas (hook & line); 25/person/day w/10 eel pot max for rec. crabber in tidal; 25/person/day in non-tidal	· Gear restrictions
DC	6"	10 eels/person/day	· Five trap limit
PRFC	6"	50 eels/person/day	· Recreational license
VA	6"	50 eels/person/day	· Recreational license, no reporting · Recreational commercial gear license, annual report required · Two eel pot limit (both licenses) · Mandatory annual catch report for eel pot license · Mesh size restrictions on eel pots
NC	6"	50 eels/person/day	· Gear restrictions · Noncommercial special device license, allowed two eel pots under Recreational Commercial Gear license
SC	None	None	· Gear restrictions
GA	None	None	
FL	None	None	· Mesh size and funnel opening restrictions on eel pots

* For specifics on licenses, gear restrictions, and area restrictions, please contact the individual state.

ATTACHMENT B

Study Requests

FirstLight Study Request #1

Model River Flows and Water Levels Upstream and Downstream from the Turners Falls Project and Integrate Project Modeling with Upstream and Downstream Project Operations

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Develop a river flow model(s) that is designed to evaluate the hydrologic changes to the river caused by the physical presence and operation of the Turners Falls Hydroelectric Project and the interrelationships between the operation of all five hydroelectric projects up for relicensing (i.e., P-1889 Turners Falls Hydroelectric Project, P-2485 Northfield Mountain Pumped Storage (NMPS), P-1904 Vernon Hydroelectric Project, P-1855 Bellows Hydroelectric Project, P-1892 Wilder Hydroelectric Project) and river inflows. The flow studies should assess the following topics:

1. Conduct quantitative hydrologic modeling of the hydrologic influences and interactions that exist between the water surface elevations of the Turners Falls Project impoundment and discharges from the Turners Falls Dam and generating facilities and the upstream and downstream hydroelectric projects. Data inputs to and outputs from the model(s) should include:

    a. withdrawals from the Turners Falls impoundment by NMPS;
    b. discharges to the Turners Falls impoundment by NMPS;
    c. discharges into the Turners Falls impoundment from the Vernon Project and other sources;
    d. existing and potential discharges from the Turners Falls Project generating facilities and spill flows;
    e. existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the Turners Falls impoundment and downstream flows from the project;
    f. existing and potential required minimum flows and/or other operation requirements at each of the four upstream projects; and
    g. minimum discharge flows ranging between 2,500 and 6,300 cfs in the bypass reach from April 15 through June 22 to support spawning, rearing, and outmigration of shortnose sturgeon at Rock Dam.

2. Document how the existing and potential outflow characteristics from the four upstream projects affect the operation of the Turners Falls Project, including downstream flow releases and Turners Falls impoundment levels.

3. Assess how the operation of the existing Turners Falls Project and upstream projects affect Holyoke Project (P-2004) operations, including:

a. how Turners Falls Project flow fluctuations affect Holyoke impoundment water levels, with emphasis on the influence of the water levels on federally listed Puritan tiger beetle habitat at Rainbow Beach in Northampton, Massachusetts, and assess what changes would be needed in Turners Falls operations to stabilize water levels at Rainbow Beach;
b. how Turners Falls Project operations affect Holyoke Project discharges and what changes in Turners Falls operations would be needed to reduce fluctuations in the discharges from the Holyoke Project.

4. To the extent predictable and practical, incorporate the potential effects of climate change on project operations over the course of the license.

Goals and Objectives

Determine the extent of alteration of river hydrology caused by operation of the project and the interactions between upstream project operations, Turners Falls operations and downstream operations at the Holyoke Project. The models will provide necessary information on what changes can be made to each of the five projects' flow releases and/or water levels restrictions, and how those changes affect downstream resources.

Specifically for the Turners Falls Project, continuous minimum discharge flows in its bypass reach need to be no less than 2,500 cfs during shortnose sturgeon spawning, rearing, and outmigration (April 15–June 22). Incorporating these parameters into the model will inform what changes, if any, need to be made to operations of upstream projects to accommodate such flows.

As other specific modifications of the operations of each of the projects are identified based on results of other requested studies, these desired conditions will need to be input into the models to assess how each change affects that project and other project operations and the implications of those changes on other resources and/or the ability to achieve desired operational changes at other projects.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.
3. Assist the Federal Energy Regulatory Commission to ensure that the continued operation of the facility is not likely to jeopardize the continued existence of shortnose sturgeon.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by project operations.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.
4. Ensure that project operations are not likely to jeopardize the continued existence of shortnose sturgeon.
5. Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing within the Montague spawning area (i.e., Rock Dam and Cabot Station spawning sites and associated early life stage rearing areas).

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a resource agency.

Existing Information

Available information in the PAD does not indicate how project operations have altered downstream hydrology, which may affect resident and migratory fish, macroinvertebrates, rare, threatened, and endangered species, aquatic plants and other biota and natural processes in the Connecticut River from below the Vernon Dam downstream to the Holyoke Dam.

Information in the PAD also does not reflect data analyzed in Kynard *et al.* 2012, which identifies minimum discharge thresholds for shortnose sturgeon spawning and rearing at the Rock Dam spawning site. Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period (April 27–May 22) (Kynard *et al.* 2012, chapter 3). In 1995 at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage sturgeon captured; spawning period was 17 days), even though no spawning was detected at Rock Dam (Kynard *et al.* 2012, chapter 3). Discharges in 1995 at Rock Dam had dropped below 2,500 cfs by March 26 (Kynard *et al.* 2012, chapter 3), indicating that even though 1995 saw the largest number of pre-spawning adults, none spawned at Rock Dam. This may indicate the need to have adequate flow well in advanced of spawning. Discharge reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning cite and not return even if flow increased to acceptable levels later during the spawning period. Researchers observed that

substrate did not change during fluctuating flows and thus cessation of spawning is likely due to velocities falling below the range preferred by gravid females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard *et al.* 2012, chapter 3). These data represent the best available scientific information and indicate that the current minimum flow thresholds at the project are not adequate for the protection of endangered shortnose sturgeon. All modeling efforts described above must incorporate the identified minimum flow and temporal parameters.

Nexus to Project Operations and Effects

The Turners Falls Project is currently operated with a seasonally varying minimum bypass flow (400 cfs from May 1 through July 15, then 120 cfs through the winter until river temperature rises to $\geq$ 7°C) and year-round minimum flow below the project of 1,433 cfs. The project operates as a daily peaking project, often with large, rapid, daily flow fluctuations between the minimum and project capacity (15,928 cfs) and fluctuations in headpond elevation (175' to 186' MSL). These changes affect biotic habitat and biota upstream and downstream of the project. Project operations and potential changes to operations to mitigate impacts are influenced by inflows and operations of upstream peaking projects and NMPS operations, and potential changes in operations of each project could affect the ability to achieve desired operational changes at other projects. Results of river flow analyses will be used to develop flow-related license requirements and/or other mitigation measures.

Methodology Consistent with Accepted Practice

River hydrology statistics and modeling are commonly employed at hydroelectric projects to assess implications of project operations on the river environment.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Level of effort and cost of model development are expected to be moderate, but to be valuable in developing license conditions, the model(s) will need to be run under various scenarios throughout the relicensing process to assess the implications of changes to the operations of each project on other projects and other resources. Therefore, ongoing consultation and re-running of the model(s) are likely to be needed throughout the relicensing process. The modeling exercise will also require coordination and cooperation between FirstLight and the upstream licensee to assure that the model inputs and outputs can be accurately related.

We would anticipate that the expected level of effort and anticipated costs will be comparable to those experienced on similar Federal Energy Regulatory Commission relicensing projects of this size (e.g., Conowingo, FERC No. 405).

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FirstLight Study Request #2

Instream Flow Habitat Assessment Downstream of Cabot Station
(Turners Falls, P-1889)

Conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species. The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, and white sucker.

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources from the Cabot tailrace of the Turners Falls Project downstream to the Route 116 bridge in Sunderland, Massachusetts. Specifically, the objective of the study is to conduct an instream flow habitat assessment of the impacts of a range of flows on the wetted area, and on the quantity and location of aquatic habitat for key species, including the impacts of hydropeaking flow fluctuations.

The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, white sucker and walleye.

For shortnose sturgeon, the flow study will need to evaluate bottom velocities in spawning and rearing areas during discharge conditions normally observed from April 15 to June 22. Protection of shortnose sturgeon spawning will necessitate establishment of discharges that create bottom velocities suitable for spawning and rearing over a sustained period of time and avoid dramatically fluctuating flows. To protect shortnose sturgeon rearing, adequate discharge without dramatic flow fluctuations is needed to ensure the rearing shoals are wetted and velocities are sufficiently protective for early life stage (ELS) rearing.

Field verification will be necessary to confirm the flow modeling results that identify the flows needed to provide sustained bottom velocities for spawning also maintain flows, depths, and water release regime adequate for spawning and rearing.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.

2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.

2. Provide an instream flow regime that meets the life history requirements of resident and migratory fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by project operations.

3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

4. Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a fish and wildlife resource agency.

Existing Information

Presently, FirstLight is required to release 1,433 cfs below the project. Information included in the PAD does not provide a detailed description of how this minimum flow was established and the Service is not aware of any previously conducted studies that evaluated the adequacy of this minimum flow in protecting aquatic resources in the 10+ miles of riverine habitat below the Cabot Station. Therefore, in order to fill this important information gap, an empirical study is needed to provide information on the relationship between flow and habitat in the Connecticut River downstream of the Cabot tailrace. Results will be used by the Service to determine an appropriate flow recommendation.

Kynard *et al.* (2012, chapter 3) examined the effects of water manipulation at the Turners Falls project on shortnose sturgeon spawning over the course of 17 years. This data does not support 1,433 cfs as an adequate minimum flow to support successful shortnose sturgeon spawning at

Cabot Station. Peaking operations at Cabot Station cause discharge fluctuations to rapidly change bottom velocities from 0.4 m/s to 1/3 m/s over 30 minutes (Kynard *et al.* 2012, chapter 3). Shortnose sturgeon have not evolved to adapt to such artificial rapid changes in velocities and therefore continue to spawn during fluctuations, even though conditions may be unsuitable and likely result in high egg mortality. During the 10 years when spawning succeeded at Cabot Station, discharge flow decreased to less than 35,460 cfs by April 29. The lowest discharge level observed while females remained on the spawning site was 4,700 cfs. Spawning behavior was not monitored during Cabot Station discharges at or below 3,500 cfs, so it is unclear what the minimum flow threshold is for spawning at Cabot Station. During naturally low flow periods, when water is held in storage for generation at a later time, tailrace shoals (including shoals along river banks), likely used by shortnose sturgeon ELS were exposed (observed during years 1995, 1998-1999, 2004) and may have resulted in ELS stranding and exposure mortality (Kynard et al 2012, chapter 3). Researchers observed that shoal exposure began when river flow below Cabot Station dropped below 7,062 cfs (Kieffer and Kynard 2007). Thus, total flow at Cabot, which may include flow from the Turners Falls Dam or Station 1, must be at least 7,062 cfs to both support adequate bottom velocities and prevent shoal exposure.

Furthermore, the emergency water control gates at Cabot Station that are used to sluice trash from the canal and balance canal flows spill large amounts of water. These large spill events create a plume of turbid turbulent flow, which cause some females to leave the area. These spill events scour bottom sediments which are then carried downstream over the spawning and rearing shoals where an entire year class of early life stages may be destroyed (Kynard *et al.* 2012, chapter 3). Information included in the PAD does not address adequate flows for shortnose sturgeon spawning and rearing. Results of the requested modeling will be used by the Service to determine an appropriate flow recommendation.

Researchers have also looked at suitable depth and velocity habitat for spawning (Kieffer and Kynard 1996; Kynard *et al.* 2012, chapter 3). Spawning sites are characterized by moderate river flows with average bottom velocities between 0.4 and 0.8 m/s (Hall *et al.* 1991, Kieffer and Kynard 1996; NMFS 1998). Water depth at the spawning site appears to be a less important habitat feature than substrate type and flow. A recent study by Kynard *et al.* (2012, chapter 6) demonstrated that females in an artificial stream will readily accept a shallow water depth of 0.6 m, with a rubble bottom, and 0.3–1.2 m/s bottom velocity. In addition, although eggs and embryos can likely tolerate very low depths, researchers measuring water depths between Turners Falls Dam and Cabot Station in order to recommend minimum flows suitable for an escape route for shortnose sturgeon trapped in the Turners Falls Dam plunge pool used a minimum depth of 1.5 x adult body depth. Because adults spawning in an artificial spawning channel frequently positioned themselves on top of one another (Kynard *et al.* 2012, Chapter 6), a minimum depth to facilitate spawning within the known Cabot Station spawning area is 3.0 body depths, or 19.2 inches.

Nexus to Project Operations and Effects

The project is currently operated with a minimum flow release that was not based on biological criteria or field study. Further, the project generates power in a peaking mode, resulting in significant within day flow fluctuations between the minimum and project capacity on an hourly

or daily basis. The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985; Blinn *et al.* 1995; Freeman *et al.* 2001). There are more than ten miles of lotic habitat below the project's discharge that are impacted by peaking operations at Cabot Station. This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for migratory fish such as American shad and federally endangered shortnose sturgeon. Shortnose sturgeon larval migrants initially become bottom dwellers and transition from living off of yolk sacs to orally feeding, which is a critical stage in their life history. While the existing license does require a continuous flow of 1,433 cfs below the project (0.20 cubic feet per second flow per square mile of drainage area - cfsm), that is equal to only 40 percent of the Aquatic Base Flow.[1] this flow does not sufficiently protect the aquatic resources, including endangered species, in this substantial reach of river, especially in the context of the magnitude, frequency, and duration of changes in habitat that likely occur between minimum and generation flows.

Results of the flow study will be used by the Service to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources below the project.

Methodology Consistent with Accepted Practice

Instream flow habitat assessments are commonly employed in developing plant operational regimes that will reduce impacts or enhance habitat conditions downstream of hydroelectric projects.

The Service requests a flow study be conducted at the project. Given the length of the river reach (10+ miles) impacted by project operations, we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[2]and has been accepted by the Federal Energy Regulatory Commission (Commission) in other licensing proceedings.[3]

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data along transects located in the reach of river below Cabot Station. The measurements should be taken over a range of test flows. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species identified by the fisheries agencies. Habitat modeling using standard PHABSIM one dimensional modeling is acceptable for the river channel downstream from the railroad bridge below the mouth of the Deerfield River. The area from the Cabot Station discharge to the railroad bridge should be modeled using two dimensional 2D modeling to better characterize flows and velocities in this complex channel area.

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[1] The Aquatic Base Flow equates to the August Median Flow as determined using unregulated hydrography or on drainage area at the project site (0.5 cfs per square mile of drainage area) if unregulated hydrography is unavailable.

[2] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

[3] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pp. 7-8, October 2007.

The types of data collected with this study should be sufficient to perform a dual-flow analysis and habitat time series or similar approaches that will permit assessment of how quality and location of habitat for target species changes over a range of flows between existing minimum flow and maximum project generation flows.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field work for instream flow studies can be reasonably extensive but will depend on consultation with the Applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-field work data analysis would result in a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to those experienced on similar Commission relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

REFERENCES

Blinn, W., J.P. Shannon, L.E. Stevens and J.P. Carder. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14: 233–248.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5: 330–339.

Freeman, M.C, Z.H. Bowen, K.D. Bovee and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11: 179–190.

Hall, W.J., T.I.J. Smith and S.D. Lamprecht. 1991. Movements and habitats of shortnose sturgeon *Acipenser brevirostrum* in the Savannah River. Copeia 1991:695-702.

Kieffer, M.C. and B. Kynard. 1996. Spawning of the shortnose sturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125:179-186.

Kieffer, M.C. and B. Kynard. 2007. Effect of Water Manipulation by the Turners Falls Dam Hydroelectric Complex on Rearing Conditions for Connecticut River Shortnose Sturgeon Early Life Stages. S.O. Conte Anadromous Fish Research Center, Turners Falls, MA.

Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

National Marine Fisheries Service (NMFS). 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

FirstLight Study Request #3

Instream Flow Habitat Assessment of the Turners Falls Bypassed Reach

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources in the bypassed reach between Turners Falls Dam and the Cabot Station discharge. Specifically, the objective of the study is to conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species.

Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, white sucker, freshwater mussels and benthic macroinvertebrates.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources within the Turners Falls bypassed reach, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide a flow regime in the bypassed reach that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels), federally listed species, and diadromous fishes.
3. Minimize the current negative effects of project operations on shortnose sturgeon spawning and rearing within known spawning areas of the bypassed natural river reach (i.e., the Rock Dam).
4. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as

amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requester is a natural resource agency.

Existing Information

The Turners Falls Project bypasses a 2.7-mile-long section of the Connecticut River. Presently, the only required spill releases from the Turners Falls Dam to the bypassed reach are 400 cfs from May 1 through July 15, and 120 cfs from July 16 until the river temperature reaches 7°C.

In addition to these flows provided at the Turners Falls Dam, the bypassed reach receives flow from one small tributary (the Fall River, drainage area of 34.2 square miles), which enters the mainstem approximately 0.16 mile below the dam. The bypassed reach also receives the discharge from Station 1, when it is generating (typically when there is flow in excess of Cabot Station's needs). This discharge enters the bypassed reach approximately 0.9 mile below the dam.

Available information in the PAD does not indicate how project operations have altered downstream hydrology, habitat quantity and quality, and water quality, which may affect resident and migratory fish, macroinvertebrates, listed species, aquatic plants and other biota and natural processes in the Connecticut River from below the Turners Falls Dam downstream to the Cabot Station discharge. The PAD also provides no detailed description of the physical or biological characteristics of the bypassed reach.

Limited information exists on the adequacy of the existing bypass flow regime to protect water quality and aquatic life. However, there is existing information (not included in the PAD) relative to minimum flows necessary for shortnose sturgeon spawning and rearing at the Rock Dam spawning site (Kynard *et al.* 2012). Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period of April 27 through May 22 (Kynard *et al.* 2012, chapter 3). In 1995, at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage sturgeon captured, and the longest spawning period of 17 days) even though no spawning was detected at Rock Dam (Kynard *et al.* 2012, chapter 3). Discharges in 1995 at Rock Dam had dropped below 2,500 cfs by March 26 (Kynard *et al.* 2012, chapter 3), which may indicate the need to have mitigated flow well in advance of spawning. Flow reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning site and not return even if flow later increased to acceptable levels. Researchers observed that the rubble substrates remained dominant during fluctuating flows, and cessation of spawning is likely due to velocities falling outside the range preferred by females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard *et al.* 2012, chapter 3). These data represent the best available scientific information and do not support current minimum flow thresholds at the project.

An empirical study is needed to provide information on the relationship between flow and habitat in the bypassed reach for the Service to use in determining a flow recommendation.

Nexus to Project Operations and Effects

The project includes a 2.7-mile-long bypassed reach. The Turners Falls Project is currently operated with a seasonally varying minimum bypass flow (200 cfs starting on May 1, increasing to 400 cfs when fish passage starts through to July 15, then reduced down to 120 cfs until river temperature drops below 7°C). The 400 cfs release is primarily to facilitate upstream movement of anadromous migrants to the spillway fish ladder at Turners Falls Dam, and the 120 cfs was intended to provide protection to shortnose sturgeon by maintaining a wetted habitat 1.5 times the maximum adult body depth through connections between pools within the bypassed reach. Neither of the currently required flows were based on quantitative, rigorous scientific studies.

This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for the federally endangered shortnose sturgeon. While the existing license does require seasonally varying flow releases from the Turners Falls Dam, we do not believe these flows sufficiently protect the aquatic resources, including endangered species, inhabiting the bypassed reach.

Results of the flow study will be used by the Service to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources in the bypassed reach for the duration of any new license issued by the Federal Energy Regulatory Commission (Commission).

Methodology Consistent with Accepted Practice

The Service requests a bypass flow study be conducted at the project. Bypass flow habitat assessments are commonly employed in developing flow release protocols that will reduce impacts or enhance habitat conditions in reaches of river bypassed by hydroelectric projects.

Given the size of the bypassed reach (2.7 miles long) and the important resources known to inhabit the reach (i.e., federally endangered shortnose sturgeon and diadromous fishes), we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[1] and has been accepted by the Commission in other licensing proceedings.[2]

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data within a range of discharge levels along transects located in the reach of river between the dam and the Cabot Station discharge. The measurements should be taken over a range of test flows up to 6,300 cfs or over a sufficient range of flows to model flows up to 6,300

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1 Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

2 Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pp. 7-8, October 2007.

cfs. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species/life stages identified by the fisheries agencies. Habitat modeling using standard PHABSIM one dimensional modeling is acceptable for the bypassed reach from the area downstream of the spillway where the river channel constricts to Rawsons Island upstream from the Rock Dam. The area from Rawson Island to the Cabot station discharge should be modeled using two dimensional 2D modeling to better characterize flows and velocities in this complex channel area. Likewise, we recommend 2D modeling in the spillway area and mouth of the Falls River to the point where the channel constricts, given this complex area with numerous potential flow discharge locations.

The flow study should incorporate the identified minimum flow and temporal parameters for shortnose sturgeon discussed in the Background and Existing Information section of this request.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field work for flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-field work data analysis would result in a moderate cost and effort. Field work associated with this study could be done in conjunction with the below-project instream flow study request. We anticipate that the level of effort and costs will be comparable to those experienced on similar Commission relicensing projects (e.g., the Glendale Project, FERC No. 2801).

REFERENCES

Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

FirstLight Study Request #4

Evaluate the Frequency and Impact of Emergency Water Control Gate Discharge Events and Bypass Flume Spill Events on Shortnose Sturgeon Spawning and Rearing Habitat in the Tailrace and Downstream from Cabot Station

(Turners Falls, P-1889)

This evaluation should directly address the impact of sediment disturbance and excessive velocities on habitat in the Cabot Station tailrace and downstream resulting from emergency water control gate discharge events and bypass spill events and effects of spill from the downstream fish bypass sluice on federally threatened shortnose sturgeon spawning and incubation.

Goals and Objectives

The goal of this study is to determine appropriate scenarios for operation of the emergency water control gates and bypass flume that will be sufficiently protective of shortnose spawning and rearing below Cabot Station from excessive water velocities and exposure to abrasive sediments dislodged and transported across spawning and rearing areas. Furthermore, avoidance or minimization of rapid fluctuations in flow is also a goal of this study applicable to the operations of the emergency water control gates and bypass flume.

The objective of the study will be to determine how often the emergency water control gates are operated to discharge large quantities of water and evaluate the impact of these events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot Station. Another objective is to understand the operation of the bypass flume that results in bypass flume spill events, and evaluate the impacts of these spill events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot station. Even when bottom velocities fall within the range optimum for shortnose sturgeon spawning, rapid fluctuations may result in sediment transport having a harmful impact on developing eggs and embryos.

Specific Objectives include:

1. Emergency water control gate discharge events

    a. Field verification during operation of the emergency water control gates during a range of spill and discharge conditions is necessary during years 2014 and 2015 if emergency water control gates will continue to be operated during shortnose sturgeon spawning and rearing (April 15–June 22).

1) Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the emergency water control gates that will avoid or minimize negative impacts to spawning and rearing habitat.

2. Bypass flume spill events

   a. Field verification during bypass flume spill events under a range of spill and discharge conditions is necessary during years 2014 and 2015 if bypass flume spill events continue to be a part of future project operations and will occur during shortnose sturgeon spawning and rearing (April 15-June 22).

      1) Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the bypass flume that will avoid or minimize negative impacts to spawning and rearing habitat.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Relative to this study request, the Service seeks to understand current emergency water control gate bypass flume operations and associated impacts to determine potential operation scenarios that avoid or minimize negative effects on shortnose sturgeon spawning a rearing.

Public Interest

The requestor is a natural resource agency.

Existing Information

The emergency water control gates are used to spill large amounts of water, and Cabot Station also spills water from the bypass flume (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). These large spill events created a plume of turbid turbulent flow, which caused some females to leave the area (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). Additional spill events were observed to scour bottom sediments which are then pushed downstream over, or deposited on spawning and rearing shoals where an entire year's class of early life stage sturgeon may be destroyed (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). Information included in the PAD does not address operation of the emergency water control gates or bypass flume and impacts on shortnose sturgeon spawning and rearing.

Nexus to Project Operations and Effects

The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985; Blinn *et al.* 1995; Freeman *et al.* 2001). One of the two critical shortnose sturgeon spawning and rearing areas in the Connecticut River is located within the Cabot Station tailrace and impacted by the project's discharges, including spill from the emergency water control gates and bypass flume. This section of the Connecticut River also contains habitat that supports important spawning and rearing areas for migratory fish such as American shad and American eel. Current operations of the emergency water control gates and bypass flume create flow dynamics that are not sufficiently protective of shortnose sturgeon spawning and rearing. Results of this study will be used by the Service to determine recommendations for operation of the emergency water control gates and bypass flume that will avoid or minimize sedimentation and improve bottom velocities that are sufficiently protective of shortnose sturgeon spawning and rearing.

Methodology Consistent with Accepted Practice

River hydrology modeling is commonly employed at hydroelectric projects to assess implications of project operations on the river environment. It is assumed that the planned hydrologic modeling can incorporate emergency water control gate operations and associated impacts. Thus, an additional model would not be required for this request.

Field assessment will be needed to collect sedimentation and bottom velocity data at the emergency water control gates and fish bypass sluice discharge areas to determine what operational scenarios of those structures avoid or minimize impacts to shortnose sturgeon spawning and rearing. Velocity gauges will be employed to collect data on bottom velocities associated with project operations at Cabot Station. Coordination of gauge placement for this request with the field measurements for the instream flow study should help minimize the number of necessary gauges. Field assessment of sedimentation may be collected using a variety of techniques. One potential method of collection of sedimentation data would be to set fine-mesh nets similar to shortnose sturgeon larval collection nets; these nets may show changes in the amount of dislodged substrate material that travels along the spawning site as a result of powerful releases at both the Cabot spillway and bypass flume.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field verification for this study request will likely be coordinated with other field work for related study requests. It is not expected that the required field work for this request will result in significant additional cost and effort beyond what is expected for field work related to the instream flow study request. Post-field work data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to that experienced on similar Federal Energy Regulatory Commission relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

REFERENCES

Blinn, W., J.P. Shannon, L.E. Stevens and J.P. Carder. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14: 233–248.

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Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

FirstLight Study Request #5

Impact of the Operations of the Turners Falls, Northfield Mountain Pumped Storage, Vernon and Bellows Falls Projects on Shad Spawning, Spawning Habitat, and Egg Deposition

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Conduct a field study of spawning by American shad in the Connecticut River mainstem downstream of Turners Falls Dam, in the Turners Falls Dam impoundment, in the Vernon Dam Project area, and downstream of Bellows Falls Dam to determine if project operations (including operations of the Northfield Mountain Pump Storage) (NMPS) negatively impact shad spawning behavior, spawning habitat use, areal extent and quality of those spawning areas, and spawning activity in terms of egg deposition in those areas.

Goals and Objectives

Determine if project operations (under the permitted and proposed operational ranges) affect American shad spawning site use and availability, spawning habitat quantity and quality, and spawning activity in the river reaches downstream from Cabot Station and in the project bypass reach of Turners Falls Dam, in the Turners Falls Dam impoundment, and in relation to NMPS operations, downstream and upstream of the Vernon Dam, and in the project area downstream of Bellows Falls Dam. The following objectives will address this request:

1. determine areas utilized by American shad for spawning by conducting nighttime visual observation of spawning activity, identify and define areas geospatially, and obtain data on physical habitat conditions affected by project operations (e.g., water depth, velocity, discharge, substrate, exposure and inundation of habitats);
2. determine project operation effects on observed spawning activity, under a range of permitted or proposed project operation conditions;
3. quantify effects (e.g., water velocity, depths, inundation, exposure of habitats) of project operation on identified spawning areas for a range of conditions, over the complete period of spawning activity; and
4. quantify spawning activity as measured by nighttime spawning/splash surveys and egg collection in areas of spawning activity, and downstream of these areas, to further determine project operation effects (location and extent of exposure from changing water levels and flows).

If it is determined that the project operations are adversely affecting the spawning activity of American shad and impacting spawning habitat, identify operational regimes that will reduce and minimize impacts to spawning habitat and spawning success. This study will require two years of field data to capture inter-annual variability to river discharge and water temperatures and to allow for evaluation of alternative flow regimes if year one studies determine that the present peaking regime negatively affects spawning.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 4 percent to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

1. to mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting instream flows;
2. natural river discharge should be taken into account when instream flow alterations are being made to a river (flow regulation) because river flow plays an important role in the migration of diadromous fish;
3. ensure that decisions on river flow allocation (e.g., irrigation, evaporative loss, out of basin water transport, hydroelectric operations) take into account instream flow needs for American shad migration, spawning, and nursery use, and minimize deviation from natural flow regimes; and
4. when considering options for restoring alosine habitat, include study of impacts and possible alteration of dam-related operations to enhance river habitat.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq.*), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764, and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad population, and numbers of shad passing Turners Falls and Vernon Dam have not met CRASC management plan objectives. Population number and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers over the last 10 years of 211,850. Since historically approximately half of the returning population of shad to the river passed upstream of Holyoke, recent returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

American shad broadcast spawn in congregations over shallow flats and rocky or sandy substrates (Mansuetti and Kolb 1953) at depths less than 10 feet and often far shallower with spawning fish swimming vigorously near the surface in a closely packed circle (Marcy 1972; MacKenzie *et al.* 1985). Fertilized eggs drift downstream until hatching (MacKenzie *et al.* 1985).

American shad are known to spawn downstream from the Turners Falls Project. Layzer (1974) identified six spawning sites from an area below the mouth of the Deerfield River (river mile 191.9) to river mile 161.7 below the Mill River in Hatfield, Massachusetts. Kuzmeskus (1977) verified 16 different spawning sites ranging from downstream of the Cabot tailrace to just upstream of the Holyoke Dam (river mile 87.1). The only parameter that all spawning sites had in common was current (Kuzmeskus 1977). The Service is not aware of any more recent studies that document whether these 16 sites are still viable spawning locations for shad. We are not aware of any studies that have determined American shad spawning habitat or spawning sites upstream of Vernon Dam to Bellows Fall Dam (historic extent of upstream range).

FirstLight Power conducted studies in the late spring and summer of 2012, and examined habitat conditions downstream of the Turners Falls Dam. The study documented that in low flow conditions, Cabot Station project operations produced fluctuations in water level elevations that

can range over 4 feet in magnitude (daily operation) at the USGS Montague Gage Station, to lower values of 2 to 3 feet at the Route 116 Bridge, Sunderland, Massachusetts (PAD). Similar short-term, limited monitoring in the upper Turners Falls Dam impoundment identified water level changes due to project operations that cyclically varied several feet on a sub-daily frequency.

Nexus to Project Operations and Effects

American shad are known to spawn at five locations downstream from the Turners Falls Project from an area below the mouth of the Deerfield River (river mile 191.9) and ten other locations downstream to river mile 161.7 below the Mill River in Hatfield (Layzer 1974; Kuzmeskus 1977).

Shad spawning is likely influenced by river flow, which fluctuates greatly due to the project's peaking mode of operation. These fluctuations may impact shad spawning activity by altering current velocities and water depth at the spawning sites. Effects on spawning behavior could include suspension of spawning activity, poor fertilization, flushing of eggs into unsuitable habitat due to higher peaking discharges, eggs dropping out into unsuitable substrate and being covered by sediment deposition, and/or eggs becoming stranded on dewatered shoal areas as peak flows subside.

While a number of shad spawning and egg deposition studies were conducted in the 1970s, that research was aimed at assessing the potential impact of developing a nuclear power station in the Montague Plains section of the Connecticut River. The Service is not aware of any studies being conducted to assess the relationship between spawning behavior, habitat use and egg deposition, and operations of the Turners Falls, NMPS, Vernon and Bellows Falls projects.

The Service is concerned that peaking operations may be altering spawning behavior and contributing to the failure of the Connecticut River shad population to meet management targets.

Methodology Consistent with Accepted Practice

The first year of study should examine known spawning areas downstream of the Turners Falls Dam project, to determine operation effects on shad spawning behavior, activity, and success. In areas upstream of Turners Falls Dam to the Bellow Falls Dam tailrace, the study should identify areas utilized for spawning by American shad. In the second year, should results from year one determine project operations affected spawning activity, access to habitat, or success downstream of Turners Falls Dam, an identical more detailed assessment (identified objectives) should be conducted in spawning areas upstream of Turners Falls Dam to the Bellows Falls Dam tailwater. Measures to reduce or eliminate any documented project operation impacts should be explored and evaluated in year two downstream of Turners Falls Dam.

The impacts to spawning behavior would best be studied by nighttime observations of actual in-river spawning behavior (Ross *et al.* 1993). Project discharge increases or decreases during actual observed spawning activity will provide empirical evidence of change in behaviors. The observational methodology should follow the protocol specified in Layzer (1974) and/or as described in Ross *et al.* (1993). The analysis should utilize the observational field data in

conjunction with operational data from the projects (station generation and spill on a sub-hourly basis). To assess the impacts of changes in generation flows, the study should include scheduled changes in project operation to ensure that routine generation changes that occur during the nighttime spawning period affect downstream spawning habitats selected for study while shad are spawning. Stier and Crance (1985) provide optimal water velocities during spawning to range between 1 to 3 ft/sec.

In areas used for spawning, the characteristics of those areas (e.g., location, depth, flow, substrate) should be recorded. The effect of project operations (discharge, water velocity, inundation and exposure) should be assessed. Drift nets will be used to collect eggs to quantify egg production before and after flow changes at the spawning site.

In the reaches above the Turners Falls Dam, nighttime observations of splashing associated with shad spawning should be done in each reach as sufficient numbers of shad are passed above each dam. Observations should be done regularly until the end of the spawning season. The use of radio-tagged adult shad from a separate study request will aid in this effort. An estimate of the total area used for spawning and an index of spawning activity should be recorded for each site.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Neither FirstLight nor TransCanada propose any studies to meet this need. Estimated cost for the study is expected to be moderate (up to $40,000) for each owner, with the majority of costs associated with field work labor.

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FirstLight Study Request #6

Telemetry Study of Upstream and Downstream Migrating Adult American Shad to Assess Passage Routes, Effectiveness, Delays, and Survival

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Vernon, P-1904)

Goals and Objectives

Assess behavior, approach routes, passage success, survival, and delay by adult American shad as they encounter the projects during both upstream and downstream migrations, under permitted project operations conditions, proposed operational conditions, and study treatment operational conditions at FirstLight Power's Turners Falls and Northfield Mountain Pumped Storage (NMPS) projects and TransCanada's Vernon Project. There are multiple fishways and issues related to both upstream and downstream passage success at the projects. Some of these issues at the Turners Falls Project are similar to and/or pertain directly to the NMPS and Vernon projects. Therefore, it is reasonable to address passage issues at all projects in a similar manner.

Telemetry Study - This requested study requires use of radio telemetry using both radio and Passive Integrated Transponder (PIT) tag types to provide information to address multiple upstream and downstream fish passage issues. The following objectives shall be addressed in these studies:

1. assessment of any migration delays resulting from the presence of the dam and peaking flow operations of the Turners Falls Project;
2. determine route selection and behavior of upstream migrating shad at the Turners Falls Project under various spill flow levels (e.g., movement to the dam, attraction to Cabot Station, attraction to Station 1 discharge, movement between locations, delay, timing, etc.). A plan and schedule for dam spill flow releases will need to be developed that provides sufficient periods of spill flow conditions, and various generating levels from Turners Falls #1 Station coupled with Cabot Station generation flows (e.g., treatments will require multiple days of consistent discharge). Evaluated spill flows should include flows between 2,500–6,300 cfs, which relate to bypass flows identified as providing spawning opportunities for shortnose sturgeon in the lower bypass reach at the Rock Dam (Kieffer and Kynard 2012). Sturgeon spawning and upstream shad passage occur concurrently;
3. assess near field, attraction to and entrance efficiency of the spillway ladder by shad reaching the dam spillway, under a range of spill conditions;
4. evaluate the internal efficiency of the Turners Falls spillway ladder;
5. continue data collection of Cabot Station ladder and gatehouse ladder efficiency, to include rates of approach to fishway entrances, entry into fishways, and passage through them, under different operational conditions that occur in these areas;
6. evaluate modifications to the Cabot Station and/or spillway fishways recommended by the U.S. Fish and Wildlife Service (Service) if they are implemented;

7. assess upstream migration from Turners Falls to the Vernon Dam in relation to NMPS's pumping and generating operations and Vernon Project peaking generation operations. Typical existing and proposed project operation alterations should be evaluated;
8. assess near field, attraction to and entrance efficiency of the Vernon Dam ladder;
9. assess internal efficiency of the Vernon Dam ladder;
10. assess upstream passage past Vermont Yankee's thermal discharge (also located on the west bank of the river 0.45 mile upstream of fish ladder exit);
11. assess upstream migration from Vernon Dam in relation to the peaking generation operations of the Bellows Falls Project. Typical existing and proposed project operation alterations should be evaluated;
12. determine post-spawn downstream migration route selection, passage efficiency, delays and survival related to the Vernon Project, including evaluation of the impact of the Vermont Yankee heated water discharge plume on downstream passage route, migrant delay/timing, efficiency and survival;
13. assess impacts of NMPS operations on up- and downstream adult shad migration, including delays, entrainment, and behavioral changes and migration direction shifts under existing and proposed project operations;
14. determine downstream passage route selection, timing/delay, and survival under varied project operational flows into the power canal and spill flows at Turners Falls Dam;
15. determine downstream passage route selection, timing/delay in the canal, Cabot Station fish bypass facility effectiveness, and survival of Cabot Station-bypassed adult shad that enter the Turners Falls canal system;
16. compare rates and or measures of delay, movement and survival, etc., among project areas or routes utilized (e.g., spill at dam vs. power canal) under the range of permitted and proposed conditions; and
17. utilize available data sets and further analyze raw data (e.g., 2003-2012 U.S. Geological Survey's Conte Anadromous Fish Research Center [Conte Lab] studies) where possible to address these questions and inform power analyses and experimental design.

Information to address all of these questions would rely on the tagging of upstream migrating adult shad at Holyoke Dam and releasing them to migrate naturally from Holyoke through the Turners Falls and Vernon projects and back downstream after spawning. Additional tagged individuals would likely need to be released farther upstream (Turners Falls canal, upstream of Turners Falls Dam, and upstream of Vernon Dam) to ensure that enough tagged individuals encounter project dams on both upstream and downstream migrations, that these individuals are exposed to a sufficient range of turbine and operational conditions to test for project effects, and to provide adequate sample sizes for statistically valid data analyses to address the many objectives listed. This study will require two years of field data collection to attempt to account for inter-annual variability in river discharge and water temperatures.

Evaluation of Past Study Data - In addition to collection and analysis of new telemetry data, substantial data has already been collected at Turners Falls from multiple years of passage assessments conducted for FirstLight by Conte Lab researchers, and there are also data from the 2011 and 2012 full river study conducted by the Conte Lab that address Turners Falls, NMPS and Vernon project migration and passage questions that have not yet been analyzed. These data include several million records each year from more than 30 radio telemetry receivers deployed

between Middletown, Connecticut and Vernon Dam. This data will provide substantial information free from the field data collection costs and therefore should be analyzed as part of this study. This data analysis should be completed in 2013 to help inform the design of subsequent field studies.

Evaluation of Methods to Get Shad Past Cabot Station for Spillway Passage at the Turners Falls Dam – The poor passage efficiency of the Cabot Station ladder, the first and most used fishway encountered by shad arriving at the Turners Falls Project, and at the entrance to the gatehouse ladder, which all Cabot Station fishway-passed fish must use, has resulted in very poor overall shad passage efficiency at the project. An alternative to passing fish at the Cabot Station is to install a fish lift at the dam that would put fish directly into the Turners Falls pool, thereby eliminating problems with the Cabot Station fishways, and the gatehouse fishway entrance and the variable passage efficiency of the gatehouse fishways. For this to be effective, attraction of shad to the Cabot Station discharge and associated delays would need to be overcome. It is possible that spillway flow releases coupled with behavioral measures at Cabot Station that dissuade shad from that tailrace could achieve this end. In order to assess the possibilities, we recommend the following study:

1. A literature search and desk-top assessment of the possible behavioral measures that could be effective in getting shad to pass Cabot Station tailrace and continue upstream to the dam.
2. Based on results of the desk-top assessment, possible evaluation of behavioral measures that are likely to be effective.
3. Field evaluation of the effect of different levels of spill at the dam that would induce fish to move past the Cabot Station into the bypass reach and up to the dam (as noted in Goals and Objectives).

In addition to passage success and delays at passage facilities, these studies would assess the impacts of project operations on migration passage delay, route, timing, injury, mortality, and passage structure attraction, retention, and success. Of particular interest will be fish behavior: during periods when project flow releases increase from the required minimum to peak generation flows, when they subside from peak generation to minimum flows, and in response to the operation of NMPS in pumping and generation modes.

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

Upstream Passage –

1. American shad must be able to locate, enter, and pass the passage facility with little effort and without stress.
2. Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
3. Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Passage –

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the least delay and best survival rate.

Based on the CRASC plan, the Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad movement and migration, the Service's goal is:

Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq.*), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a federal natural resource agency. Migratory species of fish are a trust resource for the Service due to their interjurisdictional movements. Protection and restoration of these fish is a key objective for the Service.

Existing Information

Passage of adult shad at the Turners Falls fishway complex has been the subject of intense study by the Conte Lab since before 1999. These studies have clearly demonstrated that passage through the existing fishways at the Cabot Station and spillway is poor (<10 percent in many years). Passage through the gatehouse fishway is better, but still rarely exceeds 80 percent, despite the short length of this ladder. In addition to poor passage for fish entering the ladders, shad that ascend the Cabot Station fishway experience extensive delays before entry into the gatehouse fishway. Shad that ascend spillway frequently fall back into the canal and are also subject to these upstream delays. A new entrance to the gatehouse fishway installed in 2007 led to dramatic improvements in passage out of the canal (from 5 percent to over 50 percent in 2011), but passage still falls well short of management goals. In addition, shad spend considerable time (up to several weeks) attempting to pass. These delays likely influence spawning success and survival. Adult shad, unable to pass the gatehouse fishway, experience similar delays in downstream passage, even after they have stopped trying to pass the gatehouse fishway. In addition, if there is no spill, all outmigrating shad that have passed upstream must enter the power canal and may be subject to delays exiting the canal.

During the course of these studies, a very large dataset has been compiled that could yield useful information for further improving passage of shad out of the canal in both the upstream and downstream directions. A unique feature of these data is a two-dimensional array covering the canal just downstream of the gatehouse fishway, documenting fine scale movements and occupancy of this zone. These data should be combined with computational fluid dynamics (CFD) and real-time hydraulic data to determine how canal hydraulics influence the ability of shad to locate and enter the fishway, and to identify modifications that are likely to lead to improvements in approach and entry rates. A separate CFD modeling study is requested that includes modeling of the gatehouse fishway entrance area at the head of the power canal.

In addition, whole-river shad telemetry studies performed in 2011 and 2012 will likely provide useful information and should be analyzed. These data should allow quantification of delay below Turners Falls, and could help guide studies requested above. Preliminary analyses of data through 2011 have been made available to FirstLight and the resource agencies (Castro-Santos and Haro 2005; Castro-Santos and Haro 2010).

The whole-river studies have also shown that, at least in 2011, most shad that pass Turners Falls rapidly progress upstream to Vernon Dam where extensive delays also occur. Data from the 2012 study are not available at this time, but Dr. Castro-Santos stated that similar patterns in upstream passage delay were noted in the data from both years (Dr. Theodore Castro-Santos, Conte Lab, personal communication). There are similar concerns relative to downstream passage

delays of spent shad, with existing unpublished telemetry data sets suggesting this is an issue within the Turners Falls canal.

Since the first year of operation of the Turners Falls upstream fishways (1980), an average of only 3.6 percent of American shad that passed upstream of the Holyoke Dam have successfully passed the Turners Falls Dam. The highest values for this metric has not exceed 11 percent, and are well below the noted CRASC Management Plan target range for this objective, noted earlier as 40-60 percent on a five-year running average.

Since the first year of operation of the Vernon Dam upstream fish ladder (1981), the percent passage of American shad annually passed at the Vernon Project compared to the number passed upstream of Turners Falls Dam (gatehouse counts) has averaged 39.4 percent, ranging from 0.42 percent to 116.4 percent (>100 percent due to a counting error at one or both facilities, unknown).

Nexus to Project Operations and Effects

Existing project operations (peaking power generation) and limited bypass flows have a direct impact on instream flow and zones of passage (migration corridors). Project flow releases affect passage route selection, entry into fishways, and create delays to upstream migration. Inefficient downstream bypasses can result in migration delays and increased turbine passage. Mortality of adult shad passing through these turbines is expected to be high (Bell and Kynard 1985). In addition, stresses associated with passage and delay may cause mortality as shad are unable to return to salt water in a timely manner. The project's upstream and downstream passage facilities need to be designed and operated to provide timely and effective upstream and downstream fish passage to meet restoration goals of passage to upstream habitat and maximize post-spawn survival. These factors are all critically important to the success of restoration efforts.

Methodology Consistent with Accepted Practice

Use of radio, including passive-integrated transponder (PIT) telemetry, is widely accepted as the best method to assess fish migratory behavior and passage success, and has been used extensively to assess migration and passage issues at Turners Falls, as well as other Connecticut River projects. These studies include one conducted in 2011 and 2012 by the Service and the Conte Lab, which has provided substantial information related to some of the issues identified here. The requested study will build and expand on the information collected over the past two years.

The study design must specify sample sizes, tag configurations and receiver configurations, to ensure that rates of entry and exit to the tailraces, fishways, downstream bypasses, and the bypassed reach can be calculated with sufficient precision to determine effectiveness of flow and ensonification treatments (separate study request). For project assessments at Turners Falls (e.g., Cabot Station, spillway and gatehouse ladder attraction and entry, route selection, operational effects), double-tagged (radio and PIT) shad will be required for release from Holyoke Dam. Additional shad must be released directly into the Turners Falls canal to adequately assess the

various project generation and fish passage operational and structural conditions likely to be encountered by shad.

A related request on CFD modeling in the Cabot Station tailrace, the upper power canal near the gatehouse fishway, and in the area around the entrance of the spillway ladder, will address related project operational effects that will also address identified objectives in this telemetry request. Shad captured at the Holyoke Project and tagged and released upstream of Turners Falls Dam, or tagged out of the gatehouse ladder, would help to ensure an adequate sample size to evaluate the impacts of the NMPS and Vernon projects on passage and delay.

Additional tagged shad are expected to be required for release upstream of the Vernon Dam to ensure adequate sample size to assess where shad spawn upstream of Vernon Dam (see separate study request), as well as to ensure that there is an adequate number of outmigrating spent adults to address downstream passage questions.

Existing information on captured, handled, tagged fish performance (e.g., percent that drop back, unsuitable for tracking) and factors such as timing of tagging and potentially transport, must all be carefully considered to ensure an adequate sample size of healthy (e.g., viable to characterize behavior, survival, etc.) tagged fish is available to address the many questions identified in this request (as supported by a statistical power analysis). Additionally, it will be important to ensure that an adequate number of tagged shad are available to address the downstream passage questions above, as expected losses of healthy tagged fish during upstream passage, natural mortality rates, and due to tagging-related effects are expected to reduce fish available for these assessments. The use of single PIT-tagged fish can help improve sample sizes, but will be of limited use to answer some of the passage questions we have identified.

Due to environmental variability, two years of study work will be necessary. A large array of stationary monitoring stations (radio and PIT) will be needed to address the issues identified among the project areas. A sufficient level of radio receiver and PIT reader coverage will be required, to provide an appropriate level of resolution, for data analyses, to answer these questions on project operational effects. The study will provide information on a variety of structural and operational aspects of fish migration, relative to route selection, timing, survival, and up- and downstream passage attraction, retention, delay, efficiency, survival as some examples at three projects (Turners Falls, NMPS, and Vernon). The use of video monitoring may also be utilized for specific study areas such as the spillway ladder to provide additional information on shad entrance activity, with the understanding of some data limitations associated with this approach (fish identification, water visibility).

In addition to the tagging studies, use of video monitoring of the spillway fishway would provide additional overall data on its efficiency as all shad attempting to pass could be monitored versus just those shad that have been tagged.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The requested study is extensive and will require a substantial effort and cost to capture, PIT tag, and radio tag a sufficient number of shad at the Holyoke Project to release at upstream locations. We are not aware of any other study technique that would provide project-specific fish behavior and migration information to adequately assess existing project operations and provide insight in possible alternative operations and measures needed to address observed negative impacts to fish migration success. Cost for the entire multi-project tagging, tracking and data analysis are expected to range from $400,000 to $500,000, based on past Turners Falls studies and the 2011 and 2012 shad telemetry studies. Video monitoring of the spillway fishway would add a modest cost to this study.

Due to the fact that tagged shad will move throughout the larger five project area, to varying degrees, there will be expected cost savings (e.g., radio tags) to both owner/operators, provided cooperation in study planning and implementation occurs.

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FirstLight Study Request #7

Use of an Ultrasound Array to Create Avoidance of the Cabot Station Tailrace by Pre-spawned Adult American Shad and Facilitate Upstream Movement to the Turners Falls Dam

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine if use of ultrasound is an effective behavioral mechanism to create avoidance of the Cabot tailrace area by upstream migrating adult shad. If not attracted to the Cabot Station discharge, shad may proceed upstream and pass the Turners Falls Dam via the fishway at the dam.

The objective of the study would be to establish a high frequency sound (ultrasound) array across the entire Cabot Station tailrace and determine the effect of the ensonified field on upstream and downstream migrating radio-tagged shad moving past Cabot Station. This would be accomplished by monitoring the movements and passage of shad, and the time shad spend in the tailrace area. If effective, this technology also may be applicable to the Turners Falls #1 Station discharge.

Resource Management Goals

In 1992, the Connecticut River Atlantic Salmon Commission (CRASC) developed a draft document titled: *A Management Plan for American Shad in the Connecticut River*. Management Objectives in the plan include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

Upstream Passage

1. American shad must be able to locate and enter the passage facility with little effort and without stress.
2. Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
3. Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Passage

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

Based on the CRASC plan, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to American shad movement and migration, the Service's goal is:

Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement, that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), the Federal Power Act (16 U.S.C. §791a, *et seq.*), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a federal natural resource agency.

Existing Information

The Turners Falls Project has two fish ladders that anadromous migrants must use to pass the project: one at the Cabot Station tailrace and one at the spillway. Both ladders have documented passage problems. Further, fish that are able to successfully swim up the Cabot Station ladder exit into the Cabot Station power canal and must successfully enter and ascend another fish ladder (gatehouse fishway) before entering the Turners Falls impoundment and continuing up the Connecticut River. Spillway ladder fish must also pass the gatehouse ladder to reach the impoundment. The gatehouse fishway also has well documented passage issues.

Many years of study and design changes at the gatehouse fishway have improved passage effectiveness of that facility, but overall passage through the Cabot and gatehouse fishways remains less effective than necessary to achieve management goals. A potential alternative to the current configuration of fishways at the project would be to cease using the Cabot ladder (thereby eliminating problems with that ladder and the need to pass the gatehouse ladder), and instead operate a single fish lift facility at the spillway. However, for this to be a viable option, one major issue would need to be resolved: false attraction to the Cabot Station tailrace discharge. Therefore, this study would attempt to determine if use of ultrasound technology would be an effective method to minimize false attraction to the tailrace discharge, while facilitating movement past the Cabot discharge and up to the spillway area without delay.

Much information exists about adult shad avoidance of ultrasound, and the adaptive significance seems related to avoidance of echolocation signals of predator bottlenose dolphins (Mann *et al.* 1997; 1998). These authors suggest shad can detect the echolocation clicks of dolphins up to 187 meters away. Further, in field trials in the early 1980s to develop a guidance system for downstream migrants in the first level canal of the Holyoke canal system, adult shad avoided, but were not well guided by an ultrasonic array. However, upstream migrants were guided well and even stopped entirely by the ensonified field (Kynard and Taylor 1984). Creating an ensonified field caused adult shad to leave their preferred location in the river upstream of trashracks at Holyoke Dam as long as the sound system was on.

Blueback herring also avoided the ultrasound field and behaved similarly to shad in the Holyoke Canal studies (Kynard and Taylor 1984). Acoustic barriers have been used for blueback herring on the Savannah River (Richard B. Russell Dam) and the Santee River (St. Stephen fish lift) in South Carolina, and on the Mohawk River in New York (Crescent Project, FERC No. 4678; Vischer Ferry, FERC No. 4679). Evidence from many studies that attempted to produce behavioral avoidance by adult shad strongly suggests that ultrasound is the most effective stimuli (Carlson and Popper 1997). Thus, the available evidence suggests that shad (and blueback herring) may be dissuaded from delaying at the tailrace of Cabot Station by installing and operating an ultrasound field.

In addition, one year of study on juvenile shad and blueback herring movements in the Holyoke canal (Buckley and Kynard 1985) and two years of study in an experimental flume (Kynard *et al.* 2003) found that juveniles did not exhibit an avoidance response to the same high frequency (162 kHz) that was avoided by adult shad and bluebacks at Holyoke.

Nexus to Project Operations and Effects

Given the poor performance of the upstream passage facilities at Turners Falls, studies to assess potential passage solutions are appropriate during relicensing proceedings. This study, coupled with the adult shad radio-telemetry study, can provide the information needed to select the best approach to resolve upstream shad passage at the project.

Methodology Consistent with Accepted Practices

Acoustic barriers have been used for blueback herring on the Savannah River (Richard B. Russell Dam) and Santee River (St. Stephen fish lift) in South Carolina, and on the Mohawk River in New York (Crescent Project, FERC No. 4678; Vischer Ferry, FERC No. 4679). This study would establish a high frequency sound (ultrasound) array across the entire Cabot Station tailrace and determine the effect of the ensonified field on upstream and downstream migrating shad moving through Cabot Station by monitoring shad behavior and the time that detected shad spend in the tailrace.

Shad tagged as part of the large-scale shad movement/migration telemetry study would be used to track shad movements through the Cabot Station area with the ultrasound system on versus off. Data would be analyzed to determine if ensonification is a successful deterrent mechanism (e.g., if shad spend less time in the tailrace when the area is ensonified relative to when it is not ensonified and whether shad move past Cabot Station to the spillway with limited delay).

Several businesses sell and operate ultrasound systems for fish avoidance. The use of these systems is world-wide at power production and water control facilities.

Level of Effort/Cost, and Why Alternatives Will Not Suffice

The level of effort/cost for the test will be low to moderate. Costs will be related to rental, installation, and operation of the ultrasound system, analysis of data, and production of a final report. The study could utilize the same test fish and monitoring equipment as the adult shad radiotelemetry study (although a few additional tracking stations may have to be installed in the Cabot Station tailrace).

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FirstLight Study Request #8

Three-Dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine the flow field conditions that exist in and around the fishway entrances, and upstream of both Turners Falls powerhouses (Station 1 and Cabot). The information from this request is meant to be coupled with data from the telemetry study such that a comprehensive understanding of fish behavior is developed.

The objective of this study is to develop a series of color contour maps of velocity magnitude at select discharges agreed upon by the resource agencies and the licensee. With respect to upstream passage, the results will show approach velocities and flow fields that may create a response in fish. This information can be coupled with telemetry data (from the requested shad telemetry study) and passage counts to understand which conditions are optimal for guiding migrating fish to the fishway entrances and for stimulating fishway entry.

With respect to downstream migration, the results will show velocities and flow fields in front of each powerhouse. At Cabot Station, the results will indicate to what degree, if any, flow directs downstream migrating fish towards the surface bypass weir. At Station 1, we will have an improved understanding of the magnitude of velocity in front of the turbine intakes.

Resource Management Goals

The management goals of this study request are to obtain information that will help assist in designing effective upstream fishways for upstream migrating trust species and to reduce impingement, entrainment and delay for downstream migrating fish. CFD models are a relatively cost effective way to analyze existing and future conditions. As such, changes in the amount of attraction water, changes in which turbines are operating, and which spillway gates are releasing water can all be examined. As stated, the results from this study are meant to be used along with the data generated from the telemetry study. The combined analysis from these two data sources can help assess which flow conditions are most advantageous for migrating trust species to enter the fishway under current and proposed conditions.

As for downstream migration of adult and juvenile shad, and adult eel, the results from the models will reveal flow magnitude and direction in front of each powerhouse. Given the limited information that currently exists on survival through Cabot and Station 1, our management goal is to direct as many downstream migrating fish as possible towards the uniform acceleration weir and downstream bypass. With respect to upstream passage, we want to maximize the number of fish that find and enter the fishway entrances.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a resource agency.

Existing Information and the Need for Additional Information

To date, no CFD modeled data exist in front of either fish ladder, nor do they exist in front of either powerhouse. Some preliminary modeling has been done downstream of the gatehouse, but changes to the gatehouse entrances would require updated modeling. It is our understanding that the licensee has worked with the firm Alden Research Laboratory, Inc., to develop a CFD model of the upper end of the power canal and that elevation survey data from the power canal also are available. Detailed two-dimensional movement data on shad are available from observations made between 2003 to 2005 and 2010 to 2012. By coupling and analyzing these two data sets, flow and fish movement, we believe this will have substantial benefits to our management efforts.

Nexus to Project Operations and Effects

The Turners Fall Project has direct impacts to upstream and downstream migrating shad and eel. When designing upstream passage structures, a site assessment is critical. The development of these models will give resource agencies valuable information into the hydraulic cues which may elicit a response from upstream migrants. For downstream passage, the U.S. Fish and Wildlife Service has approach velocity guidelines; the output from these models would inform the resource agencies under what conditions appropriate approach velocities are being met and when they are being exceeded

With respect to upstream migration, the auxiliary water system (AWS) plays a critical role in determining whether or not fish are attracted to the entrance. The results from this study would allow us to assess how well the AWS is performing and under what conditions it attracts the most fish.

With respect to downstream migration, the development of a CFD model under existing conditions also informs the design of future modifications and improves the survivability of downstream migrating shad and eel.

The CFD models for the spillway fishway and gatehouse fishway should be developed as part of year one studies and it would be preferable to have them completed prior to year one field studies in spring 2014. It would be useful to have the gatehouse area CFD modeling completed as soon as possible to begin comparing hydraulic conditions to the two-dimensional shad location data from prior studies. This analysis may provide information on adjustments to canal operations or structures that can subsequently be analyzed.

Understanding the entrance conditions of the spillway fishway under a range of spill conditions would be informative as we evaluate the spillway fishway entrances. If developed prior to the year one upstream shad telemetry studies, it would provide information on spill gate settings that would likely best achieve entrance and ultimately passage. Further work with the model after year one studies could evaluate changes in ladder entrance or spill conditions that could improve passage and be tested with year two telemetry, video and/or count data.

CFD modeling of the flows leading to the canal via the gatehouse and the Cabot Station and Number 1 Station forebays would have value in interpretation of year one downstream passage telemetry results, but would not need to be completed prior to the year one telemetry, downstream juvenile shad and downstream eel passage studies, as those studies will provide the context for how and where shad and eels are passing the project and how successful passage is. The CFD modeling could then be focused on the locations indicated as important based on the field studies and could assess changes to structures or operations that could be evaluated in the model. Promising alternatives could then be tested in year two studies.

Methodology Consistent with Accepted Practice

A three-dimensional CFD model has become an increasing common standard of analysis at hydro-electric projects around the nation. Within the northeast region, we have seen these types of models developed at the Holyoke (P-2004), Brunswick (P-2284), Shawmut (P-2322), Milford (P-2534) and Orono (P-2710) projects. We would expect to engage with the licensee in terms of determining the appropriate area and flows to be modeled. We expect that the spatial extent of the model at each study site will vary. Given the large number of ways that output from these models can be presented and the near infinite number of flows that could potentially be modeled, we would expect to consult with the licensee to reach agreed upon modeling efforts and scenarios to be examined.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost of developing, running and testing a CFD model can vary tremendously; one large variable in determining the cost is based on the amount of existing bathymetric data to which the Applicant currently has access. We roughly estimate that the cost of each CFD model could run as high as $50,000, assuming no bathymetric data currently exist. Proactive communication with resource agencies will reduce the cost and iterative effort. Given the level of effort that has occurred at other projects that have proposed to amend their license, we see the level of effort requested here as reasonable, given that the Applicant is seeking a renewal of its license.

FirstLight Study Request #9

Impact of Project Operations on Downstream Migration of Juvenile American Shad

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Conduct a field study of juvenile American shad outmigration in the Turners Falls impoundment and the power canal and at Turners Falls Dam, Station #1, and Cabot Station to determine if project operations negatively impact juvenile American shad survival and production.

Goals and Objectives

Determine if project operations affect juvenile American shad outmigration survival, recruitment, and production. The following objectives will address this request:

1. assess project operations effects of the Northfield Mountain Pumped Storage Project (NMPS) and Turners Falls Dam on the timing, orientation, routes, migration rates, and survival of juvenile shad;
2. determine the proportion of juvenile shad that select the gatehouse into the power canal versus the dam spill gates as a downstream passage route, under varied operational conditions, including a range of spill conditions up to full spill;
3. determine if there are any delays with downstream movement related to either spill via dam gates or through the gatehouse and within the impoundment due to operations (i.e., NMPS pumping and generation);
4. determine survival rates for juvenile spilled over/through dam gates, under varied operation conditions, including up to full spill during the annual fall power canal outage period;
5. determine the juvenile downstream passage timing and route selection in the power canal to Station 1, Cabot Station, and the Cabot Station log sluice bypass, and assess delays associated with each of these locations and with project operations (e.g., stockpiling in the canal);
6. based upon year one study results on route selection, determine the survival rate for juvenile shad entrained into Station 1; and
7. determine the survival rates for juvenile shad entrained into Cabot Station units.

If it is determined that the project operations are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects, identify operational solutions or other passage measures that will reduce and minimize these impacts within the project area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperatures, and variability in the timing and abundance of juvenile production and their outmigration timing, which may relate to spring, summer, and fall conditions. This study will complement the NMPS fish entrainment study request, which includes assessment of impacts to juvenile shad.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on juvenile American shad survival, production, and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq.*), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the Turners Falls Dam upstream fishways in 1980, American shad have had access to spawning and rearing habitat upstream of Turners Falls Dam. A number of modifications to the Turners Falls fishways have occurred since that time, with the numbers of adult shad passed at the gatehouse ladder (into Turners Falls Dam impoundment) reaching as much 60,089 in 1992, when a record 721,764 shad passed upstream of Holyoke Dam. However, since 1980, an average of only 3.6 percent of the adult shad passed upstream of Holyoke Dam subsequently have passed upstream of Turners Falls Dam, and this value has never exceeded 11 percent. This value is well below the CRASC 1992 Shad Plan objective of 40-60 percent passage from the previous dam. In addition, population number and passage numbers past Holyoke have declined substantially, with the average Holyoke passage number over the last 10 years being 211,850. Because historic data suggest that approximately half the returning adult shad to the Connecticut River pass the Holyoke Dam, recent adult returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management restoration goals for the Connecticut River, which extends to the Bellows Falls Dam. In 1990, FirstLight's predecessor, Northeast Utilities, CRASC and its member agencies, signed a Memorandum of Agreement on downstream fish passage to address both juvenile and adults at the Turners Falls and NMPS projects.

American shad broadcast spawn, with the highest spawning activity occurring in runs and lowest activity in pools and riffle/pools (Ross *et al.* 1993). Field research by Ross *et al.* (1993) in the Delaware River further noted that a combination of physical characteristics that seem to be avoided by spawning adults is slow current and greater depth. American shad year-class strength has been shown to depend on parent stock size and environmental conditions during the larval life stages (Crecco and Savoy 1984). Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski *et al.* 2003). One published study on the Connecticut River identified that juvenile shad outmigration began when declining autumn temperatures reached 19°C and peaked at 16°C (O'Leary and Kynard 1986).

Juvenile American shad production has been monitored upstream of the Vernon Dam and immediately downstream of that dam by Vermont Yankee Nuclear as part of an annual monitoring program using both boat electrofishing (since 1991) and beach seining (since 2000). Sampling of juvenile shad was also conducted by a contractor hired by Northeast Utilities in the Turners Falls impoundment in 1992. O'Donnell and Letcher (2008) examined juvenile shad early life history and migration upstream and downstream of Turners Falls Dam. Their study results led to the decision by the agencies to require earlier operation of downstream fishways to protect early season juvenile shad out-migrants (1 September prior to 2010, 15 August in 2010, and since 2011, 1 August).

Downstream juvenile clupeid passage studies at Turners Falls were conducted in the fall of 1991 which included the objectives of determining the percentage of juvenile shad and herring that pass via the bypass log sluice or that were entrained in the Cabot Station turbines, and related data (e.g., catch rates) were compared. The 1991 Downstream Clupeid Study did not assess survival rates for juveniles for either of these passage routes. The 1991 study report documented a higher rate entrainment into the project turbines (23.0 fish per minute) versus through the bypass sluice (11.6 fish per minute). It was concluded that only an estimated 54 percent (average bypass rate, weighted by estimated number bypassed) of the juvenile American shad approaching Cabot Station were bypassed via the log sluice. The range of the percent bypassed varied widely by date, between nearly 0 and 83 percent, with 'no clear explanation as to why." The report did not identify the percentage entrained into the turbines, but it can be reasoned to be substantial based on the data presented in the report, or assumed as the remaining balance (46 percent), as there were no spill events reported during this study, and therefore nowhere else for them to pass. It was further noted that entrainment rates for juveniles were consistently greatest for units 1 and 6 (ends), not uniform across all units. Although no concurrent bypass sampling occurred during the first entrainment sampling events, it was noted that "entrainment rates were relatively high during the end of September." Additional modifications have occurred over time without quantitative evaluation to improve downstream passage attraction and use to the bypass sluice, including lighting systems.

The 1994 Downstream Juvenile Shad Study report assessed juvenile shad survival from passage via the log sluice, reported to be 98 percent, based on tagged and recaptured fish (held for up to 48 hours). Scale loss (<20 percent) (22 of treatment fish) compared with scale loss of >20 percent (five of treatment fish) was examined and determined to occur in an overall total of 10 percent of study fish (adjusted by control fish data).

Nexus to Project Operations and Effects

Adult American shad passed upstream of Turners Falls Dam utilize upstream spawning habitat. Juvenile American shad production occurs in these habitats upstream of Turners Falls Dam on an annual basis. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the fishery agencies' target restoration population size.

The Service is not aware of any studies being conducted specifically designed to determine:

1. When are spill gates open at the Turners Falls Dam?
2. What proportion of juvenile outmigrant shad take that route of passage?
3. What is the rate of survival under a range of spill and gate configurations?
4. What is the timing, duration, and magnitude of juvenile shad outmigrants in summer and fall to the Turners Falls Dam and gatehouse?
5. Are there delays in migration/movement at the dam, gatehouse, Cabot Station, or Station 1?
6. For juveniles that enter the power canal, what proportion subsequently enter the Station 1 power canal?
7. As there are no downstream passage facilities at Station #1, and trash rack spacing is 2.6 inches, what is the survival rate of juvenile shad entrained at Station #1?

8. What is the rate of movement through the Turners Falls power canal, and what is the delay to juvenile shad outmigration, and the potential accumulation of juveniles in the canal (e.g., prior to the canal drawdown in September)?
9. What proportion of juvenile shad use the downstream sluice bypass versus the Cabot Station turbines under varied operational conditions, given that project operations may change (PAD notes possible increase in turbine capacity at Cabot)?
10. Based upon earlier facility studies (1991 Downstream Clupeid), a large proportion and number of juvenile shad are entrained into Cabot Station turbines. What are the associated impacts in terms of short-term and longer term survival and injury (i.e., scale loss)?

The Service is concerned that project operations may impact juvenile shad outmigration survival and is contributing to the failure of the Connecticut River shad population to meet management targets. In the PAD, proposed modifications include: Station 1 may be upgraded with new turbines; Station 1 may be closed; and/or the turbine capacity at Cabot may be increased. It is unclear how these scenarios will affect the questions identified in this request.

Methodology Consistent with Accepted Practice

The impact to juvenile shad outmigrants by project operations would be best studied by a combination of approaches, including hydroacoustic, radio telemetry, and turbine balloon tags. Project discharge over a full range of existing and, to the extent possible, potential future operational conditions at Station 1 and Cabot, at the dam (likely increased bypass reach flows in new license), and in relation to the gatehouse, should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through these areas, with hydroacoustic equipment for natural/wild fish evaluation. In addition, study fish should be collected and tagged (PIT, radio, other mark, balloon) to also empirically determine rates of survival for fish passed over or through the dam's gates, under varied operations, including up to full spill condition that occurs annually in the fall with the canal outage period. The understanding of the timing, magnitude, and duration of the wild fish outmigration will help inform the design, data/results, and assessment of tagged fish study. The release of tagged or marked fish (radio, PIT) upstream of the gatehouse induction into the power canal will provide data on concerns of delay and route selection to Station 1, Cabot Station downstream bypass, Cabot Station spill gates, and Cabot Station turbines. Additional hydroacoustic assessment at the Cabot Station forebay will provide information on wild/natural juvenile fish timing, magnitude, and duration to and through this area. Based upon year one study findings relative to the frequency, magnitude, and timing of juvenile American shad that end up in the forebay of Station 1, the determination of whether an entrainment survival study at that site is necessary will be made. Release sites for tagged fish will be determined based upon further consultation among the parties.

Radio-tagged juvenile shad will be released in areas upstream of the NMPS facility at multiple release locations, to determine operation effects on migration rates, route, orientation, entrainment, and survival, over a full range of permitted and operational conditions.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight does not propose any studies to meet this need. Estimated costs for the study are expected to be high, between $200,000 and $300,000, with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related field work labor.

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FirstLight Study Request #10

Shad Population Model for the Connecticut River

(Turners Falls, P-1889; Northfield Mountain, P-2485;
Bellows Falls, P-1855; Vernon, P-1904)

Develop an American shad annual step, mathematical simulation population model for the Connecticut River to quantify how project operations and potential restoration/mitigation measures impact the population of shad in the Connecticut River.

Goals and Objectives

The goal of the model is to assess impacts of both upstream and downstream passage at each of the Connecticut River projects and potential management options for increasing returns to the river.

Specific objectives include:

1. annual projections of returns to the Connecticut River;
2. a deterministic and stochastic option for model runs;
3. life history inputs of Connecticut River shad;
4. understanding the effect of upstream and downstream passage delay at projects;
5. calibration of the model with existing data;
6. analysis of the sensitivity of model inputs;
7. analysis of sensitivity to different levels of up- and downstream passage efficiencies at all projects; and
8. multiple output formats including a spreadsheet with yearly outputs for each input and output parameter.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem.
3. Maximize outmigrant survival for juvenile and spent adult shad.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a natural resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad populations, and numbers of shad passing Holyoke, Turners Falls and Vernon Dam have not met CRASC management goals.

Population and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers since 2000 of 229,876. Whole river population estimates have shown that approximately half of the returning population of shad pass upstream of Holyoke. Recent returns to Holyoke are far below management goals. Average passage efficiency of shad at Turners Falls (gatehouse counts) and Vernon since 2000 has been 3.1 and 20.4 percent, respectively. These too are well below the CRASC management goals.

Safe, timely and effective up- and downstream passage, along with successful spawning and juvenile production, are necessary to help achieve shad management goals for the Connecticut River.

Nexus to Project Operations and Effects

Existing project operations and fish ladder efficiencies have a direct effect on shad populations in the Connecticut River. Poor upstream passage efficiencies and delays restrict river access to returning shad. Fish unable to reach upriver spawning grounds may not spawn or have reduced

fitness or survival of young. Poor downstream passage survival and downstream passage delays affect outmigration and consequently repeat spawning, an important ecological aspect of the iteroparous Connecticut River shad population (Limberg *et al.* 2003).

The Service is concerned that poor passage efficiencies and delays at projects may be limiting access to upstream reaches of the river, altering spawning behavior, decreasing outmigration survival and contributing to the failure of the Connecticut River shad population to meet management targets (Castro-Santos and Letcher 2010).

Development of a population model will allow an assessment of individual project impacts on the population as well as the cumulative impacts of multiple projects. The model will allow managers to direct their efforts in the most efficient manner toward remedying the conditions that most impact the shad population.

Methodology Consistent with Accepted Practice

Population models are commonly used to assess anthropomorphic and natural impacts and are consistent with accepted practice. A model similar to this request was constructed for the Susquehanna River by Exelon (FERC No. 405). The model is constructed in Microsoft Access.

Specific parameters that would be included in the model:

1. upstream passage efficiency at Holyoke, Turners Falls (Cabot, gatehouse and spillway
2. ladders), Vernon fishways, and any impacts associated with Northfield Mountain Pumped Storage;
3. distribution of shad approaching the Turners Falls Project between the Cabot ladder and the spillway at the dam;
4. downstream passage efficiencies at Vernon, Northfield Mountain Pumped Storage, Turners Falls, and Holyoke projects for juveniles and adults;
5. entrainment at Mount Tom Power Plant and Vermont Yankee Nuclear Power Plant;
6. sex ratio of returning adults;
7. the proportion of virgin female adults returning at 4, 5, 6, and 7 years;
8. the proportion of repeat spawning females at 5, 6 and 7 years;
9. spawning success of females in each reach;
10. fecundity;
11. percent egg deposition;
12. fertilization success;
13. larval and juvenile in-river survival;
14. calibration factor to account for unknown parameters such as at sea survival;
15. options for fry stocking and trucking as enhancement measures;
16. start year and model run years;
17. start population;
18. rates of movement to and between barriers; and
19. temperature, river discharge, and other variables of influence to migration and other life history events.

The model should be adaptable to allow the input of new data and other inputs.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Neither FirstLight nor TransCanada have proposed any study to meet this need. Estimated cost for the study is expected to be low to moderate. As the model describes the impacts of multiple projects and two owners, both project owners would share the cost of model development.

REFERENCES

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA.

Castro-Santos, T. and B. H. Letcher. 2010. Modeling migratory bioenergetics of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous anadromous fish. Can.J.Fish.Aquat.Sci. 67: 806-830.

Limberg, K. E., K. A. Hattala and A. Kahne. 2003. American shad in its native range. Pages 125-140 in K. E. Limberg and J. R. Waldman, editors. Biodiversity, status and conservation of the world's shads. American Fisheries Society, Symposium 35, Bethesda, Maryland.

FirstLight Study Request #11

Impacts of Turners Falls Canal Drawdown on Fish Migration and Aquatic Organisms

(Turners Falls, P-1889)

Conduct a study to quantify impacts of the annual Turners Falls Canal drawdown on emigrating and resident fishes, freshwater mussels and mudpuppies in the canal.

Goals and Objectives

Quantitatively assess the effects of the Turners Falls Canal drawdown on diadromous fishes and other aquatic organisms known to be present in the canal during the annual drawdown. Objectives of this study request include:

1. Determine whether juvenile shad and American eel abundance in the canal increases leading up to the time of its closure, due to delays in downstream passage (e.g., are fish accumulating in the canal?).
2. Determine level of mortality for juvenile sea lamprey from exposure of burrow habitats.
3. Conduct surveys to determine aquatic organisms (fishes, freshwater mussels, and mudpuppies) present in the canal during the drawdown, their densities, status (stranded, dead, alive), and mapping to document habitat, substrate type, and wetted area at complete drawdown.
4. Evaluate measures to minimize aquatic organism population impacts of the canal drawdown.

Other submitted study requests complement or directly relate to this project activity and assessment of project effects, including the resultant effects of all river flow being passed over the Turners Falls Dam as spill (e.g., downstream juvenile shad study request and American eel movement and survival request).

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually; and
2. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, has the stated goal of "Protect, enhance, and restore Atlantic coast migratory stocks and critical habitat of American shad in order to achieve levels of spawning stock biomass that are sustainable, can produce a harvestable surplus, and are robust enough to withstand unforeseen threats," and includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to diadromous fishes, the Service's goal is:

Minimize current and potential negative project operation effects on diadromous fishes, including juvenile shad, adult silver eels, and sea lamprey ammocetes.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a resource agency.

Existing Information

Existing information in the PAD does not provide data on the population size or survival rates of juvenile American shad, American eels, or juvenile sea lamprey located in the power canal during the dewatering process. The power canal is dewatered in early September of each year for over a one week period to perform facility maintenance, inspections, and repairs, including substantial silt removal and bank repairs. Historically, the canal drawdown occurred in July, but

approximately five years ago, it was moved to September, where it has occurred annually since then, with the exception of 2010. The agencies were informed in a letter by FirstLight that the shift to September was at the request of the Independent System Operator–New England (ISO-NE) to avoid peak load months of June through August. Studies conducted by the previous operator, Northeast Utilities Service Company (NUSCO), to assess downstream clupeid survival and use (1991 and 1994 studies at Cabot Station) support the contention that juvenile shad out-migration is occurring within the current drawdown time frame. There are no data to suggest that out-migration would occur earlier than 1 August, but likely does begin in the month of August (O'Donnell and Letcher 2008). Based on these data, CRASC altered its Fish Passage Notification Letter for Downstream Passage Operations for juvenile shad and herring to require the Cabot Station downstream bypass to begin operating on 15 August in 2010, and then moved the date to 1 August in 2011.

It is unknown whether the power canal may, through potential mechanism(s) of delay due to its configuration or operation, cause out-migrating juvenile shad to accumulate in the canal. This information gap leads to concerns that migrant numbers may be elevated beyond simple extrapolations of surface area comparison in the canal to main stem habitat. In the PAD, FirstLight indicates that the Cabot Station forebay in the vicinity of the intake has a maximum depth of 60 feet, while the existing near-surface downstream bypass structure at the Cabot Station is designed to operate only within a depth of 6 feet of the surface. As a result, the downstream bypass only operates effectively for a short period during the drawdown period (timing of this is unknown). The only points of egress, once the fish bypass becomes unavailable, are through the turbines at Cabot Station and Station 1, and eventually at the Keith Street gate located well upstream from the Cabot Station intakes. It is unknown what the survival rates are for these passage routes, what proportion of fish are using each route, what number may become stranded and their survival rates, and how many fish are subjected to this situation. The related study requests on downstream juvenile shad outmigration and American eel outmigration outline objectives that would address some of these information gaps.

There is also a paucity of information relative to the disposition of fish moving downstream in the impoundment during the canal drawdown. Once the Turners Falls gatehouse closes its gates, all inflow passes over the dam, a situation unique to this brief one-week annual time period. Survival rates for outmigrating juvenile American shad and adult American eel moving past the project during the period of spill are not known.

Lastly, there exists an information gap regarding the fate of juvenile sea-lamprey (known as ammocetes) that reside in the soft substrate materials located in much of the lower or downstream end of the canal (Boyd Kynard, BK Riverfish, LLC, personal communication). In previous drawdowns, thousands to tens of thousands of dessicated ammocetes have been observed (Matt O'Donnell, USGS Conte Lab, personal communication). However, the distribution and abundance of ammocetes in the canal, as well as mortality rates for ammocetes during the drawdown period, have not been quantitatively determined.

Nexus to Project Operations and Effects

Previous studies at Cabot Station have documented that juvenile American shad and American eel migrate through the project area during the canal drawdown period. During normal operations (where canal water level elevations are stable), downstream migrants are able to utilize the Cabot bypass facility; however, as the canal water level is drawn down, the bypass is no longer available, and the only routes of egress are through the turbines at Cabot Station and Station 1, unless the Cabot Station spill gates are utilized (the spill gates have a canal depth limitation of approximately 16 feet). Turbine entrainment at hydropower projects has been shown to cause injury and mortality to fishes.

The annual canal drawdown was formerly conducted in July. In response to ISO-NE's request that FirstLight conduct the drawdown outside of the June through August period, FirstLight moved the drawdown to a period of time when diadromous fishes are known to be moving through the project area.

Once the canal has been drawn down, isolated shallow pools are left standing until the canal is refilled. During this period, fish (including lamprey ammocetes), amphibians, and benthic invertebrates are prone to dessication, predation or other sources of mortality or impact.

Methodology Consistent with Accepted Practice

The methods presented here are consistent with the study requests addressing downstream juvenile American shad passage and downstream American eel passage, with an emphasis on addressing survival and movement immediately prior to and during the canal drawdown. Hydroacoustic monitoring immediately upstream of the Turners Falls gatehouse, as well as upstream of opened dam gates for spill, will provide data on the timing, frequency and magnitude of natural wild juvenile shad movement into these areas, particularly the power canal. The abundance of juvenile shad moving into the canal can be derived and compared with similar data obtained with hydroacoustic equipment monitoring upstream of the Cabot Station intake and bypass, for comparisons. Juvenile shad will be PIT-tagged, released, and monitored in the canal, for movements, timing and location, including the Station 1 canal and forebay. PIT-tagged fish will be detected at the Cabot bypass sluice sampler. Juvenile fish should be specifically targeted for release immediately prior to drawdown to assess survival and movement in and through the canal. Surveys of sea lamprey ammocetes should be conducted by a stratified sampling design based upon substrate.

Lamprey density surveys, immediately after drawdown and in a subsequent later survey, may derive rates of change in observed densities and their status (live, moribund, dead); appropriate methods would need to be discussed. Surveys of remaining ponded water should be conducted immediately following drawdown and at later intervals (mid-week and end of week) to compare species occurrence and densities (relative abundance) which will be used to develop catch-curve analyses that can inform rates of mortality to the observed populations.

Assessments of freshwater mussels should also be conducted to quantify drawdown impacts. As with lamprey, the assessment can be based on sampling identified habitats in a stratified, random

design, over the three time periods noted (initial drawdown, mid-week, and end of week), tracking changes in densities and status of observed individuals among areas. Sub-sampling, with sufficient repeated measures to determine variability and acceptable level of precision of data, will inform the required sampling intensity that will be needed. This sampling intensity will be determined as the study occurs and may vary among identified species. Comparisons among the three time periods for measures of density and status will inform the evaluation of project effects for juvenile shad, sea lamprey ammocetes, freshwater mussels and mudpuppies.

The canal drawdown mitigation assessment involves evaluating alternative drawdown protocols to minimize impacts to resident and migratory fish, mussels and amphibians inhabiting the canal. Alternatives should include: (1) moving the drawdown to a time of year outside of migration seasons; (2) keeping or moving the timing of the drawdown, but utilizing technologies to keep the majority of the canal wetted during the drawdown (e.g., portadams in the forebay immediately upstream of the trashracks and at other canal intakes in need of maintenance); and (3) in combination with alternative #2, assessing whether other existing infrastructure within the forebay could be used to pass fish safely out of the canal (e.g., low level outlets, deep gates, side spillway boards, etc.). The assessment should compare the merits and drawbacks of each alternative and provide an order of magnitude cost estimate for implementation.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This study request has many elements that overlap directly with a larger-scale downstream juvenile American shad passage and downstream American eel passage study requests. With equipment costs principally covered in those requests, many components of what has already been proposed will be used in this study. However, this request does include some specific elements not specified in the other two larger requests. The study cost and effort are expected to be low to moderate. Some additional radio tags and balloon tags with additive days of field work to accurately assess impacts specific to the drawdown period will be required. Surveys for identified aquatic organisms will take several days during the drawdown period as well.

The canal drawdown mitigation assessment should require a low to moderate level of effort and cost. One staff person would evaluate alternative drawdown protocols. This should take less than one week to complete.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

O'Donnell, M and B. H. Letcher. 2008. Size and age distributions of juvenile Connecticut River American shad above Hadley Falls: influence on outmigration representation and timing. River Research Applications #24: 929-940.

FirstLight Study Request #12

Entrainment of Migratory and Riverine Fish from the Connecticut River into the Northfield Mountain Pumped Storage Project

(Northfield Mountain, P-2485)

Goals and Objectives

The goal of the study is to determine the impact of Northfield Mountain Pumped Storage Project (NMPS) during the pumping cycle on entrainment of juvenile American shad, adult shad, adult American eel, and riverine fish, including early life stages.

The objective of the study is to quantify the number of resident and migratory fishes entrained at the NMPS intake on an annual basis in order to evaluate potential impacts to riverine fish populations in the Turners Falls pool and diadromous fish migrants moving through the project area. This will be accomplished through a combination of hydroacoustic monitoring and netting using various gear types to quantify and identify species of different life stages.

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

Based on the CRASC plan, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, CRASC developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem..." Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Specific to resident riverine and migratory fish entrainment, the Service's goals are:

1. Minimize current and potential negative project operation effects such as turbine entrainment that could hinder management goals and objectives.
2. Minimize project-related sources of mortality to resident and migratory fishes in order to restore natural food web interactions and ecosystem functions and values.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a resource agency.

Existing Information

Limited project-specific information exists regarding entrainment of fish and aquatic organisms at the NMPS. As part of a 1990 Memorandum of Agreement between then-owner Northeast Utilities Service Company (NUSCO) and regulatory agencies (including the Service), NUSCO conducted studies to determine the impact of NMPS on anadromous fishes, including Atlantic salmon, American shad, and blueback herring. Results of a pilot study conducted in the fall of 1990 indicated that trap netting at the intake was ineffective at collecting fish. Gill netting and boat-shocking did result in collection of some juvenile shad, but further refinement in both methods was recommended to improve effectiveness. A total of 78 fish were collected at the intake (77 of which were American shad) by gill netting and 11 shad were collected by boat electrofishing. Hydoacoustic monitoring was deemed an effective method for monitoring entrained fish during pumpback operation. Hydroacoustic sampling over a two-week period (September 12-27, 1990) produced hourly entrainment estimates that cumulatively equaled 14,816 fish.

Based on the results of the pilot study, NUSCO developed a two-year plan to quantitatively determine the number of shad and salmon entrained at NMPS station. In 1992, an entrainment study targeting juvenile American shad life stages was conducted in the lower (mainstem river) and upper reservoirs of NMPS. The study used several gear types to quantify egg through juvenile shad densities in different areas. Entrained juveniles were sampled using an upper reservoir net. Pumping operations were modified to only run three (77 percent of sample time) and sometimes two (23 percent of sample time) of the station's four units during the study, and effort was limited to a total of 80 hours over a period spanning 9 August through 27 October (80 days). An estimated total of 1,175,900 shad eggs, 2,744,000 yolk-sac larvae, 10,525,600 post yolk-sac larvae, and 37,260 juveniles were reported entrained.

There are no reliable data on the timing, magnitude and duration of entrainment of larval riverine fishes in the NMPS area. Unlike anadromous shad and river herring, riverine species occurrence and susceptibility relative to space and time exposure windows to NMPS pumping are undocumented. The complete lack of any long-term fish population monitoring data for riverine species in the Turners Falls impoundment leaves questions unanswered on the types and extent of impacts to these populations that may be linked to the near daily cycling of river water up and down through the NMPS operations system. As a starting point, it is necessary to obtain baseline data on project operation impacts for all species potentially impacted by NMPS. An additional study request seeks to obtain a more accurate documentation of all fish species inhabiting or utilizing the Turners Falls impoundment.

Nexus to Project Operations and Effects

Entrainment of fish and aquatic organisms associated with water withdrawal and hydroelectric operations has been documented to result in injury or death of entrained organisms. Migratory and resident fish pass through the project area directly in front of the pump intakes. These organisms may be entrained and thus exposed to passage through the project pumps and reservoir supply tubes. How far from the intake these species and life stages may be drawn into the intake on a pumping cycle or how susceptible they are to the repeated daily cycles of

pumping and discharge, and how these factors vary in relation to habitat and river conditions, are unknown. Survival of fish subjected to entrainment on the pumping cycle is unknown, but regardless of whether fish survive the pumping process, they are lost to the Connecticut River system. Depending on the species, life stages, and numbers entrained, this loss could impact the ecosystem productivity of the Turners Falls pool and may hinder restoration goals for diadromous fishes.

Previous entrainment studies have been conducted at the project. Those studies, which were done 20 years ago, documented entrainment of American shad and Atlantic salmon at the project, including over 13 million yolk sac and post-yolk sac larvae of American shad. This level of entrainment is cause for concern, not only due to the resultant loss of potential adult returns, but for the important role early life history phases and juveniles play in their ecological contributions to the river system (e.g., trophic interactions).

No entrainment studies for other species of fish have been conducted at the project and require evaluation. Studies conducted in 1969 and 1970 at the Muddy Run Pumped Storage Station documented significant entrainment of eggs and larval fish. In June and July of 1970, 5.3 million eggs and 56.6 million larvae were entrained (Snyder 1975). Muddy Run and NMPS are of a similar size and both use a river as the lower reservoir. It is anticipated that a considerable number of eggs and larvae will be entrained by the NMPS.

Since the previous studies were conducted, operations at the NMPS facility have changed (e.g., the project increased the efficiency of its turbines, and raised the pumping capacity from 12,000 cfs up to 15,000 cfs), as have river conditions (e.g., Vermont Yankee has increased its thermal discharge and the Vernon Project has increased its station capacity). Further, the PAD indicates that FirstLight will evaluate the feasibility of utilizing an additional 3,009-acre feet of storage capacity to generate an additional 1,990 MWhs (this represents a 23 percent increase over existing storage and stored generation levels). While not specified in the PAD, increasing storage and generation would mean longer periods of both pumping and generation at NMPS. In addition, anticipated improvements in fish passage at the Turners Falls Project will result in increased juvenile production above the NMPS. These factors, individually or cumulatively, could increase the potential for entrainment at NMPS station.

Methodology Consistent with Accepted Practice

Previous studies used varying methodologies for determining entrainment. The 1990 study concluded that hydroacoustic monitoring at the intake was a viable method for determining entrainment of later life stages, but does not allow for identification of the species being entrained. While trap netting was ineffective at collecting fish near the intake, gill netting and boat shocking did capture some fish. Both may prove to be viable sampling methods; however, it is likely that additional testing and gear refinement will be necessary.

The 1992 study used nets at the pump discharge location into the upper reservoir to collect entrained fish. Testing showed that this method was only 10 percent efficient. Plankton netting in the nearfield area of intake was used to estimate entrainment of ichthyofauna. It is likely that a combination of methods would provide the most reliable results (e.g., hydroacoustic monitoring

at the racks during pumpback operations, variable gear sampling in the vicinity of the intake immediately prior to initiation of pumpback operations to determine species composition, and plankton netting in the nearfield area of the intake to obtain information on entrainment of ichthyofauna). As these methodologies have previously been utilized at the site, they are consistent with accepted practice (Harza Engineering Company 1991).

Although a previous entrainment study was conducted, the Service believes it should be repeated, using a modified study design. The 1992 study only collected a total of 330 juvenile shad over a three-month period (resulting in an overall estimate of 37,260 juveniles entrained, after accounting for poor net efficiency), whereas the hydroacoustic study conducted in 1990 estimated nearly 15,000 fish in 15 days (while these fish were not identified, 77 of the 78 fish collected at the intake during the study were juvenile shad). It also should be noted that in the 1992 study, juvenile shad were collected on the first day of sampling, indicating that the sampling did not begin early enough, which would mean the results are an underestimate of the number of juvenile shad that were actually entrained. In 1990, 27,908 adult shad passed the Turners Falls gatehouse, while in 1992 over 60,000 shad passed the gatehouse. The fact that the numbers entrained were so variable between study years argues for repeating the study, using a combination of previously-used methodologies (Lawler, Matusky and Skelly Engineers 1993).

The study will require deployment of at least five hydroacoustic transducers (one per rack face and one offshore). These transducers would be operated during every pumping cycle from April 15 through May 14 to assess riverine fish entrainment, from May 15 through July 15 for spent adult shad, and from July 16 through November 30 for entrainment of adult silver eels, juvenile American shad, and riverine fishes. Concurrent field sub-sampling at the intake to determine species composition would need to occur.

Sampling for planktonic fish larvae should capture early spring spawning species (white suckers) through later season centrarchid species (bass and sunfish). Active plankton trawl surveys should utilize a sampling design that adequately captures temporal and spatial changes in water pumping cycle (i.e., early start-up is local water, later cycle pumping is drawn in from both upstream and downstream habitat areas).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

We know of no other tool that will provide for this type of assessment for all fish species and organisms that may pass through the project. Cost and effort are expected to be high.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

CRASC. 1992. A Management Plan for American Shad in the Connecticut River.

Harza Engineering Company. 1991. Draft Northfield Mountain Pumped Storage Project 1990 Field Sampling Program. February 1991. Northeast Utilities Service Company, Berlin, CT.

Lawler, Matusky and Skelly Engineers (LMS). 1993. Northfield Mountain Pumped-Storage Facility – 1992 American Shad Studies. February 1993. Northeast Utilities Service Company, Berlin, CT.

Memorandum of Agreement. NUSCO. July 1990.

Snyder, D.E. 1975. Passage of fish eggs and young through a pumped storage generation station. J. Fish Res. Board Canada. 32: 1259-1266.

FirstLight Study Request #13

Model Flows in the Northfield Mountain Pumped Storage Project Intake/Tailrace Channeland Connecticut River Upstream and Downstream of the Discharge Using Computational Fluid Dynamics (CFD) Modeling

(Northfield Mountain, P-2485)

Goals and Objectives

The goal of this study is to determine the potential impacts of the Northfield Mountain Pumped Storage Project (NMPS) operations (pumping and generating) on: (1) the zone of passage for migratory fish near the turbine discharge/pump intake; (2) natural flow regimes in the area of the Connecticut River immediately upstream and downstream of the project; and (3) the potential for fish entrainment during pumping operations.

Specific objectives of the study include:

1. Develop a CFD model of the NMPS intake and tailrace channel, along with the full width of the Connecticut River upstream and downstream of the discharge.

2. Model flow characteristics upstream and downstream of the project under existing project operations (pumping and generating) and at several representative river flow levels, as well as proposed operations such as those proposed in section 3.4.4 of the PAD, and any other modifications under consideration, to assess potential impacts to fish and wildlife resources.

3. Assess velocities and flow fields at and in proximity to the NMPS intake/discharge structure when pumping or generating, and their potential to interfere with fish migration, create undesirable attraction flows, and result in fish entrainment.

4. Assess the potential for velocity barriers in the mainstem river resulting from pumping and generation flows at the project, alone or in combination with generation flows from the upstream Vernon Project and operations at the Turners Falls Project.

5. Assess the potential of a mainstem instream local flow reversal associated with pumping operations to impact migrating fish.

6. Model and then evaluate flow characteristics under alternative project operations with potential measures to avoid, minimize, or mitigate impacts to fish and wildlife resources.

Resource Management Goals

The mission of the U.S. Fish and Wildlife Service (Service) is to work with others to protect, conserve and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American public. Service trust resources include wetlands, endangered species, and migratory species, all of which have been documented to occur in the project area. The Service also is working with a number of federal, state, local, non-governmental organizations, and the public to restore and enhance trust resources in the Connecticut River Basin through comprehensive management plans and cooperative agreements. Instream flow is an important riverine habitat characteristic that can have a great impact on aquatic habitat for fish, wildlife, and plants. Flow is an important directional guidance cue for instream navigation and attraction to fishway entrances for migratory fish.

Public Interest

The requestor is a natural resource agency.

Existing Information

No project-specific information exists that will allow for a comprehensive assessment of existing project operations (pumping and generating flows) on Connecticut River flows and on fish and aquatic organisms in the project area upstream and downstream of the project. Preliminary results from an ongoing study of radio-tagged American shad by the Service and the USGS Silvio O. Conte Anadromous Fish Research Center indicate that shad are exposed to the intakes and some individuals spend substantial amounts of time in the vicinity of the intakes. The PAD does not contain any information or tool that will allow for predictions of impacts of alternative project operations, or potential mitigation measures to protect or enhance aquatic fish and wildlife resources.

Nexus to Project Operations and Effects

Existing project operations have a direct impact on instream flow and aquatic habitat in the pump/discharge area of the Connecticut River. The PAD (section 3.2.2) says that the discharge at the trash racks when operating at full capacity is 20,000 cfs and maximum pumping conditions are 15,200 cfs. Annual flow duration curves shown for below the Vernon Dam submitted in the PAD (section 4.3.1.2) (for years 1944-1973; recent and near project flows are not available; see p. 459) indicate that river flows are $\leq$ 20,000 cfs more than 85 percent of the time. Flows released from the project must therefore influence flow patterns and velocities in the Connecticut River, particularly at flows below some unknown threshold level.

Recreational users of the Connecticut River in the Turners Falls impoundment have anecdotally described flow reversals in the mainstem river. Discharges from the project could potentially be larger than river flows or at least act like a major tributary to the Connecticut River. Project flows may influence the availability and extent of upstream and downstream migration zones, or may confuse fish and delay migration.

Methodology Consistent with Accepted Practice

CFD modeling is consistent with generally accepted practice, and has been used to assess proposed modifications to the Holyoke Project (FERC No. 2004) fish passage facilities, upstream of the intakes and downstream of the dam, as well as at hydroelectric projects on the Susquehanna River to assess existing and proposed project operations, and develop mitigation measures for fish and wildlife resources.

A study plan that describes the specific modeling tools to be used, the amount of bathymetric data to be gathered, the geographic scope of the assessment and the flow conditions to be modeled will need to be developed in consultation with the Service and other parties.

Level of Effort/Cost, and Why Alternative Studies will Not Suffice

This study will require a detailed elevation map of the study area upstream and downstream of the NMPS intake structure. Some information already exists in historic construction files for the project and past hydraulic analyses. Additional bathymetric data likely will need to be collected in the field using standard survey techniques. The CFD computer program will need to simulate existing project operations, as well as accommodate all potential variations of pumping and generating, and static operation.

No project-specific instream flow analysis tool has been developed for the NMPS that will allow for assessment of existing operations and alternative operational impacts on instream flow and aquatic habitat for fish and wildlife resources. The computer model, once built, can be used to simulate flow conditions in the vicinity of the project during migratory fish passage and can be used together with behavior studies (i.e., telemetry studies and entrainment studies requested herein) to assess the impacts of varying project operations or potential mitigation operations and measures on fish migration and aquatic habitat. We know of no other tool that will provide for these types of assessments. Cost is expected to be moderate to high.

FirstLight Study Request #14

Upstream American Eel Passage Assessment at Turners Falls
(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at the Cabot Station discharge, Station #1 discharge, canal discharges, and Turners Falls Dam to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures that would potentially establish the most effective locations to place upstream eel passage facilities.

2. Collect eels with temporary trap/pass devices at areas identified from surveys as potential locations of eel concentration to assess whether eels can be collected/passed in substantial numbers, and whether locations are viable sites for permanent eel trap/pass structures.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem..." Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.

2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to upstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operational effects that could hinder management goals and objectives.
2. Minimize project-related sources of upstream passage delay, injury, and stress in order to facilitate access to historical rearing habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains no information relative to areas where eels seeking to move upstream concentrate downstream of the dam, or annual numbers of eels attempting to ascend past Turners Falls Dam. While eels have been known to ascend the Cabot Station ladder (A. Haro, U.S. Geological Survey, personal communication), its efficiency is unknown, and it is only operated during the American shad passage season (from April 1 through July 15). Eels are currently able to pass the Turners Falls Dam complex (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass Turners Falls and the proportion successfully passing the project is unknown (but suspected to be low). The downstream Holyoke Project has operated upstream eel passage facilities since 2004. Last year, these facilities passed over 40,000 juvenile eels. While there is rearing habitat in between the Holyoke and Turners Falls dams, some eels will attempt to continue upstream, and passage needs to be provided so these fish can access historical habitat.

These information gaps need to be filled so resource agencies can determine the best locations to site upstream eel passage facilities and assess whether operating the existing anadromous ladders would be an effective mechanism to move juvenile eels upstream past the project.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting

new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the project.

Nexus to Project Operations and Effects

The project generates hydropower on the head created by the Turners Falls Dam. This dam creates a barrier to upstream migrating eels. While some eels are able to pass dams, some are not, and the passability of a given dam depends on factors such as its height, hydraulics, presence of climbable surfaces, presence of predators, risk of exposure to heat or drying while climbing a dam, etc. The Turners Falls Dam is high (35 feet above bedrock), and the majority of the dam face is dry during most of the upstream eel passage season. Design of the dam is not currently amenable to passage of eels by climbing. While flow is released to the bypass reach via a bascule gate (typically the one closest to the gatehouse), this would not facilitate eel passage, as bascule gates open outward and downward (i.e., requiring the eels to essentially swim nearly upside down to get over the gate). As mentioned earlier, the existing anadromous passage facilities are not designed to pass eels, and even if some eels are able to ascend the ladders, they may incur delays (in attraction or passage rates), be size-selective (e.g., velocity barrier for small eels presented by ~8 ft/sec flow through weirs and orifices), present a potential predation risk (predators in or near the fishways), and are not operated throughout the upstream eel passage season.

Methodology Consistent with Accepted Practice

1. Objective 1: Systematic Surveys

   Surveys of eel presence and relative abundance should be conducted at regular intervals throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10°C). Surveys should consist of visual inspection and trapping in likely areas where eels may concentrate as they attempt to climb structures wetted by significant spill or leakage flow in the Turners Falls Dam complex area. These locations include: Cabot Station downstream bypass outfall, Cabot Station spillway (including attraction water stilling basin), Cabot fishway (dewatered state), USGS Conte Lab flume outfall, Number One Station outfall, various small turbine and process water outfalls from the Cabot Canal, spillway fishway attraction water stilling basin, and leakage points along the downstream face of the Turners Falls Dam (bascule and taintor gates). Methods should include visual surveys (on foot, from a boat, or snorkeling) and trapping using small mesh (< 1/8"-clear opening) baited eel pots. Visual surveys should be performed once per week, at night, preferentially during precipitation events. Trap sets should be performed once per week, with an overnight soak time. Recorded data should include location, observation of eels (presence, absence, relative numbers, relative sizes, behaviors, time/date of observation), and survey method.

2. Objective 2: Trap/Pass Collections

   Areas identified from Systematic Surveys as having a significant number of eels present should be targeted as potential areas for permanent eel trap/passes, and should be initially assessed using temporary/portable trap passes. At a minimum (regardless of survey results), temporary trap passes should be installed at the following locations: Cabot fishway attraction flow stilling basin (during dewatered fishway period), Number One Station outfall, and spillway fishway attraction flow stilling basin (during watered and dewatered fishway period), as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream migrant eels. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10°C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every two to three days. Recorded data should include location, trapping interval, absolute numbers of eels trapped, relative eel sizes, and hydraulic and environmental conditions during the trapping period.

All collected eels from surveys should be released at their point of capture; those eels collected from trap/pass collections should be transported to and released above the dam in the Turners Falls pool.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the survey component of the study would be low; a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost (estimated at $40,000) and effort.

In the PAD, the Applicant has identified the need to assess issues related to upstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The Service is not aware of any previously conducted or ongoing studies related to upstream eel passage.

FirstLight Study Request #15

Evaluation of Timing of Downstream Migratory Movements of American Eels on the Mainstem Connecticut River

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Goals and Objectives

The goal of this study is to better understand migration timing of adult, silver-phase American eels in relationship to environmental factors and operations of mainstem hydropower projects on the Connecticut River.

The objective of this study is:

Quantify and characterize the general migratory timing and presence of adult, silver-phase American eels in the Connecticut River relative to environmental factors and operations of mainstem river hydroelectric projects.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to downstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requester is a resource agency.

Existing Information

Data on timing of downstream migratory movements and rates of American eels in the mainstem Connecticut River are sparse and relatively incomplete. Preliminary data on the presence of "eel-sized" acoustic targets have been collected (Haro *et al.* 1999) within the Turners Falls Project's Cabot Station forebay that were somewhat confirmed by video monitoring at the Cabot Station downstream fish bypass; however, these were short-term studies, with acoustic

monitoring only performed from 17 September to 5 October and video monitoring only conducted between 18 September to 22 October.

Some daily monitoring of the downstream bypass at the Holyoke Dam (canal louver array) was performed in 2004 and 2005 (Kleinschmidt, Inc. 2005, 2006, Normandeau Associates 2007); these studies also were of relatively short duration (spanning from October 5 to November 10 in 2004 and September 9 to November 11 in 2005) and the sampler was only operated at night.

To date, no other directed studies of eel migratory movements have been conducted at any location on the Connecticut River mainstem. This information gap needs to be filled, as it relates directly to when downstream passage and protection measures need to be operated.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Nexus to Project Operations and Effects

The timing of downstream migration of adult eels is poorly defined for the Connecticut River; therefore, the general effects of hydroelectric project operations on eel survival to the ocean are unknown. Although separate study requests have been submitted to address project-specific downstream passage route selection, delays, and mortality of eels, general characteristics of river flow and environmental conditions may have significant relationships with project operation and eel migratory success and survival. For example, eels may tend to move immediately before or during periods of significant precipitation (or consequently river flow), times at which projects may be generating at maximum capacity or spilling, which may (or may not) present a higher passage risk to eels. Conversely, periods of low flow may be associated with a significant proportion of total river flow passing through turbine units, which present additional (or different) passage risk to eels. If discrete conditions which promote eel downstream migration are known, it may be possible to take actions with respect to project operations which reduce or minimize passage risk; i.e., operation of a bypass, reduction of intake approach velocities, directed spillage through a "safe" route, etc. These studies should provide baseline information on river-specific downstream migration to predict when silver-phase eels are expected to be migrating in the mainstem Connecticut River, from which project operations could be modified to minimize passage risks.

The studies are proposed for a single or multiple sites; the results will be relevant to all sites on the Connecticut River mainstem.

Methodology Consistent with Accepted Practice

Quantification of downstream movements of American eels in river systems requires systematic sampling of migrants throughout the migratory season. This can be accomplished with traditional active trapping methods; i.e., fyke or stow net sampling, weirs, or eel racks, but these methods are technically challenging on larger mainstem rivers, due to the scale of flows that need to be sampled, difficulties in operation throughout all flow conditions, and high debris loading during fall flows. Passive monitoring of migrant eels using hydroacoustic methods offers an alternative to active trapping. However, this form of passive monitoring requires verification of potential acoustic targets with some level of active (collection) or visual (traditional optical or acoustic video) sampling.

Two potential locations offer opportunities to conduct simultaneous passive and active sampling: the Cabot Station (Turners Falls Project) canal/forebay and the Holyoke Dam forebay and canal louver/bypass system. Each location possesses a route of downstream passage which conducts a significant proportion of river flow (Cabot canal and Holyoke forebay or canal), and each has a proximal bypass equipped with a sampler so that fish can be concentrated/collected from the passage route and identified to species. Project operations do influence the relative proportion of flow (and thus numbers of downstream migrant eels) in each passage route, so numbers of eels sampled in each route represent only a proportion of the total number of eels migrating downstream within the entire river. Because the absolute proportion of eels using a specific route at any one time is unknown, numbers of eels quantified within a route must serve as a relative index of the degree of migratory movement.

This study shall quantify eel movements in either one, or preferably both, locations for two consecutive years (since environmental conditions strongly influence migratory timing of eels, which can vary significantly from year to year) (Haro 2003). Eels will be quantified using methods similar to Haro *et al.* (1999), by continuously monitoring a fixed location at the projects with hydroacoustics. Because eels tend to concentrate in areas of dominant flow (Brown *et al.* 2009; EPRI 2001), the zone to be monitored should pass a dominant proportion of project flow throughout most periods of operation (i.e., forebay intake area). Hydroacoustic monitoring shall encompass the entire potential migratory season, beginning in mid-August and ending in mid-December, and shall operate 24 hours per day. Data will be recorded for later processing and archiving.

Systematic active quantification of eels at downstream bypass samplers shall be performed simultaneously with passive hydroacoustic monitoring, to verify presence of eels and relative abundance of eel-sized hydroacoustic targets from the hydroacoustic data. Although daily operation of the bypass sampler could be performed, a more comprehensive technique is to monitor eels entering the bypass with an acoustic camera (i.e., DIDSON, BlueView, etc.). The acoustic camera will afford positive visual identification of eels as they enter the bypass, which is a concentration point for migrating eels. Acoustic camera monitoring will also allow monitoring to be performed 24 hours a day, and will be relatively unaffected by water turbidity

(which influences effectiveness of traditional optical video monitoring). The acoustic camera system will be operated during the same time period as acoustic monitoring, and images will be recorded for later processing and archiving.

Data analyses of hydroacoustic, acoustic camera, bypass sampling, and environmental/ operational data will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the downstream migrant eel migratory timing study would be moderate, given the level of cost for instrumentation, deployment, and data review/analysis. Cost is estimated at $50,000 per year for the study.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

Haro, A. 2003. Downstream migration of silver-phase anguillid eels. Pages 215-222 in: Aida, K., K. Tsukamoto, and K. Yamauchi, eds. Eel Biology. Springer, Tokyo.

Haro, A., D. Degan, J. Horne, B. Kulik and J. Boubée. 1999. An investigation of the feasibility of employing hydroacoustic monitoring as a means to detect the presence and movement of large, adult eels (Genus *Anguilla*). S. O. Conte Anadromous Fish Research Center Internal Report No. 99-01. Turners Falls, Massachusetts. 36 pp.

Kleinschmidt, Inc. 2005. Factors influencing the timing of emigration of silver-phase American Eels, *Anguilla rostrata*, in the Connecticut River at Holyoke MA. Submitted to the City of Holyoke Gas and Electric Department. 27 pp.

Kleinschmidt, Inc. 2006. Holyoke Project (FERC No. 2004) silver-phased American eel flow priority plan. Submitted to the City of Holyoke Gas and Electric Department. 51 pp.

Normandeau Associates, Inc. 2007. American eel emigration approach and downstream passage routes at the Holyoke Project, 2006. Submitted to the City of Holyoke Gas and Electric Department. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 81 pp.

FirstLight Study Request #16

Downstream American Eel Passage Assessment at Turners Falls and Northfield Mountain Pumped Storage

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

The goal of this study is to determine the impact of two hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment of eels at the Northfield Mountain Pumped Storage (NMPS) Station removes eels from the river, effectively extirpating them from the population. Entrainment at the conventional turbines at Station 1 and Cabot Station of the Turners Falls Project can result in mortality or injury. It is important to understand the passage routes at each project and the potential for mortality to assess alternative management options to increase survival.

The objectives of this study are:

1. Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the projects; i.e., for NMPS, the proportion entrained into the intake; for Turners Falls Dam, the proportion entrained into the power canal and spilled via bascule and taintor gates; for the Cabot Canal, proportion of fish passing via spillways, turbines, and the downstream bypass.

2. Evaluate instantaneous and latent mortality and injury of eels passed via the Turners Falls Dam routes, including bascule and taintor gates, spillways, turbines, and the downstream bypass.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to downstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains information on the biology, life history, and regulatory status of American eel. It also discusses 2-D and 3-D telemetry studies that were conducted at Cabot Station in 1996, 1997, 2002 and 2003. Results of those studies indicate that a significant proportion of eels entering the Cabot forebay become entrained (90 percent in 2002, 100 percent in 2003) (Brown 2005; Brown *et al.* 2009). The PAD notes that the study done in 2003 determined that 15 of the 29 test eels were detected at the Hadley Falls Station. However, that study was not designed to assess turbine mortality.

To date, no directed studies of eel mortality at Cabot Station or eel entrainment or mortality at either Station 1 or the NMPS facility have been conducted. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made prior to any new licenses being issued for the projects.

Nexus to Project Operations and Effects

The Turners Falls Project operates as a peaking facility, except during periods when inflow exceeds the hydraulic capacity of Cabot Station and Station 1. Silver eels outmigrate during the mid-summer through late fall, a time of year when flows are generally near the maximum operating capacity of the stations. Therefore, the project would be expected to spill infrequently during the silver eel outmigration beyond the nominal amount required in the bypass reach.

Racks at Cabot Station, Station 1, and the NMPS facility are not designed to protect eels from entrainment. At Cabot, the racks have one-inch-clear spacing on the top 11 feet, with five-inch-clear spacing on the bottom 20 feet of racks. The approach velocity at the racks is approximately 2.0 feet per second at maximum hydraulic capacity. At Station 1, the racks have 2.6-inch-clear spacing and an approach velocity of 1.2 feet per second. Eels can readily pass through a 2.6-inch-clear space. NMPS has 48-foot-deep trashracks with 6-inch-clear spacing over the intake and an approach velocity of 3.5 feet per second at full pumping capacity (15,000 cfs).

As mentioned above, previous studies conducted at Cabot Station documented eel entrainment. Cabot Station has existing downstream passage facilities designed for anadromous species, but studies have documented few eels utilizing the surface bypass (likely because Cabot has a relatively deep, wide intake area). Station 1 has no passage and protection facilities. NMPS has a seasonally deployed barrier net to minimize entrainment of Atlantic salmon smolts, but it is only operated from April through June 15 annually. While no studies have been conducted at Station 1 or the NMPS facility, the rack spacing is wide enough to allow for entrainment.

Methodology Consistent with Accepted Practice

In order to understand the movements of outmigrating silver eels as they relate to operations at the NMPS facility, Station 1, and Cabot Station, radio telemetry technology should be utilized. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Muddy Run Project (FERC No. 2355).

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different telemetric methodologies. Studies also will likely benefit from data from several seasons (especially route selection studies, which may be more significantly affected by environmental conditions during a given season than mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies have been completed.

1. Objective 1: Route Selection

This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out of basin may be acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g., eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late August to mid-October), and eels should be tagged and released within seven days of collection.

NMPS Route Selection Study:

A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Eels will be released at least 5 km upstream of the NMPS project; releases should be timed so that there is a significant probability that migrating eels will encounter NMPS during the pumping stage. Radio telemetry antennas will be strategically placed to determine times eels are present within the river reach in the vicinity of the NMPS intakes, within the intakes themselves, and whether they are entrained into the upper reservoir.

Turners Falls Dam Route Selection Study:

A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during spill and non-spill periods, if possible. Tagged eels will be released at least 3 km upstream of the Turners Falls Dam, but several km below the intake to NMPS. Telemetry receivers and antennas will be located above and below the dam to assess passage via the following potential routes: entrainment into power canal; passage via spill over the bascule gates; passage via spill through the taintor gates.

Eels from the NMPS route study not entrained into the NMPS intake and migrating to the Turners Falls Dam may be used to supplement (but not serve in lieu of) these release groups.

Turners Falls Project – Canal Route Selection Study:

A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during periods of low, moderate, and high generation conditions, if possible. Eels will be released in the upper canal (ideally just downstream of the gatehouse), and allowed to volitionally descend through the canal. Telemetry receivers and antennas will be located within the canal, bypass, channel, and mainstem below Cabot Station to assess passage via the following potential routes: spillway fishway attraction water intake (if operational); Station 1 turbines; Cabot Station spillway; Cabot Station bypass; Cabot Station turbines.

Eels from the NMPS and Turners Falls Dam route studies not entrained into the NMPS intake and migrating into the Turners Falls Canal may be used to supplement (but not serve in lieu of) these release groups.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals during and after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

Movement rates (time between release and passage) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

2. Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies

Spill, bypass, and turbine mortality will be assessed using a radio-telemetric balloon tag method. A minimum number of 50 tagged eels (e.g., five separate groups of approximately 10 eels each) will be required at each location (dam bascule gate, dam taintor gate, Cabot Station spillway, Cabot Station bypass, Station 1 and Cabot Station) to

maximize the data return. Turbine mortality studies are not required at NMPS because it is assumed that all entrained fish (including eels) are lost to the Connecticut River system.

For spill mortality sites (dam bascule gate, dam taintor gate, Cabot Station spillway, Cabot Station bypass), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

For turbine mortality sites (Station 1 and Cabot Station), tagged eels will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

The turbine mortality component of the study should occur in study year two.

Data analyses of route selection and turbine mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will Not Suffice

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes to all stations, as well as at the Turners Falls Dam spillway and Cabot Station bypass, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately $75,000 for the first year of study. Costs are estimated at $100,000 per year for the route selection studies and $75,000 per year for the spill, bypass, and turbine mortality/injury studies.

In the PAD, the Applicant has identified the need to assess issues related to downstream passage for American eels at the project, but indicates that they intend to rely on information from previously conducted studies and ongoing studies. The Service is not aware of any previously conducted or ongoing studies related to downstream eel passage.

REFERENCES

Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291 in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

FirstLight Study Request #17

Determine the Fish Assemblage in the Turners Falls and Northfield Mountain Pumped Storage Project-Affected Areas

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

The goal of this request is to determine the occurrence, distribution, and relative abundance of fish species present in the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage (NMPS) project areas, which potentially includes Species of Greatest Conservation Need (SGCN) for Massachusetts, New Hampshire, and Vermont.

Specific objectives include:

1. Document fish species occurrence, distribution and abundance within the project-affected areas along spatial and temporal gradients.

2. Compare historical records of fish species occurrence in the project affected areas to results of this study.

Resource Management Goals

The Massachusetts Division of Fisheries and Wildlife, the New Hampshire Fish and Game Department and the Vermont Fish and Wildlife Department each have as a mission the protection and conservation of fish and their habitats. Riverine fish species are an important component of the river's ecology and are the basis for the sport fishery. Furthermore, several of the states' SGCN have been documented in the project-affected areas.

Determining species occurrence, distribution, and abundance will better clarify what species occur in the project area both spatially and temporally, relative to habitats which may be affected by project operations of the Turners Falls or NMPS projects. This information will better inform other results from other study requests that will be examining project operation effects on various aquatic habitats, water quality and other related concerns such as entrainment concerns at NMPS. This information will be used to make recommendations and provide full consideration for all species, including those that might not otherwise be known to occur in the project-affected area and impacts that may affect their population status through direct or indirect effects of the projects.

Public Interest

The requestor is a natural resource agency.

Existing Information

A thorough and comprehensive assessment of the fish assemblage present in the project-affected areas of the Turners Falls and NMPS projects is lacking. The PAD for these project sites notes resident fish surveys conducted by the State of Massachusetts in the early to mid-1970s and a limited 2008 sampling effort by Midwest Biodiversity Institute (contracted by EPA). The PAD identifies a total of 22 fish species in the project area which omits, as an example of its limited information basis, northern pike, tessellated darter, burbot, eastern silvery minnow, and channel catfish (Ken Sprankle, USFWS, and Jessie Leddick, MADFW, personal communication). It is unknown how many other species may inhabit or utilize aquatic habitats in the project areas, potentially including species of greatest conservation need.

The most relevant recent fish survey study related to the project-affected areas is a Connecticut River electrofishing survey conducted in 2008 (Yoder *et al.* 2009). While some sampling was conducted in both project areas during the 2008 survey, this survey did not have the same goals and objectives as those outlined above. Due to the design of the study limitations in geographic/habitat type coverage both spatially and temporally, and the use of a single gear type, these data may not be a full representation of species occurrence in the project affected areas. It follows that since information is limited regarding the composition of the fish community and their use of habitats in the project-affected area, project impacts on fish species are also unknown.

Nexus to Project Operations and Effects

Project operations have the potential to directly impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, headpond and tailwater water level fluctuations could dewater important spawning areas, or affect habitat availability, thus limiting productivity of fish species by direct impacts to their spawning success or indirectly by limiting the spawning success of forage fish species. Accordingly, a thorough understanding of the current fish assemblage structure and associated metrics is needed in order to examine any potential project-related impacts. A study request to examine project effects on aquatic habitats, as well as impacts to spawning habitats (e.g., sea lamprey and black bass) has been submitted and will compliment this request.

Methodology Consistent with Accepted Practice

An accepted and robust field sampling design (e.g., as described in Pollock *et al.* 2002 or MacKenzie *et al.* 2006) and accepted methods for collecting fish species likely to be present in the project-affected areas (Bonar *et al.* 2009) should be used to conduct field surveys. Randomly sampling multiple habitat types using a multi-gear approach will be required to ensure that all fish species present are sampled. The spatial scope of the study will be from the headwaters of the Turners Falls pool downstream to Sunderland, Massachusetts, and will omit the upper reservoir of NMPS. Sampling should occur at each selected site across multiple seasons (spring, summer, and fall). Digital photographs should be taken to avoid misidentification of certain species such as Cyprinids.

The sampling design should include replicate samples for estimation of species detection probability. Sample replicates may be gathered temporally, using different methods, by independent observers, or by randomly sampled spatial replicates (MacKenzie *et al.* 2006). For each replicate sample, data that may be important for describing variation in species occurrence and presence/absence should be collected and recorded, such as gear type, mesohabitat type, depth, velocity, flow, water temperature, substrate, time of day, day of year, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat), and/or other factors as determined by a qualified biologist. Species detection, occurrence, and/or abundance and related habitat measures on these parameters should be estimated using methods as described by Kery *et al.* (2005), MacKenzie *et al.* (2006), Wenger and Freeman (2008), or Zipkin *et al.* (2010).

This will be a one-year study, provided river discharge conditions fall within the 25-75th percentile for weekly averages. Based upon this study's results, and the information obtained from studies to survey aquatic habitats and littoral zone fish spawning, additional studies may be required if there is evidence of effects of the projects on populations or habitat of identified species.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost of the study will be moderate to high as seasonal sampling with several types of gear will be required. However, cost will also be partially dependent on the number of sites sampled, the number of sample replicates, and the extent of the covariate data that are measured, all of which may be flexible. Based on first-year study results, a second year of sampling or specific studies examining impacts of project operations on specific fish species may be needed and requested. Provided the collected data are of high quality, analysis and synthesis should take approximately 10-20 days. FirstLight did not propose any studies specifically addressing this issue.

REFERENCES

Bonar, S.A., W.A Hubert and D.W. Willis, editors. 2009. Standard methods for sampling North American freshwater fishes. American Fisheries Society, Bethesda, Maryland.

Kery, M., J.A. Royle and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. Ecological Applications 15:1450-1461.

MacKenzie, D.I., J.D. Nichols, J.A. Royle, K.H. Pollock, L.L. Bailey and J.E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier: San Diego, California.

Pollock, K.H., J.D. Nichols, T.R. Simons, G.L. Farnsworth, L.L. Bailey and J.R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. Environmetrics 13:105-119.

Wenger, S.J. and M.C. Freeman. 2008. Estimating species occurrence, abundance, and detection probability using zero-inflated distributions. Ecology 89:2953-2959.

Yoder, C.O., L.E. Hersha and B. Appel. 2009. Fish assemblage and habitat assessment of the Upper Connecticut River: preliminary results and data presentation. Final Project Report to: U.S. EPA, Region 1, Boston, MA. Center for Applied Bioassessment & Biocriteria. Midwest Biodiversity Institute. Columbus, OH.

Zipkin, E.F., J.A. Royle, D.K. Dawson and S. Bates. 2010. Multi-species occurrence models to evaluate the effects of conservation and management actions. Biological Conservation 134:479-484.

FirstLight Study Request #18

Impacts of the Turners Falls and Northfield Mountain Pumped Storage Projects on Littoral Zone Fish Habitat and Spawning

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

The goal of this study is to determine if project operations and water level fluctuations in the Turners Falls Project impoundment negatively impact anadromous and resident fish. This study complements a separate study request specific to American shad spawning and also on habitats affected by water level manipulations.

Specific objectives include:

1. delineate, quantitatively describe (e.g., substrate composition, vegetation type and abundance), and map shallow water aquatic habitat types subject to inundation and exposure due to project operations, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, etc. with very slight bathymetric change);
2. conduct analyses of the impacts of normal operations and the maximum permitted reservoir fluctuation range on the suitability of littoral zone habitats for all life stages of target species likely to inhabit these areas;
3. conduct field studies to assess timing and location of fish spawning;
4. conduct field studies to evaluate potential impacts of impoundment fluctuations on nest abandonment, spawning fish displacement, and egg dewatering; and
5. evaluate potential impoundment fluctuation ranges and how implementation of such changes would mitigate for identified impacts.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) has identified its mission as: working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Service has identified the following Northeast Regional goals to support the Service's mission and vision, the national Fisheries Program mission, and Service priorities: 1) conservation, and management of aquatic species: maintain, restore, and recover populations of species of conservation and management concern to self-sustaining levels; and 2) conservation and management of aquatic ecosystems: maintain and restore the ecological composition, structure, and function of natural and modified ecosystems to ensure the long-term sustainability of populations of species of conservation and management concern.

areas subject to dewatering and mapped relative to observations of fish nests, spawning fish, and egg deposits. During identified spawning periods for the target species, suitable spawning habitats subjected to daily project operational fluctuations will be surveyed to document the type and extent of project effects on nests or spawning habitat (e.g., nests of fallfish, lamprey, bass and sunfish) and observable eggs or larvae, relative to water level and other environmental conditions, including water temperature and water velocity in noted areas.

At least one year of data collection is necessary. A second year of study may be required should environmental (e.g., river discharge, air/water temperature) or operational conditions in the first year prove to be atypical during the study period (end of March through August).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight Power does not propose any studies to meet this need. Estimated cost for the study is moderate.

FirstLight Study Request #19

Impacts of the Turners Falls and Northfield Mountain Pumped Storage Project Operations on Tributary and Backwater Area Access and Habitats

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

One goal of this study is to determine if water level fluctuations from the Turners Falls and Northfield Mountain Pumped Storage projects result in a barrier(s) to fish movement in and out of tributaries and backwaters to the impoundments and riverine reaches below dams.

A second goal is to determine if water level fluctuations in the Turners Falls and Northfield Mountain Pumped Storage project impoundments impact water levels, available fish habitat and water quality in tributaries and backwaters to the impoundments and riverine reaches below dams, and if impacts are found, to ascertain how spatially far reaching they are and develop mitigation measures.

Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

Specific objectives include:

1. Conduct a field study of tributaries and backwaters, including water velocity and habitat data where appropriate, to evaluate potential impacts of impoundment fluctuation on fish access to tributaries and backwater areas. The study should also evaluate if changes in impoundment fluctuation range would mitigate for any identified impacts and if other mitigative measures would improve access.

2. Conduct a field study to examine potential impacts of impoundment fluctuations on water levels, available habitat and water quality in tributaries and backwaters. The evaluation should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the areas impacted by project operations.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

This requested study will facilitate the collection of information necessary to conduct effects analysis and to develop conservation measures to protect and enhance tributary and backwater access and valuable fish habitat. Maintaining connectivity between the mainstem of the Connecticut River and tributaries and backwaters is vital to the fish populations in these systems, as many fish species utilize these areas for spawning, rearing, refuge, and feeding.

Public Interest

The requestor is a natural resource agency.

Existing Information

To our knowledge, limited information exists related to this requested study.

Nexus to Project Operations and Effects

Project operations have the potential to impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, water level changes due to project operations could create conditions that could impede free movement of fish between tributaries/backwaters and the mainstem of the Connecticut River, thus limiting access to spawning habitat and/or growth opportunities. Additionally, water level changes could also alter tributary and backwater fish habitat quality, quantity, and also water quality, thus decreasing productivity and available habitat.

Methodology Consistent with Accepted Practice

Common tools to evaluate water level impacts would be used, including bathymetric mapping, substrate, depth and velocity measurements, and water quality information (dissolved oxygen, temperature, turbidity, and pH). Studies should be conducted throughout the year.

The study area for tributary and backwater fish sampling should cover all tributaries and backwaters within the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage projects. A second year of study may be required if first year data collection is

limited due to environmental or other conditions, or if river discharge in the first year proves to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight does not propose any studies to meet this need. Estimated cost for the study is moderate.

FirstLight Study Request #20

Impacts of Water Level Fluctuations on Riparian and Aquatic Vegetation Including Invasive Species and their Associated Habitats in the Turners Falls Dam Project Impoundment

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Conduct a study to quantify impacts of reservoir fluctuation on riparian, wetland, emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), littoral zone and shallow water aquatic habitats in the Turners Falls Dam impoundment.

Goals and Objectives

The goal of this study is to obtain baseline information on riparian, wetland, emergent and submerged aquatic vegetation, and associated shallow water aquatic habitats (subject to operational inundation and exposure to near exposure) known to occur in the project area. Information would be used to determine whether riparian, wetland, EAV and SAV, littoral, and shallow water (e.g., mid-river bars and shoals) habitats are impacted by current water level fluctuations permitted under the Turners Falls and Northfield Mountain Pumped Storage (NMPS) projects' licenses and whether these vegetation types and shallow water habitats can be protected and restored by modifications to project operations or other mitigation measures. This analysis needs to take into account existing and potential future limits on pond level fluctuations intended to limit recreation impacts, and the interactions of any changes in pond level fluctuation range or frequency and discharge changes under the new licenses of the Turners Falls and upstream projects. This information is needed to determine whether the project operations affect plants, habitat, and wildlife in the project area, whether aquatic vegetation and its habitats can be enhanced by modifications to project operations or other mitigative measures, and whether there is any unique or important shoreline or aquatic habitats that should be protected.

The specific objectives of the field study, at a minimum, include:

1. quantitatively describe and map wetland types within 200 feet of the shoreline, and describe associated wildlife;
2. delineate, quantitatively describe, and map all wetland types, including invasive species and wildlife observed (e.g., bald eagle nesting, water fowl nesting) within 200 feet of the shoreline, and the extent of this habitat if it extends beyond 200 feet; and
3. quantitatively describe (e.g., substrate composition, vegetation type and abundance) and map shallow water aquatic habitat types subject to project operation inundation and exposure, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, with very slight bathymetric change).

A second year of study may be required should river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

The field study should produce a habitat inventory report that includes:

1. the results of the field study in the form of maps and descriptions;
2. an assessment of project effects on wetland, riparian, littoral zone vegetation and shallow water habitats, invasive plant species, and wildlife habitat at the project;
3. recommendations for any necessary plant, habitat type, or wildlife, protection and/or invasive species control measures; and
4. recommendations for plant, habitat type, or wildlife protection and/or invasive species control measures, including riparian buffer restoration and protection and protection of key nest and roost trees for bald eagles.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Public Interest

The requestor is a resource agency.

Existing Information

Existing information in the PAD does not quantify EAV and SAV in this area, or other shallow aquatic habitat types and physical features (e.g., depths, substrates, wood structure) that are the environment for aquatic biota in the project area. The PAD does provide some limited monitoring data for 2012 (two locations) on water surface elevations that showed daily fluctuations, in the upper third of this impoundment, that varied over 4 feet on a daily cycling frequency, with fluctuations generally in the 2-foot range in low flow months for the data provided in the PAD. The current license does permit a greater pool elevation operational

fluctuation, up to a 9-foot change in elevation, based on the Turners Falls Dam water elevation. In the PAD, it is noted that these operational fluctuations under most circumstances at the Turners Falls Dam are within 3.5 feet.

In the PAD it is noted that FirstLight would like to expand its NMPS upper reservoir capacity (by up to 24 percent); how this may affect project operations and the habitats noted in this request is unknown. It is also noted that water is typically pumped to the upper reservoir in the evening and generation back to the river occurs once to twice daily, in daytime hours, based upon power needs and power value. Under current license conditions, provided set thresholds for minimum flow and Turners Falls Dam current license elevations are met, the NMPS may operate with no restriction in timing, frequency, or magnitude for pumping or generation. No data were provided on the operation of the NMPS plant over time relative to data on pumping and generation on an hourly basis averaged values were provided over monthly periods. It is unclear what the actual timing, frequency and magnitude of these NMPS operations are over the course of a year and how that relates to aquatic plant species establishment, growth, survival, littoral zone or other shallow water habitat fish spawning periods and their effects on these fishes (reproduction success and subsequent recruitment, e.g., bass and fall fish nests) in available and utilized habitat, and how the quantity and quality of these shallow water habitats are effected by project operational manipulation/alteration, as currently permitted or proposed.

The PAD provides lists of plant and wildlife species whose native ranges overlap with the project area, but it does not provide any baseline information on known occurrences of these species in the wetlands, riparian, littoral and shallow water habitats, within or adjacent to the project area. Plant and wildlife occurring in these habitats may benefit from protection, mitigation, and enhancement (PMEs) measures, given the potential effects of continuing the current semiautomatic peaking operating regime. In addition, a large-scale sediment discharge from NMPS resulted in regulatory actions by FERC, the EPA and MADEP in 2010. Continuing and as yet unresolved management plan measures relative to sediment and NMPS project operations are further concerns for shallow water, littoral zone, and wetland habitats.

The Atlantic States Marine Fisheries Commission, Atlantic Coast Diadromous Fish Habitat: A Review of utilization, threats, recommendations for conservation, and research needs (ASMFC 2009), contains a review of habitat information for these species. Recommendations in this report include: Maintain water quality and suitable habitat for all life stages of diadromous species in all rivers with populations of diadromous species.

Nexus to Project Operations and Effects

Water level fluctuations due to project operations could affect EAV and SAV habitat as well as the quantity and quality of littoral and shallow water habitat. These operational water level fluctuation effects are expected to impact fish species use of these habitats and may affect spawning fishes reproductive success and subsequent population recruitment including but not limited to American shad, blueback herring, sea lamprey, fall fish, and bluegill, which spawn in mid-to-late spring through early summer in areas subject to daily or more frequent water level fluctuations.

The current operating mode, as well as the unknowns with proposed upper reservoir expansion, may affect wetland riparian, littoral and other shallow water habitats, and promote the introduction and expansion of invasive plant species through fluctuating water levels. A study that explains the relationship between the proposed mode of operation and the type and quantity of wetland, riparian, littoral, shallow water habitats, and invasive species affected would help inform a decision on the need for protection and/or control of these resources in the license.

Riparian buffers provide for river bank stability, reduction in nutrient and sediment from runoff, shading and reduced solar heating of river waters and wildlife habitat (including eagle nesting and roosting habitat) and movement corridors. Management of the project's shorelines are within the scope of project review and a Shoreline Management Plan is likely to be required. Incorporation of riparian resource protection and enhancement into this plan will require baseline information on existing conditions.

Methodology Consistent with Accepted Practice

The PAD currently contains maps portraying general wetland types from the Cabot Station tailrace upstream to the Vernon Dam. In addition, the Service understands that detailed bathymetry exists for the Turners Falls impoundment. The proposed study should utilize this existing information in conjunction with field surveys designed to describe the characteristics of each mapped wetland, riparian, littoral and shallow water habitat, including plant species composition, relative abundance/density, habitat quality, and land use. These surveys should be conducted to describe these habitats at the lowest water level operational range permitted on a daily operation schedule, under low flow conditions. Information collected should include:

1. plant species composition, and their relative abundance/density and condition/structure (e.g., seedlings);
2. structured data, including estimates of average heights and aerial cover of each vegetation layer (specifically denoting invasive species);
3. aquatic habitat substrate composition, quantity (i.e., percent types and area), wood structure (relative abundance measure applied by area), water depths (inundated, exposed, and water less than one foot);
4. predominate land use(s) associated with each cover type;
5. wildlife sightings should be noted; and
6. field-verified wetland, riparian, and littoral and shallow water habitats and invasive species occurrences should be geo-referenced as polygons and overlain on orthophoto at a suitable scale.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

In the PAD, FirstLight identified impacts of the project operations on wetlands, riparian and littoral zone habitat as a potential issue to be addressed in relicensing. FirstLight proposed wetland vegetation mapping, but additional analysis as described above is needed to understand the impacts of the project on these resources and habitats.

A wetlands, riparian, littoral/shallow water, invasive species inventory, of the scope envisioned, would likely require six to eight months to complete and cost $40,000 to $50,000.

REFERENCES

Atlantic States Marine Fisheries Commission. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations, for conservation, and research needs. Habitat Management Series #9. Washington, D.C.

FirstLight Study Request #21

Water Quality Monitoring
(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

Determine the current water quality of the Connecticut River within the project area.

The specific objectives of this study are as follows:

1. Characterize water quality in the Turners Falls impoundment, bypass reach, canal and below the confluence of the bypass reach and canal discharge.
2. Evaluate the potential effects of project operation on water quality parameters such as temperature and dissolved oxygen (DO) in conjunction with various other water uses.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to water quality within the Turners Falls Project area, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requestor is a natural resource agency.

upstream of the confluence with the Deerfield River. In order to ensure that data are collected during a time of important biological thresholds and anticipated "worst case" conditions for DO (low flow, high temperature, antecedent of any significant rainfall event), we recommend deploying continuous data loggers at all six locations, with biweekly vertical profiles taken at the deep impoundment location from April 1 through November 15. Results should include date, time of sampling, sunrise time, GPS location, generation status (estimated flow through canal and bypass reach), precipitation data, water temperature, DO concentration and percent saturation.

If river flow and temperature conditions are representative of an "average" or "low" water year, one year of data collection should be sufficient to perform the study. If conditions are not representative (i.e., a "wet" or cool year), a second year of data collection may be necessary.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Cost would depend on the specific methodology chosen. If continuous data loggers are installed at all six locations and biweekly vertical profiles taken at the deep impoundment location from April 1 through November 15, the estimated cost of the water quality study is moderate. It is expected to take two technicians approximately one day to deploy the loggers, twelve days to collect the vertical profiles, one day to remove the loggers, one day to download the data, and five days to write the report.

In the PAD, the Applicant proposes to assess the effects of the Turners Falls and the Northfield Mountain Pumped Storage (NMPS) project operations on DO and temperature by continuously monitoring DO and temperature at locations within the project areas and gathering vertical profiles within the Turners Falls impoundment and NMPS upper reservoir.

FirstLight Study Request #22

Climate Change as it Relates to Continued Operation of the Vernon, Bellows Falls, Wilder, Northfield Mountain Pumped Storage, and Turners Falls Projects

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Goals and Objectives

The goal of this study is to determine how climate change relates to the continued operation of the Vernon, Bellows Falls, Wilder, Northfield Mountain Pumped Storage (NMPS), and Turners Falls projects.

The objectives of this study are:

1. Quantify the amount of thermal loading contributed by each respective impoundment (including the NMPS upper reservoir).
2. Using climate change prediction models, calculate how much warmer the project impoundments are projected to get in the next 30-50 years.
3. Model the effect of various project modifications on river temperature under current conditions and climate change predictions (e.g., converting to run-of-river, deep-water releases, dam removal, large-scale riparian revegetation, etc.).
4. Using climate change prediction models, determine if the projects actually provide an environmental benefit with respect to mitigating against climate change impacts (vis a vis warming of air and water temperatures) by producing low greenhouse gas emitting energy. The NMPS assessment must be based on net energy production (i.e., NMPS generates 1,143,038 MWh annually, but consumes 1,567,506 in its pumping operations, for a net consumption of 424,468 MWh annually).
5. Determine how climate change predictions will impact management of high flow events at the three projects and evaluate if changes to dam structures would mitigate adverse impacts of the existing flood management protocols.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to climate change, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize deep headpond drawdowns associated with the loss of stanchion logs during high flow events, which are predicted to increase due to climate change.
3. Minimize project-related sources of thermal increases to Connecticut River waters to mitigate against predicted climate change impacts.

The Service, along with the National Oceanic and Atmospheric Administration (NOAA) and the Association of Fish and Wildlife Agencies, developed a draft *National Fish, Wildlife and Plants Climate Adaptation Strategy* (Strategy) in 2012. The public comment period closed on March 5, 2012, and the agencies are working to finalize the document. Goal #7 of the Strategy calls for reducing non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate. The Strategy notes that some stressors (such as habitat loss and fragmentation and pollution) "are not only some of the things decision makers can control, they are also likely to interact with climate change to magnify negative impacts on fish, wildlife, and plants."

Goal #7 contains a number of strategies and associated actions, including:

Strategy 7.1: Slow and reverse habitat loss and fragmentation

Actions:

1. Consider application of offsite habitat banking linked to climate change habitat priorities as a tool to compensate for unavoidable onsite impacts and to promote habitat conservation or restoration in desirable locations.
2. Identify options for redesign and removal of existing structures/barriers where there is the greatest potential to restore natural processes.

Strategy 7.2: Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through…water resource planning, pollution abatement…

Actions:

1. Work with….water resource…planners to identify potentially conflicting needs and opportunities to minimize ecosystem degradation resulting from development and land and water use.
2. Reduce existing pollution and contaminants and increase monitoring of air and water pollution.
3. Increase restoration, enhancement, and conservation of riparian zones and buffers in agricultural and urban areas to minimize non-point source pollution.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq.*), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq.*), and the Federal Power Act (16 U.S.C. §791a, *et seq.*).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains no information relative to climate change and how climate change predictions may impact future operation of the hydroelectric plants, nor of how the projects either mitigate for or exacerbate predicted climate change impacts to freshwater ecosystems.

TransCanada's PAD provides a summary of water quality data collected in 2012. Table 1 below is a synthesis of the temperature data collected by TransCanada. It should be noted that the upper and mid-impoundment stations at each project represent the average of temperature readings taken over the entire water column, while the continuous loggers (Lower Cont. and TR) were located near the water surface. These data indicate that from the upstream end of the Wilder headpond to the Vernon tailrace, water temperature increased approximately 6°C.

Table 1. Median water temperature at monitoring stations located within the impoundments and tailraces of the three hydropower projects.

	Median Water Temperature °C			
Project	Upper Imp.	Mid-Imp.	Lower Cont.	TR
Wilder	20.86	21.83	24.08	23.59
Bellows Falls	22.43	23.67	24.86	24.38
Vernon	23.81	24.49	26.73	26.35

Relative to existing flood management protocols at each station, TransCanada's PAD identifies that all three dams utilize stanchion bays (two at Vernon, three at Bellows Falls, and four at Wilder). When inflows to each dam reach certain levels, the stanchion bays are removed, and cannot be replaced until inflows subside. The depth of these bays and the flows at which they are removed are outlined in Table 2 below.

Table 2. Summary of pertinent stanchion bay information for the Vernon, Bellows Falls, and Wilder projects.

Project	Stanchion Height (feet)	Flow Complete Removal	Triggering Stanchion
Wilder	17	145,000 cfs	
Bellow Falls	13	50,000 cfs	
Vernon	10	105,000 cfs	

The PAD provides no information on the history of stanchion removal at any of the projects (frequency, duration, timing), nor a discussion of how predicted climate change might alter management of the stanchion bays in the future (with respect to the frequency and seasonality of occurrence). There also is no discussion of potential impacts to headpond resources that occur as a result of stanchion bay removal. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations with respect to the Service's management goals and objectives, including those identified in the Strategy.

Data provided by NOAA, Climate Data Center, illustrates long-term increasing air temperatures in the Northeast (Figure 1). Long-term, monthly mean water temperature data for the Vernon Dam impoundment, monitored by Vermont Yankee, has shown significant differences over time (ANOVA analyses, $P < 0.05$) that when plotted and further analyzed by linear regression, show a significant increasing trend for the period 1974–2010 for the months of January, September, and October (Figure 2). These analyses were performed with data from Vermont Yankee, analyzed by the Massachusetts Department of Environmental Protection.

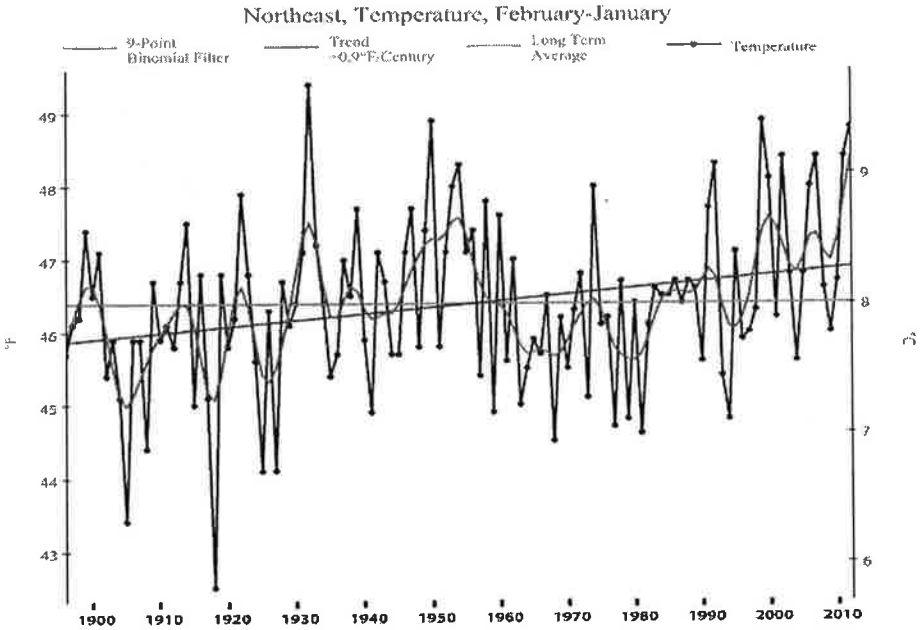

Figure 1. NOAA National Climate Data Center, Northeast 12-month average temperature for the period 1896 through 2012.

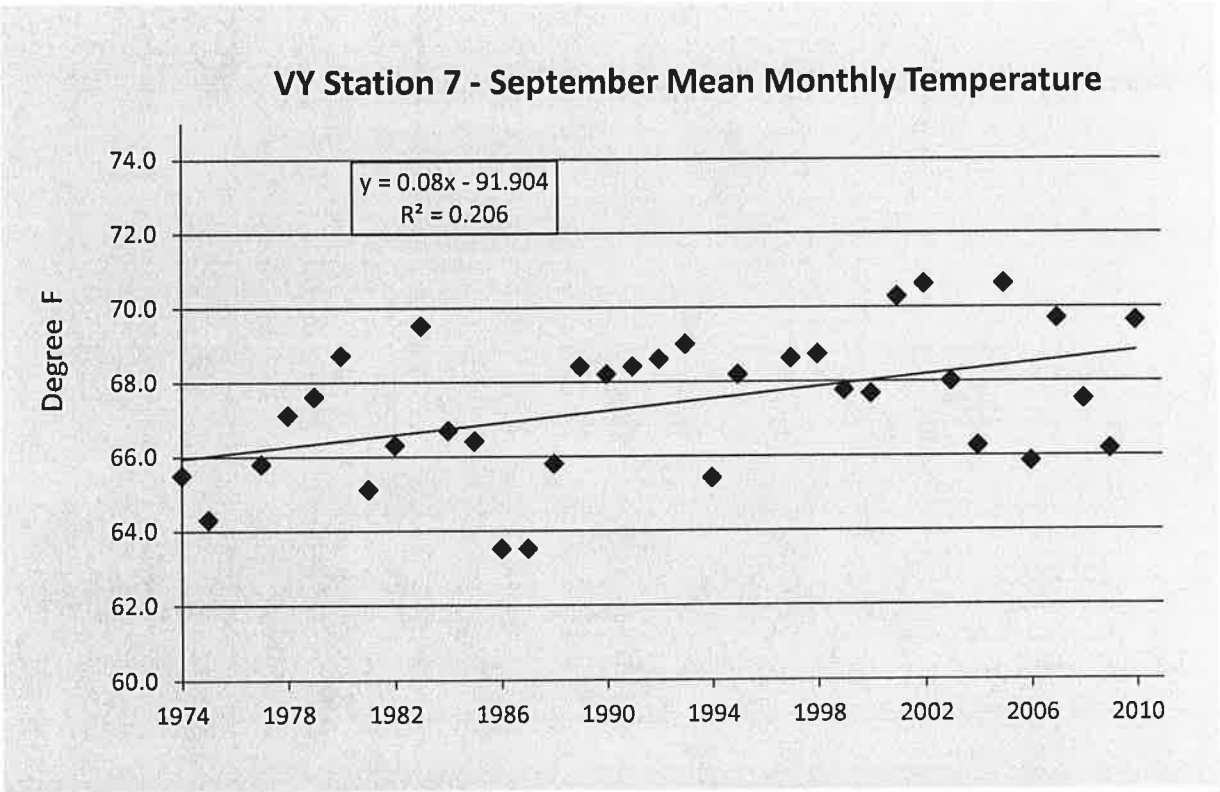

Figure 2. A plot of September's mean temperatures for Vermont Yankee's Station 7 (excludes outlier 1996 data point) for the period 1974 through 2010.

The PAD for the Turners Falls and NMPS projects provides a summary of existing water quality data compiled by FirstLight, including water temperature data obtained from the Service. The PAD also notes a 1991 study by the former licensee that modeled thermal effects of pumping to the upper reservoir. That model reported a maximum temperature difference attributable to NMPS operation of 0.21°C in the Turners Falls reach of the Connecticut River in low flow (4,000 CFS) simulation.

Nexus to Project Operations and Effects

The four mainstem projects have very long impoundments capable of storing large volumes of water (Table 3 below). These impoundments effectively have converted large portions of the Connecticut River into a series of in-river "lakes." Because water velocities slow in these impounded sections of the river, it allows for increased thermal loading and resultant higher water surface temperatures than in free-flowing sections of the river.

Table 3. Relevant characteristics of the reservoirs behind the Wilder, Bellows Falls, Vernon, Turners Falls dams and NMPS.

Project	Headpond Length (miles)	Gross Storage Volume (acre-ft.)	Average Depth (ft.)	Surface Area (acres)	Flushing Rate (days)
Wilder	45	34,350	11	3,100	3
Bellows Falls	26	26,900	10	2,804	<2
Vernon	26	40,000	16	2,550	2
Turners	20	21,500		2,110	
NMPS	n.a.	17,,050		246	n.a.

Depending on where the hydropower intakes withdraw water, these warmer surface waters may be discharged downstream, raising the temperature of those waters as well (the data in Table 1 above suggest that the projects do draw water from the upper levels of the reservoirs). This effect may be felt for miles downstream. If there are a series of impoundments (like on the Connecticut River), the cumulative impact is an overall warming of the river. Even small run-of-river dams have been shown to elevate downstream water temperature (Lessard and Hayes 2003; Saila *et al.* 2005). The most recent climate change prediction models specific to the Northeast forecast warmer air temperatures, more frequent high precipitation events, more heat waves, and an increase in the incidence of short-term droughts (Karl *et al.* 2009).

Resource concerns related to this project effect include the potential impacts to populations (reductions in abundance, structure, condition) or loss of species not tolerant of increases in temperature and other effects related to physiology such as energetic costs with warmer temperatures (Leggett 2004). As one example, American shad restoration target numbers for fish passage at mainstem dams into upstream historic habitat could be negatively impacted from artificially increased water temperatures. Water temperature has been identified as a factor in the timing (i.e., duration) of this species migration, as well as its role in gonad development and spawning (Glebe and Leggett 1981; Leggett 2004). These factors can be logically reasoned to result in accelerated rates of energy reserve use and a reduced migration window, possibly reducing the ability of fish to reach up-river habitats and further reducing the ability to survive downstream outmigration.

With respect to project operations during high flow events, all TransCanada projects have stanchion bays that are used to manage water during high flow events. Each time these stanchion bays are removed, the headponds are lowered substantially (from 10 to 17 feet, depending on the project) and must remain lowered until inflows subside. Depending on the timing and duration of these deep drawdowns, headpond resources could be negatively impacted.

All of the dams also contain other mechanisms for managing flows, such as tainter gates, sluice gates, roller gates, skimmer gates and hydraulic flood gates. All of these gates have an advantage over stanchion bays in that they do not require flows to subside significantly before they can be closed to return impoundment levels back to normal. One climate change prediction for the

Northeast is that we will see more frequent high precipitation events which will result in high flow conditions on rivers. Therefore, it is likely that the stanchion bay removal protocol will have to be employed more frequently in the future.

Methodology Consistent with Accepted Practice

1. In order to quantify the amount of thermal loading contributed by each respective impoundment, detailed bathymetry will need to be collected. This bathymetry, combined with storage volume, tributary hydrology, and project operations, should be used to calculate the thermal loading of each headpond. The individual and cumulative increase in surface water temperature due to the impoundments should then be used to predict future warming based on climate change models.

2. Analyze different mitigation strategies to understand which have the greatest benefit in terms of building resilience against the impacts of climate change on water temperature. Potential scenarios to analyze include converting the projects to run-of-river, implementing deep-water releases, removing one or more dams, conducting large-scale riparian revegetation, etc.).

3. Input to climate change models the amount of GHG emissions that would be generated if fossil fuel plants were producing the equivalent amount of net energy as the five hydropower projects to determine the impact on air and surface water temperatures.

4. Climate change prediction model output should be assessed to determine if the frequency and timing of high flow events are likely to change in the future. If high flow events that necessitate initiating the stanchion bay removal protocol are predicted to increase in frequency and/or shift in timing, the Applicant should evaluate structural and/or operational alternatives that would mitigate adverse impacts of the existing flood management protocols.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the thermal loading analysis would be low to moderate. Collecting bathymetry in the three TransCanada headponds would take two staff members less than one week to collect (it took the Kansas Biological Survey two days to collect bathymetry at a 3,500-acre lake; Jakubauskas *et al.* 2011). Bathymetry for the Turners Falls pool and NMPS upper reservoir already exist. The remaining work would be desk-based, loading relevant information into an appropriate thermal loading model to compute the estimated thermal loading of each headpond and then comparing this information to surface water data from climate change prediction models.

The high flow flood protocol study is a desktop analysis that should require low cost and effort. Climate change models already exist and that output would be downloaded and analyzed. The remaining analysis requires a review of alternative means of managing flows without the use of stanchion bays.

The Applicant did not propose any studies to meet this need in the PAD.

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Jakubauskas, M., J. deNoyelles and E.A. Martinko. 2011. Bathymetric and Sediment Survey of Elk City Reservoir, Montgomery County, Kansas. Applied Science and Technology for Reservoir Assessment (ASTRA) Program, Lawrence, KS. Report No. 2010-01.

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Saila, S.B., D. Poyer and D. Aube. 2005. Small dams and habitat quality in low order streams. Wood-Pawcatuck Watershed Association. April 29, 2005. 16 pp.

FirstLight Study Request #1

Model River Flows and Water Levels Upstream and Downstream from the Turners Falls Project and Integrate Project Modeling with Upstream and Downstream Project Operations

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Develop a river flow model(s) that is designed to evaluate the hydrologic changes to the river caused by the physical presence and operation of the Turners Falls Hydroelectric Project and the interrelationships between the operation of all five hydroelectric projects up for relicensing (i.e., P-1889 Turners Falls Hydroelectric Project, P-2485 Northfield Mountain Pumped Storage (NMPS), P-1904 Vernon Hydroelectric Project, P-1855 Bellows Hydroelectric Project, P-1892 Wilder Hydroelectric Project) and river inflows. The flow studies should assess the following topics:

1. Conduct quantitative hydrologic modeling of the hydrologic influences and interactions that exist between the water surface elevations of the Turners Falls Project impoundment and discharges from the Turners Falls Dam and generating facilities and the upstream and downstream hydroelectric projects. Data inputs to and outputs from the model(s) should include:

    a. withdrawals from the Turners Falls impoundment by NMPS;
    b. discharges to the Turners Falls impoundment by NMPS;
    c. discharges into the Turners Falls impoundment from the Vernon Project and other sources;
    d. existing and potential discharges from the Turners Falls Project generating facilities and spill flows;
    e. existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the Turners Falls impoundment and downstream flows from the project;
    f. existing and potential required minimum flows and/or other operation requirements at each of the four upstream projects; and
    g. minimum discharge flows ranging between 2,500 and 6,300 cfs in the bypass reach from April 15 through June 22 to support spawning, rearing, and outmigration of shortnose sturgeon at Rock Dam.

2. Document how the existing and potential outflow characteristics from the four upstream projects affect the operation of the Turners Falls Project, including downstream flow releases and Turners Falls impoundment levels.

3. Assess how the operation of the existing Turners Falls Project and upstream projects affect Holyoke Project (P-2004) operations, including:

a. how Turners Falls Project flow fluctuations affect Holyoke impoundment water levels, with emphasis on the influence of the water levels on federally listed Puritan tiger beetle habitat at Rainbow Beach in Northampton, Massachusetts, and assess what changes would be needed in Turners Falls operations to stabilize water levels at Rainbow Beach;
b. how Turners Falls Project operations affect Holyoke Project discharges and what changes in Turners Falls operations would be needed to reduce fluctuations in the discharges from the Holyoke Project.

4. To the extent predictable and practical, incorporate the potential effects of climate change on project operations over the course of the license.

Goals and Objectives

Determine the extent of alteration of river hydrology caused by operation of the project and the interactions between upstream project operations, Turners Falls operations and downstream operations at the Holyoke Project. The models will provide necessary information on what changes can be made to each of the five projects' flow releases and/or water levels restrictions, and how those changes affect downstream resources.

Specifically for the Turners Falls Project, continuous minimum discharge flows in its bypass reach need to be no less than 2,500 cfs during shortnose sturgeon spawning, rearing, and outmigration (April 15–June 22). Incorporating these parameters into the model will inform what changes, if any, need to be made to operations of upstream projects to accommodate such flows.

As other specific modifications of the operations of each of the projects are identified based on results of other requested studies, these desired conditions will need to be input into the models to assess how each change affects that project and other project operations and the implications of those changes on other resources and/or the ability to achieve desired operational changes at other projects.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.
3. Assist the Federal Energy Regulatory Commission to ensure that the continued operation of the facility is not likely to jeopardize the continued existence of shortnose sturgeon.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore, diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by project operations.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.
4. Ensure that project operations are not likely to jeopardize the continued existence of shortnose sturgeon.
5. Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing within the Montague spawning area (i.e., Rock Dam and Cabot Station spawning sites and associated early life stage rearing areas).

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information

Available information in the PAD does not indicate how project operations have altered downstream hydrology, which may affect resident and migratory fish, macroinvertebrates, rare, threatened, and endangered species, aquatic plants and other biota and natural processes in the Connecticut River from below the Vernon Dam downstream to the Holyoke Dam.

Information in the PAD also does not reflect data analyzed in Kynard *et al.* 2012, which identifies minimum discharge thresholds for shortnose sturgeon spawning and rearing at the Rock Dam spawning site. Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period (April 27–May 22) (Kynard *et al.* 2012, chapter 3). In 1995 at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage sturgeon captured; spawning period was 17 days), even though no spawning was detected at Rock Dam (Kynard *et al.* 2012, chapter 3). Discharges in 1995 at Rock Dam had dropped below 2,500 cfs by March 26 (Kynard *et al.* 2012, chapter 3), indicating that even though 1995 saw the largest number of pre-spawning adults, none spawned at Rock Dam. This may indicate the need to have adequate flow well in advanced of spawning. Discharge reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning cite and not return even if flow increased to acceptable levels later during the spawning period. Researchers observed that

substrate did not change during fluctuating flows and thus cessation of spawning is likely due to velocities falling below the range preferred by gravid females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard *et al.* 2012, chapter 3). These data represent the best available scientific information and indicate that the current minimum flow thresholds at the project are not adequate for the protection of endangered shortnose sturgeon. All modeling efforts described above must incorporate the identified minimum flow and temporal parameters.

Nexus to Project Operations and Effects

The Turners Falls Project is currently operated with a seasonally varying minimum bypass flow (400 cfs from May 1 through July 15, then 120 cfs through the winter until river temperature rises to ≥ 7°C) and year-round minimum flow below the project of 1,433 cfs. The project operates as a daily peaking project, often with large, rapid, daily flow fluctuations between the minimum and project capacity (15,928 cfs) and fluctuations in headpond elevation (175' to 186' MSL). These changes affect biotic habitat and biota upstream and downstream of the project. Project operations and potential changes to operations to mitigate impacts are influenced by inflows and operations of upstream peaking projects and NMPS operations, and potential changes in operations of each project could affect the ability to achieve desired operational changes at other projects. Results of river flow analyses will be used to develop flow-related license requirements and/or other mitigation measures.

Methodology Consistent with Accepted Practice

River hydrology statistics and modeling are commonly employed at hydroelectric projects to assess implications of project operations on the river environment.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Level of effort and cost of model development are expected to be moderate, but to be valuable in developing license conditions, the model(s) will need to be run under various scenarios throughout the relicensing process to assess the implications of changes to the operations of each project on other projects and other resources. Therefore, ongoing consultation and re-running of the model(s) are likely to be needed throughout the relicensing process. The modeling exercise will also require coordination and cooperation between FirstLight and the upstream licensee to assure that the model inputs and outputs can be accurately related.

We would anticipate that the expected level of effort and anticipated costs will be comparable to those experienced on similar Federal Energy Regulatory Commission relicensing projects of this size (e.g., Conowingo, FERC No. 405).

REFERENCES

Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

FirstLight Study Request #2

Instream Flow Habitat Assessment Downstream of Cabot Station
(Turners Falls, P-1889)

Conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species. The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, and white sucker.

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources from the Cabot tailrace of the Turners Falls Project downstream to the Route 116 bridge in Sunderland, Massachusetts. Specifically, the objective of the study is to conduct an instream flow habitat assessment of the impacts of a range of flows on the wetted area, and on the quantity and location of aquatic habitat for key species, including the impacts of hydropeaking flow fluctuations.

The study should include non-steady flow approaches to assess effects of within-day flow fluctuations due to peaking power operations on target fish species and benthic invertebrate communities. Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, white sucker and walleye.

For shortnose sturgeon, the flow study will need to evaluate bottom velocities in spawning and rearing areas during discharge conditions normally observed from April 15 to June 22. Protection of shortnose sturgeon spawning will necessitate establishment of discharges that create bottom velocities suitable for spawning and rearing over a sustained period of time and avoid dramatically fluctuating flows. To protect shortnose sturgeon rearing, adequate discharge without dramatic flow fluctuations is needed to ensure the rearing shoals are wetted and velocities are sufficiently protective for early life stage (ELS) rearing.

Field verification will be necessary to confirm the flow modeling results that identify the flows needed to provide sustained bottom velocities for spawning also maintain flows, depths, and water release regime adequate for spawning and rearing.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.

2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.

2. Provide an instream flow regime that meets the life history requirements of resident and migratory fish and wildlife (including invertebrates such as freshwater mussels) throughout the area impacted by project operations.

3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

4. Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a fish and wildlife resource agency.

Existing Information

Presently, FirstLight is required to release 1,433 cfs below the project. Information included in the PAD does not provide a detailed description of how this minimum flow was established and the Service is not aware of any previously conducted studies that evaluated the adequacy of this minimum flow in protecting aquatic resources in the 10+ miles of riverine habitat below the Cabot Station. Therefore, in order to fill this important information gap, an empirical study is needed to provide information on the relationship between flow and habitat in the Connecticut River downstream of the Cabot tailrace. Results will be used by the Service to determine an appropriate flow recommendation.

Kynard *et al.* (2012, chapter 3) examined the effects of water manipulation at the Turners Falls project on shortnose sturgeon spawning over the course of 17 years. This data does not support 1,433 cfs as an adequate minimum flow to support successful shortnose sturgeon spawning at

Cabot Station. Peaking operations at Cabot Station cause discharge fluctuations to rapidly change bottom velocities from 0.4 m/s to 1/3 m/s over 30 minutes (Kynard *et al.* 2012, chapter 3). Shortnose sturgeon have not evolved to adapt to such artificial rapid changes in velocities and therefore continue to spawn during fluctuations, even though conditions may be unsuitable and likely result in high egg mortality. During the 10 years when spawning succeeded at Cabot Station, discharge flow decreased to less than 35,460 cfs by April 29. The lowest discharge level observed while females remained on the spawning site was 4,700 cfs. Spawning behavior was not monitored during Cabot Station discharges at or below 3,500 cfs, so it is unclear what the minimum flow threshold is for spawning at Cabot Station. During naturally low flow periods, when water is held in storage for generation at a later time, tailrace shoals (including shoals along river banks), likely used by shortnose sturgeon ELS were exposed (observed during years 1995, 1998-1999, 2004) and may have resulted in ELS stranding and exposure mortality (Kynard et al 2012, chapter 3). Researchers observed that shoal exposure began when river flow below Cabot Station dropped below 7,062 cfs (Kieffer and Kynard 2007). Thus, total flow at Cabot, which may include flow from the Turners Falls Dam or Station 1, must be at least 7,062 cfs to both support adequate bottom velocities and prevent shoal exposure.

Furthermore, the emergency water control gates at Cabot Station that are used to sluice trash from the canal and balance canal flows spill large amounts of water. These large spill events create a plume of turbid turbulent flow, which cause some females to leave the area. These spill events scour bottom sediments which are then carried downstream over the spawning and rearing shoals where an entire year class of early life stages may be destroyed (Kynard *et al.* 2012, chapter 3). Information included in the PAD does not address adequate flows for shortnose sturgeon spawning and rearing. Results of the requested modeling will be used by the Service to determine an appropriate flow recommendation.

Researchers have also looked at suitable depth and velocity habitat for spawning (Kieffer and Kynard 1996; Kynard *et al.* 2012, chapter 3). Spawning sites are characterized by moderate river flows with average bottom velocities between 0.4 and 0.8 m/s (Hall *et al.* 1991, Kieffer and Kynard 1996; NMFS 1998). Water depth at the spawning site appears to be a less important habitat feature than substrate type and flow. A recent study by Kynard *et al.* (2012, chapter 6) demonstrated that females in an artificial stream will readily accept a shallow water depth of 0.6 m, with a rubble bottom, and 0.3–1.2 m/s bottom velocity. In addition, although eggs and embryos can likely tolerate very low depths, researchers measuring water depths between Turners Falls Dam and Cabot Station in order to recommend minimum flows suitable for an escape route for shortnose sturgeon trapped in the Turners Falls Dam plunge pool used a minimum depth of 1.5 x adult body depth. Because adults spawning in an artificial spawning channel frequently positioned themselves on top of one another (Kynard *et al.* 2012, Chapter 6), a minimum depth to facilitate spawning within the known Cabot Station spawning area is 3.0 body depths, or 19.2 inches.

Nexus to Project Operations and Effects

The project is currently operated with a minimum flow release that was not based on biological criteria or field study. Further, the project generates power in a peaking mode, resulting in significant within day flow fluctuations between the minimum and project capacity on an hourly

or daily basis. The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985; Blinn *et al.* 1995; Freeman *et al.* 2001). There are more than ten miles of lotic habitat below the project's discharge that are impacted by peaking operations at Cabot Station. This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for migratory fish such as American shad and federally endangered shortnose sturgeon. Shortnose sturgeon larval migrants initially become bottom dwellers and transition from living off of yolk sacs to orally feeding, which is a critical stage in their life history. While the existing license does require a continuous flow of 1,433 cfs below the project (0.20 cubic feet per second flow per square mile of drainage area - cfsm), that is equal to only 40 percent of the Aquatic Base Flow.[1] this flow does not sufficiently protect the aquatic resources, including endangered species, in this substantial reach of river, especially in the context of the magnitude, frequency, and duration of changes in habitat that likely occur between minimum and generation flows.

Results of the flow study will be used by the Service to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources below the project.

Methodology Consistent with Accepted Practice

Instream flow habitat assessments are commonly employed in developing plant operational regimes that will reduce impacts or enhance habitat conditions downstream of hydroelectric projects.

The Service requests a flow study be conducted at the project. Given the length of the river reach (10+ miles) impacted by project operations, we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[2]and has been accepted by the Federal Energy Regulatory Commission (Commission) in other licensing proceedings.[3]

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data along transects located in the reach of river below Cabot Station. The measurements should be taken over a range of test flows. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species identified by the fisheries agencies. Habitat modeling using standard PHABSIM one dimensional modeling is acceptable for the river channel downstream from the railroad bridge below the mouth of the Deerfield River. The area from the Cabot Station discharge to the railroad bridge should be modeled using two dimensional 2D modeling to better characterize flows and velocities in this complex channel area.

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[1] The Aquatic Base Flow equates to the August Median Flow as determined using unregulated hydrography or on drainage area at the project site (0.5 cfs per square mile of drainage area) if unregulated hydrography is unavailable.

[2] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

[3] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pp. 7-8, October 2007.

The types of data collected with this study should be sufficient to perform a dual-flow analysis and habitat time series or similar approaches that will permit assessment of how quality and location of habitat for target species changes over a range of flows between existing minimum flow and maximum project generation flows.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field work for instream flow studies can be reasonably extensive but will depend on consultation with the Applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-field work data analysis would result in a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to those experienced on similar Commission relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

REFERENCES

Blinn, W., J.P. Shannon, L.E. Stevens and J.P. Carder. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14: 233–248.

Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management 5: 330–339.

Freeman, M.C, Z.H. Bowen, K.D. Bovee and E.R. Irwin. 2001. Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecological Applications 11: 179–190.

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Kieffer, M.C. and B. Kynard. 1996. Spawning of the shortnose sturgeon in the Merrimack River, Massachusetts. Transactions of the American Fisheries Society 125:179-186.

Kieffer, M.C. and B. Kynard. 2007. Effect of Water Manipulation by the Turners Falls Dam Hydroelectric Complex on Rearing Conditions for Connecticut River Shortnose Sturgeon Early Life Stages. S.O. Conte Anadromous Fish Research Center, Turners Falls, MA.

Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

National Marine Fisheries Service (NMFS). 1998. Recovery plan for the shortnose sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

FirstLight Study Request #3

Instream Flow Habitat Assessment of the Turners Falls Bypassed Reach

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources in the bypassed reach between Turners Falls Dam and the Cabot Station discharge. Specifically, the objective of the study is to conduct an instream flow habitat study to assess the impacts of the range of the proposed project discharges on the wetted area and optimal habitat for key species.

Target fish species include the federally endangered shortnose sturgeon, American shad, fallfish, white sucker, freshwater mussels and benthic macroinvertebrates.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources within the Turners Falls bypassed reach, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide a flow regime in the bypassed reach that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels), federally listed species, and diadromous fishes.
3. Minimize the current negative effects of project operations on shortnose sturgeon spawning and rearing within known spawning areas of the bypassed natural river reach (i.e., the Rock Dam).
4. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as

amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a natural resource agency.

Existing Information

The Turners Falls Project bypasses a 2.7-mile-long section of the Connecticut River. Presently, the only required spill releases from the Turners Falls Dam to the bypassed reach are 400 cfs from May 1 through July 15, and 120 cfs from July 16 until the river temperature reaches 7°C.

In addition to these flows provided at the Turners Falls Dam, the bypassed reach receives flow from one small tributary (the Fall River, drainage area of 34.2 square miles), which enters the mainstem approximately 0.16 mile below the dam. The bypassed reach also receives the discharge from Station 1, when it is generating (typically when there is flow in excess of Cabot Station's needs). This discharge enters the bypassed reach approximately 0.9 mile below the dam.

Available information in the PAD does not indicate how project operations have altered downstream hydrology, habitat quantity and quality, and water quality, which may affect resident and migratory fish, macroinvertebrates, listed species, aquatic plants and other biota and natural processes in the Connecticut River from below the Turners Falls Dam downstream to the Cabot Station discharge. The PAD also provides no detailed description of the physical or biological characteristics of the bypassed reach.

Limited information exists on the adequacy of the existing bypass flow regime to protect water quality and aquatic life. However, there is existing information (not included in the PAD) relative to minimum flows necessary for shortnose sturgeon spawning and rearing at the Rock Dam spawning site (Kynard *et al.* 2012). Spawning success was observed at Rock Dam when discharge was between 2,500 cfs and 22,000 cfs during the spawning period of April 27 through May 22 (Kynard *et al.* 2012, chapter 3). In 1995, at the Cabot spawning area, the greatest level of spawning and spawning success occurred (i.e., 21 late stage females present, 342 early life stage sturgeon captured, and the longest spawning period of 17 days) even though no spawning was detected at Rock Dam (Kynard *et al.* 2012, chapter 3). Discharges in 1995 at Rock Dam had dropped below 2,500 cfs by March 26 (Kynard *et al.* 2012, chapter 3), which may indicate the need to have mitigated flow well in advance of spawning. Flow reductions at the Rock Dam site that occurred during spawning caused females to leave the spawning site and not return even if flow later increased to acceptable levels. Researchers observed that the rubble substrates remained dominant during fluctuating flows, and cessation of spawning is likely due to velocities falling outside the range preferred by females. Given the current flow dynamics at Rock Dam, spawning does not occur most years (Kynard *et al.* 2012, chapter 3). These data represent the best available scientific information and do not support current minimum flow thresholds at the project.

An empirical study is needed to provide information on the relationship between flow and habitat in the bypassed reach for the Service to use in determining a flow recommendation.

Nexus to Project Operations and Effects

The project includes a 2.7-mile-long bypassed reach. The Turners Falls Project is currently operated with a seasonally varying minimum bypass flow (200 cfs starting on May 1, increasing to 400 cfs when fish passage starts through to July 15, then reduced down to 120 cfs until river temperature drops below 7°C). The 400 cfs release is primarily to facilitate upstream movement of anadromous migrants to the spillway fish ladder at Turners Falls Dam, and the 120 cfs was intended to provide protection to shortnose sturgeon by maintaining a wetted habitat 1.5 times the maximum adult body depth through connections between pools within the bypassed reach. Neither of the currently required flows were based on quantitative, rigorous scientific studies.

This section of the Connecticut River contains habitat that supports native riverine species, including important spawning and rearing habitat for the federally endangered shortnose sturgeon. While the existing license does require seasonally varying flow releases from the Turners Falls Dam, we do not believe these flows sufficiently protect the aquatic resources, including endangered species, inhabiting the bypassed reach.

Results of the flow study will be used by the Service to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources in the bypassed reach for the duration of any new license issued by the Federal Energy Regulatory Commission (Commission).

Methodology Consistent with Accepted Practice

The Service requests a bypass flow study be conducted at the project. Bypass flow habitat assessments are commonly employed in developing flow release protocols that will reduce impacts or enhance habitat conditions in reaches of river bypassed by hydroelectric projects.

Given the size of the bypassed reach (2.7 miles long) and the important resources known to inhabit the reach (i.e., federally endangered shortnose sturgeon and diadromous fishes), we believe a study methodology that utilizes an IFIM approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[1] and has been accepted by the Commission in other licensing proceedings.[2]

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data within a range of discharge levels along transects located in the reach of river between the dam and the Cabot Station discharge. The measurements should be taken over a range of test flows up to 6,300 cfs or over a sufficient range of flows to model flows up to 6,300

[1] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

[2] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pp. 7-8, October 2007.

cfs. This information then should be synthesized to quantify habitat suitability (using mutually agreed upon HSI curves) of each test flow for target species/life stages identified by the fisheries agencies. Habitat modeling using standard PHABSIM one dimensional modeling is acceptable for the bypassed reach from the area downstream of the spillway where the river channel constricts to Rawsons Island upstream from the Rock Dam. The area from Rawson Island to the Cabot station discharge should be modeled using two dimensional 2D modeling to better characterize flows and velocities in this complex channel area. Likewise, we recommend 2D modeling in the spillway area and mouth of the Falls River to the point where the channel constricts, given this complex area with numerous potential flow discharge locations.

The flow study should incorporate the identified minimum flow and temporal parameters for shortnose sturgeon discussed in the Background and Existing Information section of this request.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field work for flow studies can be reasonably extensive but will depend on consultation with the applicant on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-field work data analysis would result in a moderate cost and effort. Field work associated with this study could be done in conjunction with the below-project instream flow study request. We anticipate that the level of effort and costs will be comparable to those experienced on similar Commission relicensing projects (e.g., the Glendale Project, FERC No. 2801).

REFERENCES

Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

FirstLight Study Request #4

Evaluate the Frequency and Impact of Emergency Water Control Gate Discharge Events and Bypass Flume Spill Events on Shortnose Sturgeon Spawning and Rearing Habitat in the Tailrace and Downstream from Cabot Station

(Turners Falls, P-1889)

This evaluation should directly address the impact of sediment disturbance and excessive velocities on habitat in the Cabot Station tailrace and downstream resulting from emergency water control gate discharge events and bypass spill events and effects of spill from the downstream fish bypass sluice on federally threatened shortnose sturgeon spawning and incubation.

Goals and Objectives

The goal of this study is to determine appropriate scenarios for operation of the emergency water control gates and bypass flume that will be sufficiently protective of shortnose spawning and rearing below Cabot Station from excessive water velocities and exposure to abrasive sediments dislodged and transported across spawning and rearing areas. Furthermore, avoidance or minimization of rapid fluctuations in flow is also a goal of this study applicable to the operations of the emergency water control gates and bypass flume.

The objective of the study will be to determine how often the emergency water control gates are operated to discharge large quantities of water and evaluate the impact of these events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot Station. Another objective is to understand the operation of the bypass flume that results in bypass flume spill events, and evaluate the impacts of these spill events on sediment transport and bottom velocities within known shortnose sturgeon spawning and rearing habitat below Cabot station. Even when bottom velocities fall within the range optimum for shortnose sturgeon spawning, rapid fluctuations may result in sediment transport having a harmful impact on developing eggs and embryos.

Specific Objectives include:

1. Emergency water control gate discharge events

    a. Field verification during operation of the emergency water control gates during a range of spill and discharge conditions is necessary during years 2014 and 2015 if emergency water control gates will continue to be operated during shortnose sturgeon spawning and rearing (April 15–June 22).

1) Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the emergency water control gates that will avoid or minimize negative impacts to spawning and rearing habitat.

2. Bypass flume spill events

a. Field verification during bypass flume spill events under a range of spill and discharge conditions is necessary during years 2014 and 2015 if bypass flume spill events continue to be a part of future project operations and will occur during shortnose sturgeon spawning and rearing (April 15-June 22).

1) Collection of sedimentation and bottom velocity data during 2014 and 2015 is necessary to verify proposed alternative operation scenarios for the bypass flume that will avoid or minimize negative impacts to spawning and rearing habitat.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Relative to this study request, the Service seeks to understand current emergency water control gate bypass flume operations and associated impacts to determine potential operation scenarios that avoid or minimize negative effects on shortnose sturgeon spawning a rearing.

Public Interest

The requestor is a natural resource agency.

Existing Information

The emergency water control gates are used to spill large amounts of water, and Cabot Station also spills water from the bypass flume (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). These large spill events created a plume of turbid turbulent flow, which caused some females to leave the area (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). Additional spill events were observed to scour bottom sediments which are then pushed downstream over, or deposited on spawning and rearing shoals where an entire year's class of early life stage sturgeon may be destroyed (Kynard *et al.* 2012, chapter 3; Kieffer and Kynard 2007). Information included in the PAD does not address operation of the emergency water control gates or bypass flume and impacts on shortnose sturgeon spawning and rearing.

Nexus to Project Operations and Effects

The large and rapid changes in flow releases from hydropower dams are known to cause adverse effects on habitat and biota downstream of the project (Cushman 1985; Blinn *et al.* 1995; Freeman *et al.* 2001). One of the two critical shortnose sturgeon spawning and rearing areas in the Connecticut River is located within the Cabot Station tailrace and impacted by the project's discharges, including spill from the emergency water control gates and bypass flume. This section of the Connecticut River also contains habitat that supports important spawning and rearing areas for migratory fish such as American shad and American eel. Current operations of the emergency water control gates and bypass flume create flow dynamics that are not sufficiently protective of shortnose sturgeon spawning and rearing. Results of this study will be used by the Service to determine recommendations for operation of the emergency water control gates and bypass flume that will avoid or minimize sedimentation and improve bottom velocities that are sufficiently protective of shortnose sturgeon spawning and rearing.

Methodology Consistent with Accepted Practice

River hydrology modeling is commonly employed at hydroelectric projects to assess implications of project operations on the river environment. It is assumed that the planned hydrologic modeling can incorporate emergency water control gate operations and associated impacts. Thus, an additional model would not be required for this request.

Field assessment will be needed to collect sedimentation and bottom velocity data at the emergency water control gates and fish bypass sluice discharge areas to determine what operational scenarios of those structures avoid or minimize impacts to shortnose sturgeon spawning and rearing. Velocity gauges will be employed to collect data on bottom velocities associated with project operations at Cabot Station. Coordination of gauge placement for this request with the field measurements for the instream flow study should help minimize the number of necessary gauges. Field assessment of sedimentation may be collected using a variety of techniques. One potential method of collection of sedimentation data would be to set fine-mesh nets similar to shortnose sturgeon larval collection nets; these nets may show changes in the amount of dislodged substrate material that travels along the spawning site as a result of powerful releases at both the Cabot spillway and bypass flume.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Field verification for this study request will likely be coordinated with other field work for related study requests. It is not expected that the required field work for this request will result in significant additional cost and effort beyond what is expected for field work related to the instream flow study request. Post-field work data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to that experienced on similar Federal Energy Regulatory Commission relicensing projects of this size (e.g., the Conowingo Project, FERC No. 405).

REFERENCES

Blinn, W., J.P. Shannon, L.E. Stevens and J.P. Carder. 1995. Consequences of fluctuating discharge for lotic communities. Journal of the North American Benthological Society 14: 233–248.

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Kynard, B., P. Bronzi and H. Rosenthal, eds. 2012. Life history and behaviour of Connecticut River shortnose and other sturgeons. Special Publication no. 4. World Sturgeon Conservation Society, Norderstedt, Germany.

FirstLight Study Request #5

Impact of the Operations of the Turners Falls, Northfield Mountain Pumped Storage, Vernon and Bellows Falls Projects on Shad Spawning, Spawning Habitat, and Egg Deposition

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Conduct a field study of spawning by American shad in the Connecticut River mainstem downstream of Turners Falls Dam, in the Turners Falls Dam impoundment, in the Vernon Dam Project area, and downstream of Bellows Falls Dam to determine if project operations (including operations of the Northfield Mountain Pump Storage) (NMPS) negatively impact shad spawning behavior, spawning habitat use, areal extent and quality of those spawning areas, and spawning activity in terms of egg deposition in those areas.

Goals and Objectives

Determine if project operations (under the permitted and proposed operational ranges) affect American shad spawning site use and availability, spawning habitat quantity and quality, and spawning activity in the river reaches downstream from Cabot Station and in the project bypass reach of Turners Falls Dam, in the Turners Falls Dam impoundment, and in relation to NMPS operations, downstream and upstream of the Vernon Dam, and in the project area downstream of Bellows Falls Dam. The following objectives will address this request:

1. determine areas utilized by American shad for spawning by conducting nighttime visual observation of spawning activity, identify and define areas geospatially, and obtain data on physical habitat conditions affected by project operations (e.g., water depth, velocity, discharge, substrate, exposure and inundation of habitats);
2. determine project operation effects on observed spawning activity, under a range of permitted or proposed project operation conditions;
3. quantify effects (e.g., water velocity, depths, inundation, exposure of habitats) of project operation on identified spawning areas for a range of conditions, over the complete period of spawning activity; and
4. quantify spawning activity as measured by nighttime spawning/splash surveys and egg collection in areas of spawning activity, and downstream of these areas, to further determine project operation effects (location and extent of exposure from changing water levels and flows).

If it is determined that the project operations are adversely affecting the spawning activity of American shad and impacting spawning habitat, identify operational regimes that will reduce and minimize impacts to spawning habitat and spawning success. This study will require two years of field data to capture inter-annual variability to river discharge and water temperatures and to allow for evaluation of alternative flow regimes if year one studies determine that the present peaking regime negatively affects spawning.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 4 percent to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

1. to mitigate hydrological changes from dams, consider operational changes such as turbine venting, aerating reservoirs upstream of hydroelectric plants, aerating flows downstream, and adjusting instream flows;
2. natural river discharge should be taken into account when instream flow alterations are being made to a river (flow regulation) because river flow plays an important role in the migration of diadromous fish;
3. ensure that decisions on river flow allocation (e.g., irrigation, evaporative loss, out of basin water transport, hydroelectric operations) take into account instream flow needs for American shad migration, spawning, and nursery use, and minimize deviation from natural flow regimes; and
4. when considering options for restoring alosine habitat, include study of impacts and possible alteration of dam-related operations to enhance river habitat.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764, and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad population, and numbers of shad passing Turners Falls and Vernon Dam have not met CRASC management plan objectives. Population number and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers over the last 10 years of 211,850. Since historically approximately half of the returning population of shad to the river passed upstream of Holyoke, recent returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management goals for the Connecticut River.

American shad broadcast spawn in congregations over shallow flats and rocky or sandy substrates (Mansuetti and Kolb 1953) at depths less than 10 feet and often far shallower with spawning fish swimming vigorously near the surface in a closely packed circle (Marcy 1972; MacKenzie *et al.* 1985). Fertilized eggs drift downstream until hatching (MacKenzie *et al.* 1985).

American shad are known to spawn downstream from the Turners Falls Project. Layzer (1974) identified six spawning sites from an area below the mouth of the Deerfield River (river mile 191.9) to river mile 161.7 below the Mill River in Hatfield, Massachusetts. Kuzmeskus (1977) verified 16 different spawning sites ranging from downstream of the Cabot tailrace to just upstream of the Holyoke Dam (river mile 87.1). The only parameter that all spawning sites had in common was current (Kuzmeskus 1977). The Service is not aware of any more recent studies that document whether these 16 sites are still viable spawning locations for shad. We are not aware of any studies that have determined American shad spawning habitat or spawning sites upstream of Vernon Dam to Bellows Fall Dam (historic extent of upstream range).

FirstLight Power conducted studies in the late spring and summer of 2012, and examined habitat conditions downstream of the Turners Falls Dam. The study documented that in low flow conditions, Cabot Station project operations produced fluctuations in water level elevations that

can range over 4 feet in magnitude (daily operation) at the USGS Montague Gage Station, to lower values of 2 to 3 feet at the Route 116 Bridge, Sunderland, Massachusetts (PAD). Similar short-term, limited monitoring in the upper Turners Falls Dam impoundment identified water level changes due to project operations that cyclically varied several feet on a sub-daily frequency.

Nexus to Project Operations and Effects

American shad are known to spawn at five locations downstream from the Turners Falls Project from an area below the mouth of the Deerfield River (river mile 191.9) and ten other locations downstream to river mile 161.7 below the Mill River in Hatfield (Layzer 1974; Kuzmeskus 1977).

Shad spawning is likely influenced by river flow, which fluctuates greatly due to the project's peaking mode of operation. These fluctuations may impact shad spawning activity by altering current velocities and water depth at the spawning sites. Effects on spawning behavior could include suspension of spawning activity, poor fertilization, flushing of eggs into unsuitable habitat due to higher peaking discharges, eggs dropping out into unsuitable substrate and being covered by sediment deposition, and/or eggs becoming stranded on dewatered shoal areas as peak flows subside.

While a number of shad spawning and egg deposition studies were conducted in the 1970s, that research was aimed at assessing the potential impact of developing a nuclear power station in the Montague Plains section of the Connecticut River. The Service is not aware of any studies being conducted to assess the relationship between spawning behavior, habitat use and egg deposition, and operations of the Turners Falls, NMPS, Vernon and Bellows Falls projects.

The Service is concerned that peaking operations may be altering spawning behavior and contributing to the failure of the Connecticut River shad population to meet management targets.

Methodology Consistent with Accepted Practice

The first year of study should examine known spawning areas downstream of the Turners Falls Dam project, to determine operation effects on shad spawning behavior, activity, and success. In areas upstream of Turners Falls Dam to the Bellow Falls Dam tailrace, the study should identify areas utilized for spawning by American shad. In the second year, should results from year one determine project operations affected spawning activity, access to habitat, or success downstream of Turners Falls Dam, an identical more detailed assessment (identified objectives) should be conducted in spawning areas upstream of Turners Falls Dam to the Bellows Falls Dam tailwater. Measures to reduce or eliminate any documented project operation impacts should be explored and evaluated in year two downstream of Turners Falls Dam.

The impacts to spawning behavior would best be studied by nighttime observations of actual in-river spawning behavior (Ross *et al.* 1993). Project discharge increases or decreases during actual observed spawning activity will provide empirical evidence of change in behaviors. The observational methodology should follow the protocol specified in Layzer (1974) and/or as described in Ross *et al.* (1993). The analysis should utilize the observational field data in

conjunction with operational data from the projects (station generation and spill on a sub-hourly basis). To assess the impacts of changes in generation flows, the study should include scheduled changes in project operation to ensure that routine generation changes that occur during the nighttime spawning period affect downstream spawning habitats selected for study while shad are spawning. Stier and Crance (1985) provide optimal water velocities during spawning to range between 1 to 3 ft/sec.

In areas used for spawning, the characteristics of those areas (e.g., location, depth, flow, substrate) should be recorded. The effect of project operations (discharge, water velocity, inundation and exposure) should be assessed. Drift nets will be used to collect eggs to quantify egg production before and after flow changes at the spawning site.

In the reaches above the Turners Falls Dam, nighttime observations of splashing associated with shad spawning should be done in each reach as sufficient numbers of shad are passed above each dam. Observations should be done regularly until the end of the spawning season. The use of radio-tagged adult shad from a separate study request will aid in this effort. An estimate of the total area used for spawning and an index of spawning activity should be recorded for each site.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Neither FirstLight nor TransCanada propose any studies to meet this need. Estimated cost for the study is expected to be moderate (up to $40,000) for each owner, with the majority of costs associated with field work labor.

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FirstLight Study Request #6

Telemetry Study of Upstream and Downstream Migrating Adult American Shad to Assess Passage Routes, Effectiveness, Delays, and Survival

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Vernon, P-1904)

Goals and Objectives

Assess behavior, approach routes, passage success, survival, and delay by adult American shad as they encounter the projects during both upstream and downstream migrations, under permitted project operations conditions, proposed operational conditions, and study treatment operational conditions at FirstLight Power's Turners Falls and Northfield Mountain Pumped Storage (NMPS) projects and TransCanada's Vernon Project. There are multiple fishways and issues related to both upstream and downstream passage success at the projects. Some of these issues at the Turners Falls Project are similar to and/or pertain directly to the NMPS and Vernon projects. Therefore, it is reasonable to address passage issues at all projects in a similar manner.

Telemetry Study - This requested study requires use of radio telemetry using both radio and Passive Integrated Transponder (PIT) tag types to provide information to address multiple upstream and downstream fish passage issues. The following objectives shall be addressed in these studies:

1. assessment of any migration delays resulting from the presence of the dam and peaking flow operations of the Turners Falls Project;
2. determine route selection and behavior of upstream migrating shad at the Turners Falls Project under various spill flow levels (e.g., movement to the dam, attraction to Cabot Station, attraction to Station 1 discharge, movement between locations, delay, timing, etc.). A plan and schedule for dam spill flow releases will need to be developed that provides sufficient periods of spill flow conditions, and various generating levels from Turners Falls #1 Station coupled with Cabot Station generation flows (e.g., treatments will require multiple days of consistent discharge). Evaluated spill flows should include flows between 2,500–6,300 cfs, which relate to bypass flows identified as providing spawning opportunities for shortnose sturgeon in the lower bypass reach at the Rock Dam (Kieffer and Kynard 2012). Sturgeon spawning and upstream shad passage occur concurrently;
3. assess near field, attraction to and entrance efficiency of the spillway ladder by shad reaching the dam spillway, under a range of spill conditions;
4. evaluate the internal efficiency of the Turners Falls spillway ladder;
5. continue data collection of Cabot Station ladder and gatehouse ladder efficiency, to include rates of approach to fishway entrances, entry into fishways, and passage through them, under different operational conditions that occur in these areas;
6. evaluate modifications to the Cabot Station and/or spillway fishways recommended by the U.S. Fish and Wildlife Service (Service) if they are implemented;

7. assess upstream migration from Turners Falls to the Vernon Dam in relation to NMPS's pumping and generating operations and Vernon Project peaking generation operations. Typical existing and proposed project operation alterations should be evaluated;
8. assess near field, attraction to and entrance efficiency of the Vernon Dam ladder;
9. assess internal efficiency of the Vernon Dam ladder;
10. assess upstream passage past Vermont Yankee's thermal discharge (also located on the west bank of the river 0.45 mile upstream of fish ladder exit);
11. assess upstream migration from Vernon Dam in relation to the peaking generation operations of the Bellows Falls Project. Typical existing and proposed project operation alterations should be evaluated;
12. determine post-spawn downstream migration route selection, passage efficiency, delays and survival related to the Vernon Project, including evaluation of the impact of the Vermont Yankee heated water discharge plume on downstream passage route, migrant delay/timing, efficiency and survival;
13. assess impacts of NMPS operations on up- and downstream adult shad migration, including delays, entrainment, and behavioral changes and migration direction shifts under existing and proposed project operations;
14. determine downstream passage route selection, timing/delay, and survival under varied project operational flows into the power canal and spill flows at Turners Falls Dam;
15. determine downstream passage route selection, timing/delay in the canal, Cabot Station fish bypass facility effectiveness, and survival of Cabot Station-bypassed adult shad that enter the Turners Falls canal system;
16. compare rates and or measures of delay, movement and survival, etc., among project areas or routes utilized (e.g., spill at dam vs. power canal) under the range of permitted and proposed conditions; and
17. utilize available data sets and further analyze raw data (e.g., 2003-2012 U.S. Geological Survey's Conte Anadromous Fish Research Center [Conte Lab] studies) where possible to address these questions and inform power analyses and experimental design.

Information to address all of these questions would rely on the tagging of upstream migrating adult shad at Holyoke Dam and releasing them to migrate naturally from Holyoke through the Turners Falls and Vernon projects and back downstream after spawning. Additional tagged individuals would likely need to be released farther upstream (Turners Falls canal, upstream of Turners Falls Dam, and upstream of Vernon Dam) to ensure that enough tagged individuals encounter project dams on both upstream and downstream migrations, that these individuals are exposed to a sufficient range of turbine and operational conditions to test for project effects, and to provide adequate sample sizes for statistically valid data analyses to address the many objectives listed. This study will require two years of field data collection to attempt to account for inter-annual variability in river discharge and water temperatures.

Evaluation of Past Study Data - In addition to collection and analysis of new telemetry data, substantial data has already been collected at Turners Falls from multiple years of passage assessments conducted for FirstLight by Conte Lab researchers, and there are also data from the 2011 and 2012 full river study conducted by the Conte Lab that address Turners Falls, NMPS and Vernon project migration and passage questions that have not yet been analyzed. These data include several million records each year from more than 30 radio telemetry receivers deployed

between Middletown, Connecticut and Vernon Dam. This data will provide substantial information free from the field data collection costs and therefore should be analyzed as part of this study. This data analysis should be completed in 2013 to help inform the design of subsequent field studies.

Evaluation of Methods to Get Shad Past Cabot Station for Spillway Passage at the Turners Falls Dam – The poor passage efficiency of the Cabot Station ladder, the first and most used fishway encountered by shad arriving at the Turners Falls Project, and at the entrance to the gatehouse ladder, which all Cabot Station fishway-passed fish must use, has resulted in very poor overall shad passage efficiency at the project. An alternative to passing fish at the Cabot Station is to install a fish lift at the dam that would put fish directly into the Turners Falls pool, thereby eliminating problems with the Cabot Station fishways, and the gatehouse fishway entrance and the variable passage efficiency of the gatehouse fishways. For this to be effective, attraction of shad to the Cabot Station discharge and associated delays would need to be overcome. It is possible that spillway flow releases coupled with behavioral measures at Cabot Station that dissuade shad from that tailrace could achieve this end. In order to assess the possibilities, we recommend the following study:

1. A literature search and desk-top assessment of the possible behavioral measures that could be effective in getting shad to pass Cabot Station tailrace and continue upstream to the dam.
2. Based on results of the desk-top assessment, possible evaluation of behavioral measures that are likely to be effective.
3. Field evaluation of the effect of different levels of spill at the dam that would induce fish to move past the Cabot Station into the bypass reach and up to the dam (as noted in Goals and Objectives).

In addition to passage success and delays at passage facilities, these studies would assess the impacts of project operations on migration passage delay, route, timing, injury, mortality, and passage structure attraction, retention, and success. Of particular interest will be fish behavior: during periods when project flow releases increase from the required minimum to peak generation flows, when they subside from peak generation to minimum flows, and in response to the operation of NMPS in pumping and generation modes.

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

Upstream Passage –

1. American shad must be able to locate, enter, and pass the passage facility with little effort and without stress.
2. Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
3. Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Passage –

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the least delay and best survival rate.

Based on the CRASC plan, the Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad movement and migration, the Service's goal is:

Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a federal natural resource agency. Migratory species of fish are a trust resource for the Service due to their interjurisdictional movements. Protection and restoration of these fish is a key objective for the Service.

Existing Information

Passage of adult shad at the Turners Falls fishway complex has been the subject of intense study by the Conte Lab since before 1999. These studies have clearly demonstrated that passage through the existing fishways at the Cabot Station and spillway is poor (<10 percent in many years). Passage through the gatehouse fishway is better, but still rarely exceeds 80 percent, despite the short length of this ladder. In addition to poor passage for fish entering the ladders, shad that ascend the Cabot Station fishway experience extensive delays before entry into the gatehouse fishway. Shad that ascend spillway frequently fall back into the canal and are also subject to these upstream delays. A new entrance to the gatehouse fishway installed in 2007 led to dramatic improvements in passage out of the canal (from 5 percent to over 50 percent in 2011), but passage still falls well short of management goals. In addition, shad spend considerable time (up to several weeks) attempting to pass. These delays likely influence spawning success and survival. Adult shad, unable to pass the gatehouse fishway, experience similar delays in downstream passage, even after they have stopped trying to pass the gatehouse fishway. In addition, if there is no spill, all outmigrating shad that have passed upstream must enter the power canal and may be subject to delays exiting the canal.

During the course of these studies, a very large dataset has been compiled that could yield useful information for further improving passage of shad out of the canal in both the upstream and downstream directions. A unique feature of these data is a two-dimensional array covering the canal just downstream of the gatehouse fishway, documenting fine scale movements and occupancy of this zone. These data should be combined with computational fluid dynamics (CFD) and real-time hydraulic data to determine how canal hydraulics influence the ability of shad to locate and enter the fishway, and to identify modifications that are likely to lead to improvements in approach and entry rates. A separate CFD modeling study is requested that includes modeling of the gatehouse fishway entrance area at the head of the power canal.

In addition, whole-river shad telemetry studies performed in 2011 and 2012 will likely provide useful information and should be analyzed. These data should allow quantification of delay below Turners Falls, and could help guide studies requested above. Preliminary analyses of data through 2011 have been made available to FirstLight and the resource agencies (Castro-Santos and Haro 2005; Castro-Santos and Haro 2010).

The whole-river studies have also shown that, at least in 2011, most shad that pass Turners Falls rapidly progress upstream to Vernon Dam where extensive delays also occur. Data from the 2012 study are not available at this time, but Dr. Castro-Santos stated that similar patterns in upstream passage delay were noted in the data from both years (Dr. Theodore Castro-Santos, Conte Lab, personal communication). There are similar concerns relative to downstream passage

delays of spent shad, with existing unpublished telemetry data sets suggesting this is an issue within the Turners Falls canal.

Since the first year of operation of the Turners Falls upstream fishways (1980), an average of only 3.6 percent of American shad that passed upstream of the Holyoke Dam have successfully passed the Turners Falls Dam. The highest values for this metric has not exceed 11 percent, and are well below the noted CRASC Management Plan target range for this objective, noted earlier as 40-60 percent on a five-year running average.

Since the first year of operation of the Vernon Dam upstream fish ladder (1981), the percent passage of American shad annually passed at the Vernon Project compared to the number passed upstream of Turners Falls Dam (gatehouse counts) has averaged 39.4 percent, ranging from 0.42 percent to 116.4 percent (>100 percent due to a counting error at one or both facilities, unknown).

Nexus to Project Operations and Effects

Existing project operations (peaking power generation) and limited bypass flows have a direct impact on instream flow and zones of passage (migration corridors). Project flow releases affect passage route selection, entry into fishways, and create delays to upstream migration. Inefficient downstream bypasses can result in migration delays and increased turbine passage. Mortality of adult shad passing through these turbines is expected to be high (Bell and Kynard 1985). In addition, stresses associated with passage and delay may cause mortality as shad are unable to return to salt water in a timely manner. The project's upstream and downstream passage facilities need to be designed and operated to provide timely and effective upstream and downstream fish passage to meet restoration goals of passage to upstream habitat and maximize post-spawn survival. These factors are all critically important to the success of restoration efforts.

Methodology Consistent with Accepted Practice

Use of radio, including passive-integrated transponder (PIT) telemetry, is widely accepted as the best method to assess fish migratory behavior and passage success, and has been used extensively to assess migration and passage issues at Turners Falls, as well as other Connecticut River projects. These studies include one conducted in 2011 and 2012 by the Service and the Conte Lab, which has provided substantial information related to some of the issues identified here. The requested study will build and expand on the information collected over the past two years.

The study design must specify sample sizes, tag configurations and receiver configurations, to ensure that rates of entry and exit to the tailraces, fishways, downstream bypasses, and the bypassed reach can be calculated with sufficient precision to determine effectiveness of flow and ensonification treatments (separate study request). For project assessments at Turners Falls (e.g., Cabot Station, spillway and gatehouse ladder attraction and entry, route selection, operational effects), double-tagged (radio and PIT) shad will be required for release from Holyoke Dam. Additional shad must be released directly into the Turners Falls canal to adequately assess the

various project generation and fish passage operational and structural conditions likely to be encountered by shad.

A related request on CFD modeling in the Cabot Station tailrace, the upper power canal near the gatehouse fishway, and in the area around the entrance of the spillway ladder, will address related project operational effects that will also address identified objectives in this telemetry request. Shad captured at the Holyoke Project and tagged and released upstream of Turners Falls Dam, or tagged out of the gatehouse ladder, would help to ensure an adequate sample size to evaluate the impacts of the NMPS and Vernon projects on passage and delay.

Additional tagged shad are expected to be required for release upstream of the Vernon Dam to ensure adequate sample size to assess where shad spawn upstream of Vernon Dam (see separate study request), as well as to ensure that there is an adequate number of outmigrating spent adults to address downstream passage questions.

Existing information on captured, handled, tagged fish performance (e.g., percent that drop back, unsuitable for tracking) and factors such as timing of tagging and potentially transport, must all be carefully considered to ensure an adequate sample size of healthy (e.g., viable to characterize behavior, survival, etc.) tagged fish is available to address the many questions identified in this request (as supported by a statistical power analysis). Additionally, it will be important to ensure that an adequate number of tagged shad are available to address the downstream passage questions above, as expected losses of healthy tagged fish during upstream passage, natural mortality rates, and due to tagging-related effects are expected to reduce fish available for these assessments. The use of single PIT-tagged fish can help improve sample sizes, but will be of limited use to answer some of the passage questions we have identified.

Due to environmental variability, two years of study work will be necessary. A large array of stationary monitoring stations (radio and PIT) will be needed to address the issues identified among the project areas. A sufficient level of radio receiver and PIT reader coverage will be required, to provide an appropriate level of resolution, for data analyses, to answer these questions on project operational effects. The study will provide information on a variety of structural and operational aspects of fish migration, relative to route selection, timing, survival, and up- and downstream passage attraction, retention, delay, efficiency, survival as some examples at three projects (Turners Falls, NMPS, and Vernon). The use of video monitoring may also be utilized for specific study areas such as the spillway ladder to provide additional information on shad entrance activity, with the understanding of some data limitations associated with this approach (fish identification, water visibility).

In addition to the tagging studies, use of video monitoring of the spillway fishway would provide additional overall data on its efficiency as all shad attempting to pass could be monitored versus just those shad that have been tagged.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The requested study is extensive and will require a substantial effort and cost to capture, PIT tag, and radio tag a sufficient number of shad at the Holyoke Project to release at upstream locations. We are not aware of any other study technique that would provide project-specific fish behavior and migration information to adequately assess existing project operations and provide insight in possible alternative operations and measures needed to address observed negative impacts to fish migration success. Cost for the entire multi-project tagging, tracking and data analysis are expected to range from $400,000 to $500,000, based on past Turners Falls studies and the 2011 and 2012 shad telemetry studies. Video monitoring of the spillway fishway would add a modest cost to this study.

Due to the fact that tagged shad will move throughout the larger five project area, to varying degrees, there will be expected cost savings (e.g., radio tags) to both owner/operators, provided cooperation in study planning and implementation occurs.

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FirstLight Study Request #7

Use of an Ultrasound Array to Create Avoidance of the Cabot Station Tailrace by Pre-spawned Adult American Shad and Facilitate Upstream Movement to the Turners Falls Dam

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine if use of ultrasound is an effective behavioral mechanism to create avoidance of the Cabot tailrace area by upstream migrating adult shad. If not attracted to the Cabot Station discharge, shad may proceed upstream and pass the Turners Falls Dam via the fishway at the dam.

The objective of the study would be to establish a high frequency sound (ultrasound) array across the entire Cabot Station tailrace and determine the effect of the ensonified field on upstream and downstream migrating radio-tagged shad moving past Cabot Station. This would be accomplished by monitoring the movements and passage of shad, and the time shad spend in the tailrace area. If effective, this technology also may be applicable to the Turners Falls #1 Station discharge.

Resource Management Goals

In 1992, the Connecticut River Atlantic Salmon Commission (CRASC) developed a draft document titled: *A Management Plan for American Shad in the Connecticut River*. Management Objectives in the plan include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

Upstream Passage

1. American shad must be able to locate and enter the passage facility with little effort and without stress.
2. Where appropriate, improve upstream fish passage effectiveness through operational or structural modifications at impediments to migration.
3. Fish that have ascended the passage facility should be guided/routed to an appropriate area so that they can continue upstream migration, and avoid being swept back downstream below the obstruction.

Downstream Passage

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines,, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

Based on the CRASC plan, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to American shad movement and migration, the Service's goal is:

Minimize current and potential negative project operation effects such as migration delays, false attraction, turbine entrainment, survival of project passage routes, and trashrack impingement, that could hinder management goals and objectives.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a federal natural resource agency.

Existing Information

The Turners Falls Project has two fish ladders that anadromous migrants must use to pass the project: one at the Cabot Station tailrace and one at the spillway. Both ladders have documented passage problems. Further, fish that are able to successfully swim up the Cabot Station ladder exit into the Cabot Station power canal and must successfully enter and ascend another fish ladder (gatehouse fishway) before entering the Turners Falls impoundment and continuing up the Connecticut River. Spillway ladder fish must also pass the gatehouse ladder to reach the impoundment. The gatehouse fishway also has well documented passage issues.

Many years of study and design changes at the gatehouse fishway have improved passage effectiveness of that facility, but overall passage through the Cabot and gatehouse fishways remains less effective than necessary to achieve management goals. A potential alternative to the current configuration of fishways at the project would be to cease using the Cabot ladder (thereby eliminating problems with that ladder and the need to pass the gatehouse ladder), and instead operate a single fish lift facility at the spillway. However, for this to be a viable option, one major issue would need to be resolved: false attraction to the Cabot Station tailrace discharge. Therefore, this study would attempt to determine if use of ultrasound technology would be an effective method to minimize false attraction to the tailrace discharge, while facilitating movement past the Cabot discharge and up to the spillway area without delay.

Much information exists about adult shad avoidance of ultrasound, and the adaptive significance seems related to avoidance of echolocation signals of predator bottlenose dolphins (Mann *et al.* 1997; 1998). These authors suggest shad can detect the echolocation clicks of dolphins up to 187 meters away. Further, in field trials in the early 1980s to develop a guidance system for downstream migrants in the first level canal of the Holyoke canal system, adult shad avoided, but were not well guided by an ultrasonic array. However, upstream migrants were guided well and even stopped entirely by the ensonified field (Kynard and Taylor 1984). Creating an ensonified field caused adult shad to leave their preferred location in the river upstream of trashracks at Holyoke Dam as long as the sound system was on.

Blueback herring also avoided the ultrasound field and behaved similarly to shad in the Holyoke Canal studies (Kynard and Taylor 1984). Acoustic barriers have been used for blueback herring on the Savannah River (Richard B. Russell Dam) and the Santee River (St. Stephen fish lift) in South Carolina, and on the Mohawk River in New York (Crescent Project, FERC No. 4678; Vischer Ferry, FERC No. 4679). Evidence from many studies that attempted to produce behavioral avoidance by adult shad strongly suggests that ultrasound is the most effective stimuli (Carlson and Popper 1997). Thus, the available evidence suggests that shad (and blueback herring) may be dissuaded from delaying at the tailrace of Cabot Station by installing and operating an ultrasound field.

In addition, one year of study on juvenile shad and blueback herring movements in the Holyoke canal (Buckley and Kynard 1985) and two years of study in an experimental flume (Kynard *et al.* 2003) found that juveniles did not exhibit an avoidance response to the same high frequency (162 kHz) that was avoided by adult shad and bluebacks at Holyoke.

Nexus to Project Operations and Effects

Given the poor performance of the upstream passage facilities at Turners Falls, studies to assess potential passage solutions are appropriate during relicensing proceedings. This study, coupled with the adult shad radio-telemetry study, can provide the information needed to select the best approach to resolve upstream shad passage at the project.

Methodology Consistent with Accepted Practices

Acoustic barriers have been used for blueback herring on the Savannah River (Richard B. Russell Dam) and Santee River (St. Stephen fish lift) in South Carolina, and on the Mohawk River in New York (Crescent Project, FERC No. 4678; Vischer Ferry, FERC No. 4679). This study would establish a high frequency sound (ultrasound) array across the entire Cabot Station tailrace and determine the effect of the ensonified field on upstream and downstream migrating shad moving through Cabot Station by monitoring shad behavior and the time that detected shad spend in the tailrace.

Shad tagged as part of the large-scale shad movement/migration telemetry study would be used to track shad movements through the Cabot Station area with the ultrasound system on versus off. Data would be analyzed to determine if ensonification is a successful deterrent mechanism (e.g., if shad spend less time in the tailrace when the area is ensonified relative to when it is not ensonified and whether shad move past Cabot Station to the spillway with limited delay).

Several businesses sell and operate ultrasound systems for fish avoidance. The use of these systems is world-wide at power production and water control facilities.

Level of Effort/Cost, and Why Alternatives Will Not Suffice

The level of effort/cost for the test will be low to moderate. Costs will be related to rental, installation, and operation of the ultrasound system, analysis of data, and production of a final report. The study could utilize the same test fish and monitoring equipment as the adult shad radiotelemetry study (although a few additional tracking stations may have to be installed in the Cabot Station tailrace).

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FirstLight Study Request #8

Three-Dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays

(Turners Falls, P-1889)

Goals and Objectives

The goal of this study is to determine the flow field conditions that exist in and around the fishway entrances, and upstream of both Turners Falls powerhouses (Station 1 and Cabot). The information from this request is meant to be coupled with data from the telemetry study such that a comprehensive understanding of fish behavior is developed.

The objective of this study is to develop a series of color contour maps of velocity magnitude at select discharges agreed upon by the resource agencies and the licensee. With respect to upstream passage, the results will show approach velocities and flow fields that may create a response in fish. This information can be coupled with telemetry data (from the requested shad telemetry study) and passage counts to understand which conditions are optimal for guiding migrating fish to the fishway entrances and for stimulating fishway entry.

With respect to downstream migration, the results will show velocities and flow fields in front of each powerhouse. At Cabot Station, the results will indicate to what degree, if any, flow directs downstream migrating fish towards the surface bypass weir. At Station 1, we will have an improved understanding of the magnitude of velocity in front of the turbine intakes.

Resource Management Goals

The management goals of this study request are to obtain information that will help assist in designing effective upstream fishways for upstream migrating trust species and to reduce impingement, entrainment and delay for downstream migrating fish. CFD models are a relatively cost effective way to analyze existing and future conditions. As such, changes in the amount of attraction water, changes in which turbines are operating, and which spillway gates are releasing water can all be examined. As stated, the results from this study are meant to be used along with the data generated from the telemetry study. The combined analysis from these two data sources can help assess which flow conditions are most advantageous for migrating trust species to enter the fishway under current and proposed conditions.

As for downstream migration of adult and juvenile shad, and adult eel, the results from the models will reveal flow magnitude and direction in front of each powerhouse. Given the limited information that currently exists on survival through Cabot and Station 1, our management goal is to direct as many downstream migrating fish as possible towards the uniform acceleration weir and downstream bypass. With respect to upstream passage, we want to maximize the number of fish that find and enter the fishway entrances.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information and the Need for Additional Information

To date, no CFD modeled data exist in front of either fish ladder, nor do they exist in front of either powerhouse. Some preliminary modeling has been done downstream of the gatehouse, but changes to the gatehouse entrances would require updated modeling. It is our understanding that the licensee has worked with the firm Alden Research Laboratory, Inc., to develop a CFD model of the upper end of the power canal and that elevation survey data from the power canal also are available. Detailed two-dimensional movement data on shad are available from observations made between 2003 to 2005 and 2010 to 2012. By coupling and analyzing these two data sets, flow and fish movement, we believe this will have substantial benefits to our management efforts.

Nexus to Project Operations and Effects

The Turners Fall Project has direct impacts to upstream and downstream migrating shad and eel. When designing upstream passage structures, a site assessment is critical. The development of these models will give resource agencies valuable information into the hydraulic cues which may elicit a response from upstream migrants. For downstream passage, the U.S. Fish and Wildlife Service has approach velocity guidelines; the output from these models would inform the resource agencies under what conditions appropriate approach velocities are being met and when they are being exceeded

With respect to upstream migration, the auxiliary water system (AWS) plays a critical role in determining whether or not fish are attracted to the entrance. The results from this study would allow us to assess how well the AWS is performing and under what conditions it attracts the most fish.

With respect to downstream migration, the development of a CFD model under existing conditions also informs the design of future modifications and improves the survivability of downstream migrating shad and eel.

The CFD models for the spillway fishway and gatehouse fishway should be developed as part of year one studies and it would be preferable to have them completed prior to year one field studies in spring 2014. It would be useful to have the gatehouse area CFD modeling completed as soon as possible to begin comparing hydraulic conditions to the two-dimensional shad location data from prior studies. This analysis may provide information on adjustments to canal operations or structures that can subsequently be analyzed.

Understanding the entrance conditions of the spillway fishway under a range of spill conditions would be informative as we evaluate the spillway fishway entrances. If developed prior to the year one upstream shad telemetry studies, it would provide information on spill gate settings that would likely best achieve entrance and ultimately passage. Further work with the model after year one studies could evaluate changes in ladder entrance or spill conditions that could improve passage and be tested with year two telemetry, video and/or count data.

CFD modeling of the flows leading to the canal via the gatehouse and the Cabot Station and Number 1 Station forebays would have value in interpretation of year one downstream passage telemetry results, but would not need to be completed prior to the year one telemetry, downstream juvenile shad and downstream eel passage studies, as those studies will provide the context for how and where shad and eels are passing the project and how successful passage is. The CFD modeling could then be focused on the locations indicated as important based on the field studies and could assess changes to structures or operations that could be evaluated in the model. Promising alternatives could then be tested in year two studies.

Methodology Consistent with Accepted Practice

A three-dimensional CFD model has become an increasing common standard of analysis at hydro-electric projects around the nation. Within the northeast region, we have seen these types of models developed at the Holyoke (P-2004), Brunswick (P-2284), Shawmut (P-2322), Milford (P-2534) and Orono (P-2710) projects. We would expect to engage with the licensee in terms of determining the appropriate area and flows to be modeled. We expect that the spatial extent of the model at each study site will vary. Given the large number of ways that output from these models can be presented and the near infinite number of flows that could potentially be modeled, we would expect to consult with the licensee to reach agreed upon modeling efforts and scenarios to be examined.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost of developing, running and testing a CFD model can vary tremendously; one large variable in determining the cost is based on the amount of existing bathymetric data to which the Applicant currently has access. We roughly estimate that the cost of each CFD model could run as high as $50,000, assuming no bathymetric data currently exist. Proactive communication with resource agencies will reduce the cost and iterative effort. Given the level of effort that has occurred at other projects that have proposed to amend their license, we see the level of effort requested here as reasonable, given that the Applicant is seeking a renewal of its license.

FirstLight Study Request #9

Impact of Project Operations on Downstream Migration of Juvenile American Shad

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Conduct a field study of juvenile American shad outmigration in the Turners Falls impoundment and the power canal and at Turners Falls Dam, Station #1, and Cabot Station to determine if project operations negatively impact juvenile American shad survival and production.

Goals and Objectives

Determine if project operations affect juvenile American shad outmigration survival, recruitment, and production. The following objectives will address this request:

1. assess project operations effects of the Northfield Mountain Pumped Storage Project (NMPS) and Turners Falls Dam on the timing, orientation, routes, migration rates, and survival of juvenile shad;
2. determine the proportion of juvenile shad that select the gatehouse into the power canal versus the dam spill gates as a downstream passage route, under varied operational conditions, including a range of spill conditions up to full spill;
3. determine if there are any delays with downstream movement related to either spill via dam gates or through the gatehouse and within the impoundment due to operations (i.e., NMPS pumping and generation);
4. determine survival rates for juvenile spilled over/through dam gates, under varied operation conditions, including up to full spill during the annual fall power canal outage period;
5. determine the juvenile downstream passage timing and route selection in the power canal to Station 1, Cabot Station, and the Cabot Station log sluice bypass, and assess delays associated with each of these locations and with project operations (e.g., stockpiling in the canal);
6. based upon year one study results on route selection, determine the survival rate for juvenile shad entrained into Station 1; and
7. determine the survival rates for juvenile shad entrained into Cabot Station units.

If it is determined that the project operations are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects, identify operational solutions or other passage measures that will reduce and minimize these impacts within the project area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperatures, and variability in the timing and abundance of juvenile production and their outmigration timing, which may relate to spring, summer, and fall conditions. This study will complement the NMPS fish entrainment study request, which includes assessment of impacts to juvenile shad.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on juvenile American shad survival, production, and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a resource agency.

Existing Information

Since the construction of the Turners Falls Dam upstream fishways in 1980, American shad have had access to spawning and rearing habitat upstream of Turners Falls Dam. A number of modifications to the Turners Falls fishways have occurred since that time, with the numbers of adult shad passed at the gatehouse ladder (into Turners Falls Dam impoundment) reaching as much 60,089 in 1992, when a record 721,764 shad passed upstream of Holyoke Dam. However, since 1980, an average of only 3.6 percent of the adult shad passed upstream of Holyoke Dam subsequently have passed upstream of Turners Falls Dam, and this value has never exceeded 11 percent. This value is well below the CRASC 1992 Shad Plan objective of 40-60 percent passage from the previous dam. In addition, population number and passage numbers past Holyoke have declined substantially, with the average Holyoke passage number over the last 10 years being 211,850. Because historic data suggest that approximately half the returning adult shad to the Connecticut River pass the Holyoke Dam, recent adult returns are far below management goals. Effective upstream and downstream passage and successful in-river spawning and juvenile production are necessary to help achieve shad management restoration goals for the Connecticut River, which extends to the Bellows Falls Dam. In 1990, FirstLight's predecessor, Northeast Utilities, CRASC and its member agencies, signed a Memorandum of Agreement on downstream fish passage to address both juvenile and adults at the Turners Falls and NMPS projects.

American shad broadcast spawn, with the highest spawning activity occurring in runs and lowest activity in pools and riffle/pools (Ross *et al.* 1993). Field research by Ross *et al.* (1993) in the Delaware River further noted that a combination of physical characteristics that seem to be avoided by spawning adults is slow current and greater depth. American shad year-class strength has been shown to depend on parent stock size and environmental conditions during the larval life stages (Crecco and Savoy 1984). Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski *et al.* 2003). One published study on the Connecticut River identified that juvenile shad outmigration began when declining autumn temperatures reached 19°C and peaked at 16°C (O'Leary and Kynard 1986).

Juvenile American shad production has been monitored upstream of the Vernon Dam and immediately downstream of that dam by Vermont Yankee Nuclear as part of an annual monitoring program using both boat electrofishing (since 1991) and beach seining (since 2000). Sampling of juvenile shad was also conducted by a contractor hired by Northeast Utilities in the Turners Falls impoundment in 1992. O'Donnell and Letcher (2008) examined juvenile shad early life history and migration upstream and downstream of Turners Falls Dam. Their study results led to the decision by the agencies to require earlier operation of downstream fishways to protect early season juvenile shad out-migrants (1 September prior to 2010, 15 August in 2010, and since 2011, 1 August).

Downstream juvenile clupeid passage studies at Turners Falls were conducted in the fall of 1991 which included the objectives of determining the percentage of juvenile shad and herring that pass via the bypass log sluice or that were entrained in the Cabot Station turbines, and related data (e.g., catch rates) were compared. The 1991 Downstream Clupeid Study did not assess survival rates for juveniles for either of these passage routes. The 1991 study report documented a higher rate entrainment into the project turbines (23.0 fish per minute) versus through the bypass sluice (11.6 fish per minute). It was concluded that only an estimated 54 percent (average bypass rate, weighted by estimated number bypassed) of the juvenile American shad approaching Cabot Station were bypassed via the log sluice. The range of the percent bypassed varied widely by date, between nearly 0 and 83 percent, with 'no clear explanation as to why." The report did not identify the percentage entrained into the turbines, but it can be reasoned to be substantial based on the data presented in the report, or assumed as the remaining balance (46 percent), as there were no spill events reported during this study, and therefore nowhere else for them to pass. It was further noted that entrainment rates for juveniles were consistently greatest for units 1 and 6 (ends), not uniform across all units. Although no concurrent bypass sampling occurred during the first entrainment sampling events, it was noted that "entrainment rates were relatively high during the end of September." Additional modifications have occurred over time without quantitative evaluation to improve downstream passage attraction and use to the bypass sluice, including lighting systems.

The 1994 Downstream Juvenile Shad Study report assessed juvenile shad survival from passage via the log sluice, reported to be 98 percent, based on tagged and recaptured fish (held for up to 48 hours). Scale loss (<20 percent) (22 of treatment fish) compared with scale loss of >20 percent (five of treatment fish) was examined and determined to occur in an overall total of 10 percent of study fish (adjusted by control fish data).

Nexus to Project Operations and Effects

Adult American shad passed upstream of Turners Falls Dam utilize upstream spawning habitat. Juvenile American shad production occurs in these habitats upstream of Turners Falls Dam on an annual basis. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the fishery agencies' target restoration population size.

The Service is not aware of any studies being conducted specifically designed to determine:

1. When are spill gates open at the Turners Falls Dam?
2. What proportion of juvenile outmigrant shad take that route of passage?
3. What is the rate of survival under a range of spill and gate configurations?
4. What is the timing, duration, and magnitude of juvenile shad outmigrants in summer and fall to the Turners Falls Dam and gatehouse?
5. Are there delays in migration/movement at the dam, gatehouse, Cabot Station, or Station 1?
6. For juveniles that enter the power canal, what proportion subsequently enter the Station 1 power canal?
7. As there are no downstream passage facilities at Station #1, and trash rack spacing is 2.6 inches, what is the survival rate of juvenile shad entrained at Station #1?

8. What is the rate of movement through the Turners Falls power canal, and what is the delay to juvenile shad outmigration, and the potential accumulation of juveniles in the canal (e.g., prior to the canal drawdown in September)?
9. What proportion of juvenile shad use the downstream sluice bypass versus the Cabot Station turbines under varied operational conditions, given that project operations may change (PAD notes possible increase in turbine capacity at Cabot)?
10. Based upon earlier facility studies (1991 Downstream Clupeid), a large proportion and number of juvenile shad are entrained into Cabot Station turbines. What are the associated impacts in terms of short-term and longer term survival and injury (i.e., scale loss)?

The Service is concerned that project operations may impact juvenile shad outmigration survival and is contributing to the failure of the Connecticut River shad population to meet management targets. In the PAD, proposed modifications include: Station 1 may be upgraded with new turbines; Station 1 may be closed; and/or the turbine capacity at Cabot may be increased. It is unclear how these scenarios will affect the questions identified in this request.

Methodology Consistent with Accepted Practice

The impact to juvenile shad outmigrants by project operations would be best studied by a combination of approaches, including hydroacoustic, radio telemetry, and turbine balloon tags. Project discharge over a full range of existing and, to the extent possible, potential future operational conditions at Station 1 and Cabot, at the dam (likely increased bypass reach flows in new license), and in relation to the gatehouse, should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through these areas, with hydroacoustic equipment for natural/wild fish evaluation. In addition, study fish should be collected and tagged (PIT, radio, other mark, balloon) to also empirically determine rates of survival for fish passed over or through the dam's gates, under varied operations, including up to full spill condition that occurs annually in the fall with the canal outage period. The understanding of the timing, magnitude, and duration of the wild fish outmigration will help inform the design, data/results, and assessment of tagged fish study. The release of tagged or marked fish (radio, PIT) upstream of the gatehouse induction into the power canal will provide data on concerns of delay and route selection to Station 1, Cabot Station downstream bypass, Cabot Station spill gates, and Cabot Station turbines. Additional hydroacoustic assessment at the Cabot Station forebay will provide information on wild/natural juvenile fish timing, magnitude, and duration to and through this area. Based upon year one study findings relative to the frequency, magnitude, and timing of juvenile American shad that end up in the forebay of Station 1, the determination of whether an entrainment survival study at that site is necessary will be made. Release sites for tagged fish will be determined based upon further consultation among the parties.

Radio-tagged juvenile shad will be released in areas upstream of the NMPS facility at multiple release locations, to determine operation effects on migration rates, route, orientation, entrainment, and survival, over a full range of permitted and operational conditions.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight does not propose any studies to meet this need. Estimated costs for the study are expected to be high, between $200,000 and $300,000, with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related field work labor.

REFERENCES

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.

Crecco, V. A. and T. F. Savoy. 1984. Effects of fluctuations in hydrographic conditions on year-class strength of American shad (Alosa sapidissima) in the Connecticut River. Canadian Journal of Fisheries and Aquatic Sciences 41: 1216-1223.

O'Donnell, M. and B. H. Letcher. 2008. Size and age distributions of juvenile Connecticut River American shad above Hadley Falls: influence on outmigration representation and timing. River Research Applications #24: 929-940.

O'Leary, J. A. and B. Kynard. 1986. Behavior, length, and sex ration of seaward-migrating juvenile American shad and blueback herring in the Connecticut River. Transactions of the American Fisheries Society 115: 529-536

Ross, R. M., T. W. Backman and R. M. Bennett. 1993. Evaluation of habitat suitability index models for riverine life stages of American shad, with proposed models for premigratory juveniles. Biological Report 14. U. S. DOI, U. S. Fish and Wildlife Service. Washington, D.C.

Zydlewski, J., S. D. McCormick and J. G. Kunkel. 2003. Late migration and seawater entry is physiological disadvantageous for American shad juveniles. Journal of Fish Biology #63, 1521-1537.

FirstLight Study Request #10

Shad Population Model for the Connecticut River

(Turners Falls, P-1889; Northfield Mountain, P-2485;
Bellows Falls, P-1855; Vernon, P-1904)

Develop an American shad annual step, mathematical simulation population model for the Connecticut River to quantify how project operations and potential restoration/mitigation measures impact the population of shad in the Connecticut River.

Goals and Objectives

The goal of the model is to assess impacts of both upstream and downstream passage at each of the Connecticut River projects and potential management options for increasing returns to the river.

Specific objectives include:

1. annual projections of returns to the Connecticut River;
2. a deterministic and stochastic option for model runs;
3. life history inputs of Connecticut River shad;
4. understanding the effect of upstream and downstream passage delay at projects;
5. calibration of the model with existing data;
6. analysis of the sensitivity of model inputs;
7. analysis of sensitivity to different levels of up- and downstream passage efficiencies at all projects; and
8. multiple output formats including a spreadsheet with yearly outputs for each input and output parameter.

Resource Management Goals

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 include the following:

1. Achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually.
2. Achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem.
3. Maximize outmigrant survival for juvenile and spent adult shad.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to American shad, the Service's goal is:

Minimize current and potential negative project operation effects on American shad spawning and recruitment.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a natural resource agency.

Existing Information

Since the construction of the first fish lift facility at Holyoke Dam in 1967, American shad have had access to spawning and rearing habitat upstream from Holyoke Dam. A number of improvements to the Holyoke fishway have occurred since that time, but while the numbers of shad lifted at Holyoke have reached as much as 721,764 and the overall shad population to the river exceeded 1.6 million shad in 1992 (CRASC 1992), total shad populations, and numbers of shad passing Holyoke, Turners Falls and Vernon Dam have not met CRASC management goals.

Population and passage numbers past Holyoke have declined substantially from those totals in recent years, with average Holyoke passage numbers since 2000 of 229,876. Whole river population estimates have shown that approximately half of the returning population of shad pass upstream of Holyoke. Recent returns to Holyoke are far below management goals. Average passage efficiency of shad at Turners Falls (gatehouse counts) and Vernon since 2000 has been 3.1 and 20.4 percent, respectively. These too are well below the CRASC management goals.

Safe, timely and effective up- and downstream passage, along with successful spawning and juvenile production, are necessary to help achieve shad management goals for the Connecticut River.

Nexus to Project Operations and Effects

Existing project operations and fish ladder efficiencies have a direct effect on shad populations in the Connecticut River. Poor upstream passage efficiencies and delays restrict river access to returning shad. Fish unable to reach upriver spawning grounds may not spawn or have reduced

fitness or survival of young. Poor downstream passage survival and downstream passage delays affect outmigration and consequently repeat spawning, an important ecological aspect of the iteroparous Connecticut River shad population (Limberg *et al.* 2003).

The Service is concerned that poor passage efficiencies and delays at projects may be limiting access to upstream reaches of the river, altering spawning behavior, decreasing outmigration survival and contributing to the failure of the Connecticut River shad population to meet management targets (Castro-Santos and Letcher 2010).

Development of a population model will allow an assessment of individual project impacts on the population as well as the cumulative impacts of multiple projects. The model will allow managers to direct their efforts in the most efficient manner toward remedying the conditions that most impact the shad population.

Methodology Consistent with Accepted Practice

Population models are commonly used to assess anthropomorphic and natural impacts and are consistent with accepted practice. A model similar to this request was constructed for the Susquehanna River by Exelon (FERC No. 405). The model is constructed in Microsoft Access.

Specific parameters that would be included in the model:

1. upstream passage efficiency at Holyoke, Turners Falls (Cabot, gatehouse and spillway
2. ladders), Vernon fishways, and any impacts associated with Northfield Mountain Pumped Storage;
3. distribution of shad approaching the Turners Falls Project between the Cabot ladder and the spillway at the dam;
4. downstream passage efficiencies at Vernon, Northfield Mountain Pumped Storage, Turners Falls, and Holyoke projects for juveniles and adults;
5. entrainment at Mount Tom Power Plant and Vermont Yankee Nuclear Power Plant;
6. sex ratio of returning adults;
7. the proportion of virgin female adults returning at 4, 5, 6, and 7 years;
8. the proportion of repeat spawning females at 5, 6 and 7 years;
9. spawning success of females in each reach;
10. fecundity;
11. percent egg deposition;
12. fertilization success;
13. larval and juvenile in-river survival;
14. calibration factor to account for unknown parameters such as at sea survival;
15. options for fry stocking and trucking as enhancement measures;
16. start year and model run years;
17. start population;
18. rates of movement to and between barriers; and
19. temperature, river discharge, and other variables of influence to migration and other life history events.

The model should be adaptable to allow the input of new data and other inputs.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Neither FirstLight nor TransCanada have proposed any study to meet this need. Estimated cost for the study is expected to be low to moderate. As the model describes the impacts of multiple projects and two owners, both project owners would share the cost of model development.

REFERENCES

CRASC (Connecticut River Atlantic Salmon Commission). 1992. A management plan for American shad in the Connecticut River basin. Sunderland, MA.

Castro-Santos, T. and B. H. Letcher. 2010. Modeling migratory bioenergetics of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous anadromous fish. Can.J.Fish.Aquat.Sci. 67: 806-830.

Limberg, K. E., K. A. Hattala and A. Kahne. 2003. American shad in its native range. Pages 125-140 in K. E. Limberg and J. R. Waldman, editors. Biodiversity, status and conservation of the world's shads. American Fisheries Society, Symposium 35, Bethesda, Maryland.

FirstLight Study Request #11

Impacts of Turners Falls Canal Drawdown on Fish Migration and Aquatic Organisms

(Turners Falls, P-1889)

Conduct a study to quantify impacts of the annual Turners Falls Canal drawdown on emigrating and resident fishes, freshwater mussels and mudpuppies in the canal.

Goals and Objectives

Quantitatively assess the effects of the Turners Falls Canal drawdown on diadromous fishes and other aquatic organisms known to be present in the canal during the annual drawdown.
Objectives of this study request include:

1. Determine whether juvenile shad and American eel abundance in the canal increases leading up to the time of its closure, due to delays in downstream passage (e.g., are fish accumulating in the canal?).
2. Determine level of mortality for juvenile sea lamprey from exposure of burrow habitats.
3. Conduct surveys to determine aquatic organisms (fishes, freshwater mussels, and mudpuppies) present in the canal during the drawdown, their densities, status (stranded, dead, alive), and mapping to document habitat, substrate type, and wetted area at complete drawdown.
4. Evaluate measures to minimize aquatic organism population impacts of the canal drawdown.

Other submitted study requests complement or directly relate to this project activity and assessment of project effects, including the resultant effects of all river flow being passed over the Turners Falls Dam as spill (e.g., downstream juvenile shad study request and American eel movement and survival request).

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually; and
2. maximize outmigrant survival for juvenile and spent adult shad.

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, has the stated goal of "Protect, enhance, and restore Atlantic coast migratory stocks and critical habitat of American shad in order to achieve levels of spawning stock biomass that are sustainable, can produce a harvestable surplus, and are robust enough to withstand unforeseen threats," and includes the following objective:

Maximize the number of juvenile recruits emigrating from freshwater stock complexes:

To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to diadromous fishes, the Service's goal is:

Minimize current and potential negative project operation effects on diadromous fishes, including juvenile shad, adult silver eels, and sea lamprey ammocetes.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information

Existing information in the PAD does not provide data on the population size or survival rates of juvenile American shad, American eels, or juvenile sea lamprey located in the power canal during the dewatering process. The power canal is dewatered in early September of each year for over a one week period to perform facility maintenance, inspections, and repairs, including substantial silt removal and bank repairs. Historically, the canal drawdown occurred in July, but

approximately five years ago, it was moved to September, where it has occurred annually since then, with the exception of 2010. The agencies were informed in a letter by FirstLight that the shift to September was at the request of the Independent System Operator–New England (ISO-NE) to avoid peak load months of June through August. Studies conducted by the previous operator, Northeast Utilities Service Company (NUSCO), to assess downstream clupeid survival and use (1991 and 1994 studies at Cabot Station) support the contention that juvenile shad out-migration is occurring within the current drawdown time frame. There are no data to suggest that out-migration would occur earlier than 1 August, but likely does begin in the month of August (O'Donnell and Letcher 2008). Based on these data, CRASC altered its Fish Passage Notification Letter for Downstream Passage Operations for juvenile shad and herring to require the Cabot Station downstream bypass to begin operating on 15 August in 2010, and then moved the date to 1 August in 2011.

It is unknown whether the power canal may, through potential mechanism(s) of delay due to its configuration or operation, cause out-migrating juvenile shad to accumulate in the canal. This information gap leads to concerns that migrant numbers may be elevated beyond simple extrapolations of surface area comparison in the canal to main stem habitat. In the PAD, FirstLight indicates that the Cabot Station forebay in the vicinity of the intake has a maximum depth of 60 feet, while the existing near-surface downstream bypass structure at the Cabot Station is designed to operate only within a depth of 6 feet of the surface. As a result, the downstream bypass only operates effectively for a short period during the drawdown period (timing of this is unknown). The only points of egress, once the fish bypass becomes unavailable, are through the turbines at Cabot Station and Station 1, and eventually at the Keith Street gate located well upstream from the Cabot Station intakes. It is unknown what the survival rates are for these passage routes, what proportion of fish are using each route, what number may become stranded and their survival rates, and how many fish are subjected to this situation. The related study requests on downstream juvenile shad outmigration and American eel outmigration outline objectives that would address some of these information gaps.

There is also a paucity of information relative to the disposition of fish moving downstream in the impoundment during the canal drawdown. Once the Turners Falls gatehouse closes its gates, all inflow passes over the dam, a situation unique to this brief one-week annual time period. Survival rates for outmigrating juvenile American shad and adult American eel moving past the project during the period of spill are not known.

Lastly, there exists an information gap regarding the fate of juvenile sea-lamprey (known as ammocetes) that reside in the soft substrate materials located in much of the lower or downstream end of the canal (Boyd Kynard, BK Riverfish, LLC, personal communication). In previous drawdowns, thousands to tens of thousands of dessicated ammocetes have been observed (Matt O'Donnell, USGS Conte Lab, personal communication). However, the distribution and abundance of ammocetes in the canal, as well as mortality rates for ammocetes during the drawdown period, have not been quantitatively determined.

Nexus to Project Operations and Effects

Previous studies at Cabot Station have documented that juvenile American shad and American eel migrate through the project area during the canal drawdown period. During normal operations (where canal water level elevations are stable), downstream migrants are able to utilize the Cabot bypass facility; however, as the canal water level is drawn down, the bypass is no longer available, and the only routes of egress are through the turbines at Cabot Station and Station 1, unless the Cabot Station spill gates are utilized (the spill gates have a canal depth limitation of approximately 16 feet). Turbine entrainment at hydropower projects has been shown to cause injury and mortality to fishes.

The annual canal drawdown was formerly conducted in July. In response to ISO-NE's request that FirstLight conduct the drawdown outside of the June through August period, FirstLight moved the drawdown to a period of time when diadromous fishes are known to be moving through the project area.

Once the canal has been drawn down, isolated shallow pools are left standing until the canal is refilled. During this period, fish (including lamprey ammocetes), amphibians, and benthic invertebrates are prone to dessication, predation or other sources of mortality or impact.

Methodology Consistent with Accepted Practice

The methods presented here are consistent with the study requests addressing downstream juvenile American shad passage and downstream American eel passage, with an emphasis on addressing survival and movement immediately prior to and during the canal drawdown. Hydroacoustic monitoring immediately upstream of the Turners Falls gatehouse, as well as upstream of opened dam gates for spill, will provide data on the timing, frequency and magnitude of natural wild juvenile shad movement into these areas, particularly the power canal. The abundance of juvenile shad moving into the canal can be derived and compared with similar data obtained with hydroacoustic equipment monitoring upstream of the Cabot Station intake and bypass, for comparisons. Juvenile shad will be PIT-tagged, released, and monitored in the canal, for movements, timing and location, including the Station 1 canal and forebay. PIT-tagged fish will be detected at the Cabot bypass sluice sampler. Juvenile fish should be specifically targeted for release immediately prior to drawdown to assess survival and movement in and through the canal. Surveys of sea lamprey ammocetes should be conducted by a stratified sampling design based upon substrate.

Lamprey density surveys, immediately after drawdown and in a subsequent later survey, may derive rates of change in observed densities and their status (live, moribund, dead); appropriate methods would need to be discussed. Surveys of remaining ponded water should be conducted immediately following drawdown and at later intervals (mid-week and end of week) to compare species occurrence and densities (relative abundance) which will be used to develop catch-curve analyses that can inform rates of mortality to the observed populations.

Assessments of freshwater mussels should also be conducted to quantify drawdown impacts. As with lamprey, the assessment can be based on sampling identified habitats in a stratified, random

design, over the three time periods noted (initial drawdown, mid-week, and end of week), tracking changes in densities and status of observed individuals among areas. Sub-sampling, with sufficient repeated measures to determine variability and acceptable level of precision of data, will inform the required sampling intensity that will be needed. This sampling intensity will be determined as the study occurs and may vary among identified species. Comparisons among the three time periods for measures of density and status will inform the evaluation of project effects for juvenile shad, sea lamprey ammocetes, freshwater mussels and mudpuppies.

The canal drawdown mitigation assessment involves evaluating alternative drawdown protocols to minimize impacts to resident and migratory fish, mussels and amphibians inhabiting the canal. Alternatives should include: (1) moving the drawdown to a time of year outside of migration seasons; (2) keeping or moving the timing of the drawdown, but utilizing technologies to keep the majority of the canal wetted during the drawdown (e.g., portadams in the forebay immediately upstream of the trashracks and at other canal intakes in need of maintenance); and (3) in combination with alternative #2, assessing whether other existing infrastructure within the forebay could be used to pass fish safely out of the canal (e.g., low level outlets, deep gates, side spillway boards, etc.). The assessment should compare the merits and drawbacks of each alternative and provide an order of magnitude cost estimate for implementation.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This study request has many elements that overlap directly with a larger-scale downstream juvenile American shad passage and downstream American eel passage study requests. With equipment costs principally covered in those requests, many components of what has already been proposed will be used in this study. However, this request does include some specific elements not specified in the other two larger requests. The study cost and effort are expected to be low to moderate. Some additional radio tags and balloon tags with additive days of field work to accurately assess impacts specific to the drawdown period will be required. Surveys for identified aquatic organisms will take several days during the drawdown period as well.

The canal drawdown mitigation assessment should require a low to moderate level of effort and cost. One staff person would evaluate alternative drawdown protocols. This should take less than one week to complete.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

O'Donnell, M and B. H. Letcher. 2008. Size and age distributions of juvenile Connecticut River American shad above Hadley Falls: influence on outmigration representation and timing. River Research Applications #24: 929-940.

FirstLight Study Request #12

Entrainment of Migratory and Riverine Fish from the Connecticut River into the Northfield Mountain Pumped Storage Project

(Northfield Mountain, P-2485)

Goals and Objectives

The goal of the study is to determine the impact of Northfield Mountain Pumped Storage Project (NMPS) during the pumping cycle on entrainment of juvenile American shad, adult shad, adult American eel, and riverine fish, including early life stages.

The objective of the study is to quantify the number of resident and migratory fishes entrained at the NMPS intake on an annual basis in order to evaluate potential impacts to riverine fish populations in the Turners Falls pool and diadromous fish migrants moving through the project area. This will be accomplished through a combination of hydroacoustic monitoring and netting using various gear types to quantify and identify species of different life stages.

Resource Management Goals

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 include the following:

1. achieve and sustain an adult population of 1.5 to 2 million individuals entering the mouth of the Connecticut River annually;
2. achieve annual passage of 40 to 60 percent of the spawning run (based on a five-year running average) at each successive upstream barrier on the Connecticut River mainstem; and
3. maximize outmigrant survival for juvenile and spent adult shad.

Based on the CRASC plan, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, CRASC developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Specific to resident riverine and migratory fish entrainment, the Service's goals are:

1. Minimize current and potential negative project operation effects such as turbine entrainment that could hinder management goals and objectives.
2. Minimize project-related sources of mortality to resident and migratory fishes in order to restore natural food web interactions and ecosystem functions and values.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a resource agency.

Existing Information

Limited project-specific information exists regarding entrainment of fish and aquatic organisms at the NMPS. As part of a 1990 Memorandum of Agreement between then-owner Northeast Utilities Service Company (NUSCO) and regulatory agencies (including the Service), NUSCO conducted studies to determine the impact of NMPS on anadromous fishes, including Atlantic salmon, American shad, and blueback herring. Results of a pilot study conducted in the fall of 1990 indicated that trap netting at the intake was ineffective at collecting fish. Gill netting and boat-shocking did result in collection of some juvenile shad, but further refinement in both methods was recommended to improve effectiveness. A total of 78 fish were collected at the intake (77 of which were American shad) by gill netting and 11 shad were collected by boat electrofishing. Hydoacoustic monitoring was deemed an effective method for monitoring entrained fish during pumpback operation. Hydroacoustic sampling over a two-week period (September 12-27, 1990) produced hourly entrainment estimates that cumulatively equaled 14,816 fish.

Based on the results of the pilot study, NUSCO developed a two-year plan to quantitatively determine the number of shad and salmon entrained at NMPS station. In 1992, an entrainment study targeting juvenile American shad life stages was conducted in the lower (mainstem river) and upper reservoirs of NMPS. The study used several gear types to quantify egg through juvenile shad densities in different areas. Entrained juveniles were sampled using an upper reservoir net. Pumping operations were modified to only run three (77 percent of sample time) and sometimes two (23 percent of sample time) of the station's four units during the study, and effort was limited to a total of 80 hours over a period spanning 9 August through 27 October (80 days). An estimated total of 1,175,900 shad eggs, 2,744,000 yolk-sac larvae, 10,525,600 post yolk-sac larvae, and 37,260 juveniles were reported entrained.

There are no reliable data on the timing, magnitude and duration of entrainment of larval riverine fishes in the NMPS area. Unlike anadromous shad and river herring, riverine species occurrence and susceptibility relative to space and time exposure windows to NMPS pumping are undocumented. The complete lack of any long-term fish population monitoring data for riverine species in the Turners Falls impoundment leaves questions unanswered on the types and extent of impacts to these populations that may be linked to the near daily cycling of river water up and down through the NMPS operations system. As a starting point, it is necessary to obtain baseline data on project operation impacts for all species potentially impacted by NMPS. An additional study request seeks to obtain a more accurate documentation of all fish species inhabiting or utilizing the Turners Falls impoundment.

Nexus to Project Operations and Effects

Entrainment of fish and aquatic organisms associated with water withdrawal and hydroelectric operations has been documented to result in injury or death of entrained organisms. Migratory and resident fish pass through the project area directly in front of the pump intakes. These organisms may be entrained and thus exposed to passage through the project pumps and reservoir supply tubes. How far from the intake these species and life stages may be drawn into the intake on a pumping cycle or how susceptible they are to the repeated daily cycles of

pumping and discharge, and how these factors vary in relation to habitat and river conditions, are unknown. Survival of fish subjected to entrainment on the pumping cycle is unknown, but regardless of whether fish survive the pumping process, they are lost to the Connecticut River system. Depending on the species, life stages, and numbers entrained, this loss could impact the ecosystem productivity of the Turners Falls pool and may hinder restoration goals for diadromous fishes.

Previous entrainment studies have been conducted at the project. Those studies, which were done 20 years ago, documented entrainment of American shad and Atlantic salmon at the project, including over 13 million yolk sac and post-yolk sac larvae of American shad. This level of entrainment is cause for concern, not only due to the resultant loss of potential adult returns, but for the important role early life history phases and juveniles play in their ecological contributions to the river system (e.g., trophic interactions).

No entrainment studies for other species of fish have been conducted at the project and require evaluation. Studies conducted in 1969 and 1970 at the Muddy Run Pumped Storage Station documented significant entrainment of eggs and larval fish. In June and July of 1970, 5.3 million eggs and 56.6 million larvae were entrained (Snyder 1975). Muddy Run and NMPS are of a similar size and both use a river as the lower reservoir. It is anticipated that a considerable number of eggs and larvae will be entrained by the NMPS.

Since the previous studies were conducted, operations at the NMPS facility have changed (e.g., the project increased the efficiency of its turbines, and raised the pumping capacity from 12,000 cfs up to 15,000 cfs), as have river conditions (e.g., Vermont Yankee has increased its thermal discharge and the Vernon Project has increased its station capacity). Further, the PAD indicates that FirstLight will evaluate the feasibility of utilizing an additional 3,009-acre feet of storage capacity to generate an additional 1,990 MWhs (this represents a 23 percent increase over existing storage and stored generation levels). While not specified in the PAD, increasing storage and generation would mean longer periods of both pumping and generation at NMPS. In addition, anticipated improvements in fish passage at the Turners Falls Project will result in increased juvenile production above the NMPS. These factors, individually or cumulatively, could increase the potential for entrainment at NMPS station.

Methodology Consistent with Accepted Practice

Previous studies used varying methodologies for determining entrainment. The 1990 study concluded that hydroacoustic monitoring at the intake was a viable method for determining entrainment of later life stages, but does not allow for identification of the species being entrained. While trap netting was ineffective at collecting fish near the intake, gill netting and boat shocking did capture some fish. Both may prove to be viable sampling methods; however, it is likely that additional testing and gear refinement will be necessary.

The 1992 study used nets at the pump discharge location into the upper reservoir to collect entrained fish. Testing showed that this method was only 10 percent efficient. Plankton netting in the nearfield area of intake was used to estimate entrainment of ichthyofauna. It is likely that a combination of methods would provide the most reliable results (e.g., hydroacoustic monitoring

at the racks during pumpback operations, variable gear sampling in the vicinity of the intake immediately prior to initiation of pumpback operations to determine species composition, and plankton netting in the nearfield area of the intake to obtain information on entrainment of ichthyofauna). As these methodologies have previously been utilized at the site, they are consistent with accepted practice (Harza Engineering Company 1991).

Although a previous entrainment study was conducted, the Service believes it should be repeated, using a modified study design. The 1992 study only collected a total of 330 juvenile shad over a three-month period (resulting in an overall estimate of 37,260 juveniles entrained, after accounting for poor net efficiency), whereas the hydroacoustic study conducted in 1990 estimated nearly 15,000 fish in 15 days (while these fish were not identified, 77 of the 78 fish collected at the intake during the study were juvenile shad). It also should be noted that in the 1992 study, juvenile shad were collected on the first day of sampling, indicating that the sampling did not begin early enough, which would mean the results are an underestimate of the number of juvenile shad that were actually entrained. In 1990, 27,908 adult shad passed the Turners Falls gatehouse, while in 1992 over 60,000 shad passed the gatehouse. The fact that the numbers entrained were so variable between study years argues for repeating the study, using a combination of previously-used methodologies (Lawler, Matusky and Skelly Engineers 1993).

The study will require deployment of at least five hydroacoustic transducers (one per rack face and one offshore). These transducers would be operated during every pumping cycle from April 15 through May 14 to assess riverine fish entrainment, from May 15 through July 15 for spent adult shad, and from July 16 through November 30 for entrainment of adult silver eels, juvenile American shad, and riverine fishes. Concurrent field sub-sampling at the intake to determine species composition would need to occur.

Sampling for planktonic fish larvae should capture early spring spawning species (white suckers) through later season centrarchid species (bass and sunfish). Active plankton trawl surveys should utilize a sampling design that adequately captures temporal and spatial changes in water pumping cycle (i.e., early start-up is local water, later cycle pumping is drawn in from both upstream and downstream habitat areas).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

We know of no other tool that will provide for this type of assessment for all fish species and organisms that may pass through the project. Cost and effort are expected to be high.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

CRASC. 1992. A Management Plan for American Shad in the Connecticut River.

Harza Engineering Company. 1991. Draft Northfield Mountain Pumped Storage Project 1990 Field Sampling Program. February 1991. Northeast Utilities Service Company, Berlin, CT.

Lawler, Matusky and Skelly Engineers (LMS). 1993. Northfield Mountain Pumped-Storage Facility – 1992 American Shad Studies. February 1993. Northeast Utilities Service Company, Berlin, CT.

Memorandum of Agreement. NUSCO. July 1990.

Snyder, D.E. 1975. Passage of fish eggs and young through a pumped storage generation station. J. Fish Res. Board Canada. 32: 1259-1266.

FirstLight Study Request #13

Model Flows in the Northfield Mountain Pumped Storage Project Intake/Tailrace Channeland Connecticut River Upstream and Downstream of the Discharge Using Computational Fluid Dynamics (CFD) Modeling

(Northfield Mountain, P-2485)

Goals and Objectives

The goal of this study is to determine the potential impacts of the Northfield Mountain Pumped Storage Project (NMPS) operations (pumping and generating) on: (1) the zone of passage for migratory fish near the turbine discharge/pump intake; (2) natural flow regimes in the area of the Connecticut River immediately upstream and downstream of the project; and (3) the potential for fish entrainment during pumping operations.

Specific objectives of the study include:

1. Develop a CFD model of the NMPS intake and tailrace channel, along with the full width of the Connecticut River upstream and downstream of the discharge.

2. Model flow characteristics upstream and downstream of the project under existing project operations (pumping and generating) and at several representative river flow levels, as well as proposed operations such as those proposed in section 3.4.4 of the PAD, and any other modifications under consideration, to assess potential impacts to fish and wildlife resources.

3. Assess velocities and flow fields at and in proximity to the NMPS intake/discharge structure when pumping or generating, and their potential to interfere with fish migration, create undesirable attraction flows, and result in fish entrainment.

4. Assess the potential for velocity barriers in the mainstem river resulting from pumping and generation flows at the project, alone or in combination with generation flows from the upstream Vernon Project and operations at the Turners Falls Project.

5. Assess the potential of a mainstem instream local flow reversal associated with pumping operations to impact migrating fish.

6. Model and then evaluate flow characteristics under alternative project operations with potential measures to avoid, minimize, or mitigate impacts to fish and wildlife resources.

Resource Management Goals

The mission of the U.S. Fish and Wildlife Service (Service) is to work with others to protect, conserve and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American public. Service trust resources include wetlands, endangered species, and migratory species, all of which have been documented to occur in the project area. The Service also is working with a number of federal, state, local, non-governmental organizations, and the public to restore and enhance trust resources in the Connecticut River Basin through comprehensive management plans and cooperative agreements. Instream flow is an important riverine habitat characteristic that can have a great impact on aquatic habitat for fish, wildlife, and plants. Flow is an important directional guidance cue for instream navigation and attraction to fishway entrances for migratory fish.

Public Interest

The requestor is a natural resource agency.

Existing Information

No project-specific information exists that will allow for a comprehensive assessment of existing project operations (pumping and generating flows) on Connecticut River flows and on fish and aquatic organisms in the project area upstream and downstream of the project. Preliminary results from an ongoing study of radio-tagged American shad by the Service and the USGS Silvio O. Conte Anadromous Fish Research Center indicate that shad are exposed to the intakes and some individuals spend substantial amounts of time in the vicinity of the intakes. The PAD does not contain any information or tool that will allow for predictions of impacts of alternative project operations, or potential mitigation measures to protect or enhance aquatic fish and wildlife resources.

Nexus to Project Operations and Effects

Existing project operations have a direct impact on instream flow and aquatic habitat in the pump/discharge area of the Connecticut River. The PAD (section 3.2.2) says that the discharge at the trash racks when operating at full capacity is 20,000 cfs and maximum pumping conditions are 15,200 cfs. Annual flow duration curves shown for below the Vernon Dam submitted in the PAD (section 4.3.1.2) (for years 1944-1973; recent and near project flows are not available; see p. 459) indicate that river flows are $\leq$ 20,000 cfs more than 85 percent of the time. Flows released from the project must therefore influence flow patterns and velocities in the Connecticut River, particularly at flows below some unknown threshold level.

Recreational users of the Connecticut River in the Turners Falls impoundment have anecdotally described flow reversals in the mainstem river. Discharges from the project could potentially be larger than river flows or at least act like a major tributary to the Connecticut River. Project flows may influence the availability and extent of upstream and downstream migration zones, or may confuse fish and delay migration.

Methodology Consistent with Accepted Practice

CFD modeling is consistent with generally accepted practice, and has been used to assess proposed modifications to the Holyoke Project (FERC No. 2004) fish passage facilities, upstream of the intakes and downstream of the dam, as well as at hydroelectric projects on the Susquehanna River to assess existing and proposed project operations, and develop mitigation measures for fish and wildlife resources.

A study plan that describes the specific modeling tools to be used, the amount of bathymetric data to be gathered, the geographic scope of the assessment and the flow conditions to be modeled will need to be developed in consultation with the Service and other parties.

Level of Effort/Cost, and Why Alternative Studies will Not Suffice

This study will require a detailed elevation map of the study area upstream and downstream of the NMPS intake structure. Some information already exists in historic construction files for the project and past hydraulic analyses. Additional bathymetric data likely will need to be collected in the field using standard survey techniques. The CFD computer program will need to simulate existing project operations, as well as accommodate all potential variations of pumping and generating, and static operation.

No project-specific instream flow analysis tool has been developed for the NMPS that will allow for assessment of existing operations and alternative operational impacts on instream flow and aquatic habitat for fish and wildlife resources. The computer model, once built, can be used to simulate flow conditions in the vicinity of the project during migratory fish passage and can be used together with behavior studies (i.e., telemetry studies and entrainment studies requested herein) to assess the impacts of varying project operations or potential mitigation operations and measures on fish migration and aquatic habitat. We know of no other tool that will provide for these types of assessments. Cost is expected to be moderate to high.

FirstLight Study Request #14

Upstream American Eel Passage Assessment at Turners Falls

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at the Cabot Station discharge, Station #1 discharge, canal discharges, and Turners Falls Dam to identify areas of concentration of eels staging in pools or attempting to ascend wetted structures that would potentially establish the most effective locations to place upstream eel passage facilities.

2. Collect eels with temporary trap/pass devices at areas identified from surveys as potential locations of eel concentration to assess whether eels can be collected/passed in substantial numbers, and whether locations are viable sites for permanent eel trap/pass structures.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.

2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to upstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operational effects that could hinder management goals and objectives.
2. Minimize project-related sources of upstream passage delay, injury, and stress in order to facilitate access to historical rearing habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains no information relative to areas where eels seeking to move upstream concentrate downstream of the dam, or annual numbers of eels attempting to ascend past Turners Falls Dam. While eels have been known to ascend the Cabot Station ladder (A. Haro, U.S. Geological Survey, personal communication), its efficiency is unknown, and it is only operated during the American shad passage season (from April 1 through July 15). Eels are currently able to pass the Turners Falls Dam complex (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass Turners Falls and the proportion successfully passing the project is unknown (but suspected to be low). The downstream Holyoke Project has operated upstream eel passage facilities since 2004. Last year, these facilities passed over 40,000 juvenile eels. While there is rearing habitat in between the Holyoke and Turners Falls dams, some eels will attempt to continue upstream, and passage needs to be provided so these fish can access historical habitat.

These information gaps need to be filled so resource agencies can determine the best locations to site upstream eel passage facilities and assess whether operating the existing anadromous ladders would be an effective mechanism to move juvenile eels upstream past the project.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting

new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the project.

Nexus to Project Operations and Effects

The project generates hydropower on the head created by the Turners Falls Dam. This dam creates a barrier to upstream migrating eels. While some eels are able to pass dams, some are not, and the passability of a given dam depends on factors such as its height, hydraulics, presence of climbable surfaces, presence of predators, risk of exposure to heat or drying while climbing a dam, etc. The Turners Falls Dam is high (35 feet above bedrock), and the majority of the dam face is dry during most of the upstream eel passage season. Design of the dam is not currently amenable to passage of eels by climbing. While flow is released to the bypass reach via a bascule gate (typically the one closest to the gatehouse), this would not facilitate eel passage, as bascule gates open outward and downward (i.e., requiring the eels to essentially swim nearly upside down to get over the gate). As mentioned earlier, the existing anadromous passage facilities are not designed to pass eels, and even if some eels are able to ascend the ladders, they may incur delays (in attraction or passage rates), be size-selective (e.g., velocity barrier for small eels presented by ~8 ft/sec flow through weirs and orifices), present a potential predation risk (predators in or near the fishways), and are not operated throughout the upstream eel passage season.

Methodology Consistent with Accepted Practice

1. Objective 1: Systematic Surveys

   Surveys of eel presence and relative abundance should be conducted at regular intervals throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10°C). Surveys should consist of visual inspection and trapping in likely areas where eels may concentrate as they attempt to climb structures wetted by significant spill or leakage flow in the Turners Falls Dam complex area. These locations include: Cabot Station downstream bypass outfall, Cabot Station spillway (including attraction water stilling basin), Cabot fishway (dewatered state), USGS Conte Lab flume outfall, Number One Station outfall, various small turbine and process water outfalls from the Cabot Canal, spillway fishway attraction water stilling basin, and leakage points along the downstream face of the Turners Falls Dam (bascule and taintor gates). Methods should include visual surveys (on foot, from a boat, or snorkeling) and trapping using small mesh (< 1/8”-clear opening) baited eel pots. Visual surveys should be performed once per week, at night, preferentially during precipitation events. Trap sets should be performed once per week, with an overnight soak time. Recorded data should include location, observation of eels (presence, absence, relative numbers, relative sizes, behaviors, time/date of observation), and survey method.

2. Objective 2: Trap/Pass Collections

   Areas identified from Systematic Surveys as having a significant number of eels present should be targeted as potential areas for permanent eel trap/passes, and should be initially assessed using temporary/portable trap passes. At a minimum (regardless of survey results), temporary trap passes should be installed at the following locations: Cabot fishway attraction flow stilling basin (during dewatered fishway period), Number One Station outfall, and spillway fishway attraction flow stilling basin (during watered and dewatered fishway period), as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream migrant eels. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1 May to ~15 October, or when river temperatures exceed 10°C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every two to three days. Recorded data should include location, trapping interval, absolute numbers of eels trapped, relative eel sizes, and hydraulic and environmental conditions during the trapping period.

All collected eels from surveys should be released at their point of capture; those eels collected from trap/pass collections should be transported to and released above the dam in the Turners Falls pool.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the survey component of the study would be low; a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost (estimated at $40,000) and effort.

In the PAD, the Applicant has identified the need to assess issues related to upstream passage for American eels at the project, but indicates that it intends to rely on information from previously conducted studies and ongoing studies. The Service is not aware of any previously conducted or ongoing studies related to upstream eel passage.

FirstLight Study Request #15

Evaluation of Timing of Downstream Migratory Movements of American Eels on the Mainstem Connecticut River

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Goals and Objectives

The goal of this study is to better understand migration timing of adult, silver-phase American eels in relationship to environmental factors and operations of mainstem hydropower projects on the Connecticut River.

The objective of this study is:

Quantify and characterize the general migratory timing and presence of adult, silver-phase American eels in the Connecticut River relative to environmental factors and operations of mainstem river hydroelectric projects.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to downstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

Data on timing of downstream migratory movements and rates of American eels in the mainstem Connecticut River are sparse and relatively incomplete. Preliminary data on the presence of "eel-sized" acoustic targets have been collected (Haro *et al.* 1999) within the Turners Falls Project's Cabot Station forebay that were somewhat confirmed by video monitoring at the Cabot Station downstream fish bypass; however, these were short-term studies, with acoustic

monitoring only performed from 17 September to 5 October and video monitoring only conducted between 18 September to 22 October.

Some daily monitoring of the downstream bypass at the Holyoke Dam (canal louver array) was performed in 2004 and 2005 (Kleinschmidt, Inc. 2005, 2006, Normandeau Associates 2007); these studies also were of relatively short duration (spanning from October 5 to November 10 in 2004 and September 9 to November 11 in 2005) and the sampler was only operated at night.

To date, no other directed studies of eel migratory movements have been conducted at any location on the Connecticut River mainstem. This information gap needs to be filled, as it relates directly to when downstream passage and protection measures need to be operated.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made before any new licenses are issued for the projects.

Nexus to Project Operations and Effects

The timing of downstream migration of adult eels is poorly defined for the Connecticut River; therefore, the general effects of hydroelectric project operations on eel survival to the ocean are unknown. Although separate study requests have been submitted to address project-specific downstream passage route selection, delays, and mortality of eels, general characteristics of river flow and environmental conditions may have significant relationships with project operation and eel migratory success and survival. For example, eels may tend to move immediately before or during periods of significant precipitation (or consequently river flow), times at which projects may be generating at maximum capacity or spilling, which may (or may not) present a higher passage risk to eels. Conversely, periods of low flow may be associated with a significant proportion of total river flow passing through turbine units, which present additional (or different) passage risk to eels. If discrete conditions which promote eel downstream migration are known, it may be possible to take actions with respect to project operations which reduce or minimize passage risk; i.e., operation of a bypass, reduction of intake approach velocities, directed spillage through a "safe" route, etc. These studies should provide baseline information on river-specific downstream migration to predict when silver-phase eels are expected to be migrating in the mainstem Connecticut River, from which project operations could be modified to minimize passage risks.

The studies are proposed for a single or multiple sites; the results will be relevant to all sites on the Connecticut River mainstem.

Methodology Consistent with Accepted Practice

Quantification of downstream movements of American eels in river systems requires systematic sampling of migrants throughout the migratory season. This can be accomplished with traditional active trapping methods; i.e., fyke or stow net sampling, weirs, or eel racks, but these methods are technically challenging on larger mainstem rivers, due to the scale of flows that need to be sampled, difficulties in operation throughout all flow conditions, and high debris loading during fall flows. Passive monitoring of migrant eels using hydroacoustic methods offers an alternative to active trapping. However, this form of passive monitoring requires verification of potential acoustic targets with some level of active (collection) or visual (traditional optical or acoustic video) sampling.

Two potential locations offer opportunities to conduct simultaneous passive and active sampling: the Cabot Station (Turners Falls Project) canal/forebay and the Holyoke Dam forebay and canal louver/bypass system. Each location possesses a route of downstream passage which conducts a significant proportion of river flow (Cabot canal and Holyoke forebay or canal), and each has a proximal bypass equipped with a sampler so that fish can be concentrated/collected from the passage route and identified to species. Project operations do influence the relative proportion of flow (and thus numbers of downstream migrant eels) in each passage route, so numbers of eels sampled in each route represent only a proportion of the total number of eels migrating downstream within the entire river. Because the absolute proportion of eels using a specific route at any one time is unknown, numbers of eels quantified within a route must serve as a relative index of the degree of migratory movement.

This study shall quantify eel movements in either one, or preferably both, locations for two consecutive years (since environmental conditions strongly influence migratory timing of eels, which can vary significantly from year to year) (Haro 2003). Eels will be quantified using methods similar to Haro *et al.* (1999), by continuously monitoring a fixed location at the projects with hydroacoustics. Because eels tend to concentrate in areas of dominant flow (Brown *et al.* 2009; EPRI 2001), the zone to be monitored should pass a dominant proportion of project flow throughout most periods of operation (i.e., forebay intake area). Hydroacoustic monitoring shall encompass the entire potential migratory season, beginning in mid-August and ending in mid-December, and shall operate 24 hours per day. Data will be recorded for later processing and archiving.

Systematic active quantification of eels at downstream bypass samplers shall be performed simultaneously with passive hydroacoustic monitoring, to verify presence of eels and relative abundance of eel-sized hydroacoustic targets from the hydroacoustic data. Although daily operation of the bypass sampler could be performed, a more comprehensive technique is to monitor eels entering the bypass with an acoustic camera (i.e., DIDSON, BlueView, etc.). The acoustic camera will afford positive visual identification of eels as they enter the bypass, which is a concentration point for migrating eels. Acoustic camera monitoring will also allow monitoring to be performed 24 hours a day, and will be relatively unaffected by water turbidity

(which influences effectiveness of traditional optical video monitoring). The acoustic camera system will be operated during the same time period as acoustic monitoring, and images will be recorded for later processing and archiving.

Data analyses of hydroacoustic, acoustic camera, bypass sampling, and environmental/ operational data will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the downstream migrant eel migratory timing study would be moderate, given the level of cost for instrumentation, deployment, and data review/analysis. Cost is estimated at $50,000 per year for the study.

The Applicant did not propose any studies to meet this need in the PAD.

REFERENCES

Brown, L., A. Haro, and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

EPRI (Electric Power Research Institute). 2001. Review and documentation of research and technologies on passage and protection of downstream migrating catadromous eels at hydroelectric facilities. EPRI Technical Report No. 1000730, Palo Alto, California 270 pp.

Haro, A. 2003. Downstream migration of silver-phase anguillid eels. Pages 215-222 in: Aida, K., K. Tsukamoto, and K. Yamauchi, eds. Eel Biology. Springer, Tokyo.

Haro, A., D. Degan, J. Horne, B. Kulik and J. Boubée. 1999. An investigation of the feasibility of employing hydroacoustic monitoring as a means to detect the presence and movement of large, adult eels (Genus *Anguilla*). S. O. Conte Anadromous Fish Research Center Internal Report No. 99-01. Turners Falls, Massachusetts. 36 pp.

Kleinschmidt, Inc. 2005. Factors influencing the timing of emigration of silver-phase American Eels, *Anguilla rostrata*, in the Connecticut River at Holyoke MA. Submitted to the City of Holyoke Gas and Electric Department. 27 pp.

Kleinschmidt, Inc. 2006. Holyoke Project (FERC No. 2004) silver-phased American eel flow priority plan. Submitted to the City of Holyoke Gas and Electric Department. 51 pp.

Normandeau Associates, Inc. 2007. American eel emigration approach and downstream passage routes at the Holyoke Project, 2006. Submitted to the City of Holyoke Gas and Electric Department. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 81 pp.

FirstLight Study Request #16

Downstream American Eel Passage Assessment at Turners Falls and Northfield Mountain Pumped Storage

(Turners Falls, P-1889; Northfield Mountain, P-2485**)**

Goals and Objectives

The goal of this study is to determine the impact of two hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment of eels at the Northfield Mountain Pumped Storage (NMPS) Station removes eels from the river, effectively extirpating them from the population. Entrainment at the conventional turbines at Station 1 and Cabot Station of the Turners Falls Project can result in mortality or injury. It is important to understand the passage routes at each project and the potential for mortality to assess alternative management options to increase survival.

The objectives of this study are:

1. Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the projects; i.e., for NMPS, the proportion entrained into the intake; for Turners Falls Dam, the proportion entrained into the power canal and spilled via bascule and taintor gates; for the Cabot Canal, proportion of fish passing via spillways, turbines, and the downstream bypass.

2. Evaluate instantaneous and latent mortality and injury of eels passed via the Turners Falls Dam routes, including bascule and taintor gates, spillways, turbines, and the downstream bypass.

Resource Management Goals

The Atlantic States Marine Fisheries Commission (ASMFC) has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Federal Energy Regulatory Commission relicensing process.

In addition, the Connecticut River Atlantic Salmon Commission (CRASC) developed A Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basin in 2005. The goal of the plan is "to protect and enhance the abundance of the American eel resource to ensure its continued role in the Connecticut River Basin ecosystem…" Management objectives in the plan include the following:

1. protect and enhance eel populations where they currently exist;
2. where practical, restore populations to waters where they had historical abundance;
3. provide effective upstream and downstream fish passage around dams and other barriers within the species' range in the basin; and
4. comply with all requirements of the Fishery Management Plan of the ASMFC.

Based on these plans, the U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to downstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains information on the biology, life history, and regulatory status of American eel. It also discusses 2-D and 3-D telemetry studies that were conducted at Cabot Station in 1996, 1997, 2002 and 2003. Results of those studies indicate that a significant proportion of eels entering the Cabot forebay become entrained (90 percent in 2002, 100 percent in 2003) (Brown 2005; Brown *et al.* 2009). The PAD notes that the study done in 2003 determined that 15 of the 29 test eels were detected at the Hadley Falls Station. However, that study was not designed to assess turbine mortality.

To date, no directed studies of eel mortality at Cabot Station or eel entrainment or mortality at either Station 1 or the NMPS facility have been conducted. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

We also note that within the past seven years, the Service has received two petitions to list the American eel under the Endangered Species Act. The first petition was received on November 18, 2004. On July 6, 2005, the Service issued a substantial 90-day finding on the petition and initiated a 12-month status review that concluded on February 2, 2007 with a finding that listing was not warranted. The second petition was filed on April 30, 2010 by the Council for Endangered Species Act Reliability (CESAR). On September 29, 2011, the Service issued a substantial 90-day finding and initiated a 12-month status review. The Service is still accepting new American eel information for the ongoing status review. The Service also is currently in settlement negotiations with CESAR on their legal complaint that the Service failed to complete the 12-month finding within the statutory timeframe. Although the date for completion of the Service's 12-month finding on the latest petition is uncertain, it is likely that it will be made prior to any new licenses being issued for the projects.

Nexus to Project Operations and Effects

The Turners Falls Project operates as a peaking facility, except during periods when inflow exceeds the hydraulic capacity of Cabot Station and Station 1. Silver eels outmigrate during the mid-summer through late fall, a time of year when flows are generally near the maximum operating capacity of the stations. Therefore, the project would be expected to spill infrequently during the silver eel outmigration beyond the nominal amount required in the bypass reach.

Racks at Cabot Station, Station 1, and the NMPS facility are not designed to protect eels from entrainment. At Cabot, the racks have one-inch-clear spacing on the top 11 feet, with five-inch-clear spacing on the bottom 20 feet of racks. The approach velocity at the racks is approximately 2.0 feet per second at maximum hydraulic capacity. At Station 1, the racks have 2.6-inch-clear spacing and an approach velocity of 1.2 feet per second. Eels can readily pass through a 2.6-inch-clear space. NMPS has 48-foot-deep trashracks with 6-inch-clear spacing over the intake and an approach velocity of 3.5 feet per second at full pumping capacity (15,000 cfs).

As mentioned above, previous studies conducted at Cabot Station documented eel entrainment. Cabot Station has existing downstream passage facilities designed for anadromous species, but studies have documented few eels utilizing the surface bypass (likely because Cabot has a relatively deep, wide intake area). Station 1 has no passage and protection facilities. NMPS has a seasonally deployed barrier net to minimize entrainment of Atlantic salmon smolts, but it is only operated from April through June 15 annually. While no studies have been conducted at Station 1 or the NMPS facility, the rack spacing is wide enough to allow for entrainment.

Methodology Consistent with Accepted Practice

In order to understand the movements of outmigrating silver eels as they relate to operations at the NMPS facility, Station 1, and Cabot Station, radio telemetry technology should be utilized. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Muddy Run Project (FERC No. 2355).

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different telemetric methodologies. Studies also will likely benefit from data from several seasons (especially route selection studies, which may be more significantly affected by environmental conditions during a given season than mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies have been completed.

1. Objective 1: Route Selection

   This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out of basin may be acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g., eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late August to mid-October), and eels should be tagged and released within seven days of collection.

   NMPS Route Selection Study:

   A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Eels will be released at least 5 km upstream of the NMPS project; releases should be timed so that there is a significant probability that migrating eels will encounter NMPS during the pumping stage. Radio telemetry antennas will be strategically placed to determine times eels are present within the river reach in the vicinity of the NMPS intakes, within the intakes themselves, and whether they are entrained into the upper reservoir.

Turners Falls Dam Route Selection Study:

A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during spill and non-spill periods, if possible. Tagged eels will be released at least 3 km upstream of the Turners Falls Dam, but several km below the intake to NMPS. Telemetry receivers and antennas will be located above and below the dam to assess passage via the following potential routes: entrainment into power canal; passage via spill over the bascule gates; passage via spill through the taintor gates.

Eels from the NMPS route study not entrained into the NMPS intake and migrating to the Turners Falls Dam may be used to supplement (but not serve in lieu of) these release groups.

Turners Falls Project – Canal Route Selection Study:

A minimum number of 50 telemetered eels (e.g., five separate groups of approximately 10 eels each) will be required to maximize the data return. Groups of eels should be released during periods of low, moderate, and high generation conditions, if possible. Eels will be released in the upper canal (ideally just downstream of the gatehouse), and allowed to volitionally descend through the canal. Telemetry receivers and antennas will be located within the canal, bypass, channel, and mainstem below Cabot Station to assess passage via the following potential routes: spillway fishway attraction water intake (if operational); Station 1 turbines; Cabot Station spillway; Cabot Station bypass; Cabot Station turbines.

Eels from the NMPS and Turners Falls Dam route studies not entrained into the NMPS intake and migrating into the Turners Falls Canal may be used to supplement (but not serve in lieu of) these release groups.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals during and after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

Movement rates (time between release and passage) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

2. Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies

Spill, bypass, and turbine mortality will be assessed using a radio-telemetric balloon tag method. A minimum number of 50 tagged eels (e.g., five separate groups of approximately 10 eels each) will be required at each location (dam bascule gate, dam taintor gate, Cabot Station spillway, Cabot Station bypass, Station 1 and Cabot Station) to

maximize the data return. Turbine mortality studies are not required at NMPS because it is assumed that all entrained fish (including eels) are lost to the Connecticut River system.

For spill mortality sites (dam bascule gate, dam taintor gate, Cabot Station spillway, Cabot Station bypass), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

For turbine mortality sites (Station 1 and Cabot Station), tagged eels will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec, to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Cabot Station will be performed at regular intervals after releases to confirm routes and fates of passed fish, or fish lost to follow-up.

The turbine mortality component of the study should occur in study year two.

Data analyses of route selection and turbine mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will Not Suffice

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes to all stations, as well as at the Turners Falls Dam spillway and Cabot Station bypass, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately $75,000 for the first year of study. Costs are estimated at $100,000 per year for the route selection studies and $75,000 per year for the spill, bypass, and turbine mortality/injury studies.

In the PAD, the Applicant has identified the need to assess issues related to downstream passage for American eels at the project, but indicates that they intend to rely on information from previously conducted studies and ongoing studies. The Service is not aware of any previously conducted or ongoing studies related to downstream eel passage.

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Brown, L.S. 2005. Characterizing the downstream passage behavior of silver phase American eels at a small hydroelectric facility. M.Sc. Thesis, Department of Natural Resource Conservation, University of Massachusetts, Amherst, Massachusetts. 110 pp.

Brown, L., A. Haro and T. Castro-Santos. 2009. Three-dimensional movement of silver-phase American eels in the forebay of a small hydroelectric facility. Pages 277-291 in: J. Casselman et al. editors. Eels at the Edge: Science, Status, and Conservation Concerns. American Fisheries Society, Bethesda, MD.

FirstLight Study Request #17

Determine the Fish Assemblage in the Turners Falls and Northfield Mountain Pumped Storage Project-Affected Areas

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

The goal of this request is to determine the occurrence, distribution, and relative abundance of fish species present in the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage (NMPS) project areas, which potentially includes Species of Greatest Conservation Need (SGCN) for Massachusetts, New Hampshire, and Vermont.

Specific objectives include:

1. Document fish species occurrence, distribution and abundance within the project-affected areas along spatial and temporal gradients.

2. Compare historical records of fish species occurrence in the project affected areas to results of this study.

Resource Management Goals

The Massachusetts Division of Fisheries and Wildlife, the New Hampshire Fish and Game Department and the Vermont Fish and Wildlife Department each have as a mission the protection and conservation of fish and their habitats. Riverine fish species are an important component of the river's ecology and are the basis for the sport fishery. Furthermore, several of the states' SGCN have been documented in the project-affected areas.

Determining species occurrence, distribution, and abundance will better clarify what species occur in the project area both spatially and temporally, relative to habitats which may be affected by project operations of the Turners Falls or NMPS projects. This information will better inform other results from other study requests that will be examining project operation effects on various aquatic habitats, water quality and other related concerns such as entrainment concerns at NMPS. This information will be used to make recommendations and provide full consideration for all species, including those that might not otherwise be known to occur in the project-affected area and impacts that may affect their population status through direct or indirect effects of the projects.

Public Interest

The requestor is a natural resource agency.

Existing Information

A thorough and comprehensive assessment of the fish assemblage present in the project-affected areas of the Turners Falls and NMPS projects is lacking. The PAD for these project sites notes resident fish surveys conducted by the State of Massachusetts in the early to mid-1970s and a limited 2008 sampling effort by Midwest Biodiversity Institute (contracted by EPA). The PAD identifies a total of 22 fish species in the project area which omits, as an example of its limited information basis, northern pike, tessellated darter, burbot, eastern silvery minnow, and channel catfish (Ken Sprankle, USFWS, and Jessie Leddick, MADFW, personal communication). It is unknown how many other species may inhabit or utilize aquatic habitats in the project areas, potentially including species of greatest conservation need.

The most relevant recent fish survey study related to the project-affected areas is a Connecticut River electrofishing survey conducted in 2008 (Yoder *et al.* 2009). While some sampling was conducted in both project areas during the 2008 survey, this survey did not have the same goals and objectives as those outlined above. Due to the design of the study limitations in geographic/habitat type coverage both spatially and temporally, and the use of a single gear type, these data may not be a full representation of species occurrence in the project affected areas. It follows that since information is limited regarding the composition of the fish community and their use of habitats in the project-affected area, project impacts on fish species are also unknown.

Nexus to Project Operations and Effects

Project operations have the potential to directly impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, headpond and tailwater water level fluctuations could dewater important spawning areas, or affect habitat availability, thus limiting productivity of fish species by direct impacts to their spawning success or indirectly by limiting the spawning success of forage fish species. Accordingly, a thorough understanding of the current fish assemblage structure and associated metrics is needed in order to examine any potential project-related impacts. A study request to examine project effects on aquatic habitats, as well as impacts to spawning habitats (e.g., sea lamprey and black bass) has been submitted and will compliment this request.

Methodology Consistent with Accepted Practice

An accepted and robust field sampling design (e.g., as described in Pollock *et al.* 2002 or MacKenzie *et al.* 2006) and accepted methods for collecting fish species likely to be present in the project-affected areas (Bonar *et al.* 2009) should be used to conduct field surveys. Randomly sampling multiple habitat types using a multi-gear approach will be required to ensure that all fish species present are sampled. The spatial scope of the study will be from the headwaters of the Turners Falls pool downstream to Sunderland, Massachusetts, and will omit the upper reservoir of NMPS. Sampling should occur at each selected site across multiple seasons (spring, summer, and fall). Digital photographs should be taken to avoid misidentification of certain species such as Cyprinids.

The sampling design should include replicate samples for estimation of species detection probability. Sample replicates may be gathered temporally, using different methods, by independent observers, or by randomly sampled spatial replicates (MacKenzie *et al.* 2006). For each replicate sample, data that may be important for describing variation in species occurrence and presence/absence should be collected and recorded, such as gear type, mesohabitat type, depth, velocity, flow, water temperature, substrate, time of day, day of year, presence of cover, proportion of vegetation cover, size of individuals collected (juveniles may select different habitat), and/or other factors as determined by a qualified biologist. Species detection, occurrence, and/or abundance and related habitat measures on these parameters should be estimated using methods as described by Kery *et al.* (2005), MacKenzie *et al.* (2006), Wenger and Freeman (2008), or Zipkin *et al.* (2010).

This will be a one-year study, provided river discharge conditions fall within the 25-75th percentile for weekly averages. Based upon this study's results, and the information obtained from studies to survey aquatic habitats and littoral zone fish spawning, additional studies may be required if there is evidence of effects of the projects on populations or habitat of identified species.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost of the study will be moderate to high as seasonal sampling with several types of gear will be required. However, cost will also be partially dependent on the number of sites sampled, the number of sample replicates, and the extent of the covariate data that are measured, all of which may be flexible. Based on first-year study results, a second year of sampling or specific studies examining impacts of project operations on specific fish species may be needed and requested. Provided the collected data are of high quality, analysis and synthesis should take approximately 10-20 days. FirstLight did not propose any studies specifically addressing this issue.

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Zipkin, E.F., J.A. Royle, D.K. Dawson and S. Bates. 2010. Multi-species occurrence models to evaluate the effects of conservation and management actions. Biological Conservation 134:479-484.

FirstLight Study Request #18

Impacts of the Turners Falls and Northfield Mountain Pumped Storage Projects on Littoral Zone Fish Habitat and Spawning

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

The goal of this study is to determine if project operations and water level fluctuations in the Turners Falls Project impoundment negatively impact anadromous and resident fish. This study complements a separate study request specific to American shad spawning and also on habitats affected by water level manipulations.

Specific objectives include:

1. delineate, quantitatively describe (e.g., substrate composition, vegetation type and abundance), and map shallow water aquatic habitat types subject to inundation and exposure due to project operations, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, etc. with very slight bathymetric change);
2. conduct analyses of the impacts of normal operations and the maximum permitted reservoir fluctuation range on the suitability of littoral zone habitats for all life stages of target species likely to inhabit these areas;
3. conduct field studies to assess timing and location of fish spawning;
4. conduct field studies to evaluate potential impacts of impoundment fluctuations on nest abandonment, spawning fish displacement, and egg dewatering; and
5. evaluate potential impoundment fluctuation ranges and how implementation of such changes would mitigate for identified impacts.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) has identified its mission as: working with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Service has identified the following Northeast Regional goals to support the Service's mission and vision, the national Fisheries Program mission, and Service priorities: 1) conservation, and management of aquatic species: maintain, restore, and recover populations of species of conservation and management concern to self-sustaining levels; and 2) conservation and management of aquatic ecosystems: maintain and restore the ecological composition, structure, and function of natural and modified ecosystems to ensure the long-term sustainability of populations of species of conservation and management concern.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the areas impacted by project operations.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

A mission of both the New Hampshire Fish and Game Department and the Massachusetts Division of Fisheries and Wildlife is to protect and conserve fish and their habitats. Resident fish species are an important component of the river's ecology and in some cases are the basis for a sport fishery. This requested study will help protect and conserve resident fish species by ensuring project operations do not negatively impact their spawning success and spawning habitats.

Public Interest

The requestor is a resource agency.

Existing Information

To our knowledge, no information exists related to this requested study. The Massachusetts Integrated List of Waters shows the project area from the Vermont/New Hampshire state line to the Turners Falls Dam impaired due to "other flow regime alterations."

Nexus to Project Operations and Effects

Project operations have the potential to impact fish species by influencing spawning success and spawning habitat quality and quantity. For example, water level changes due to project operations could create conditions where fish eggs are exposed to air, where spawning habitat is dewatered, and/or where fish abandon nests containing eggs.

Methodology Consistent with Accepted Practice

Common tools to evaluate water level impacts would be used, including bathymetric mapping and measurement of physical habitat characteristics such as substrate, depth and velocity. Studies should be conducted throughout the spawning season (e.g., April through August).

Common tools to evaluate fish spawning would be used, including visual observations of habitats and sampled fish (i.e., in spawning condition, coloration, gonads mature, and other external features that become developed with spawning) collected using techniques such as electrofishing, seining and other net gear during defined environmental and/or time windows for spawning activity. Project operation-impacted areas should be quantified to identify and define

areas subject to dewatering and mapped relative to observations of fish nests, spawning fish, and egg deposits. During identified spawning periods for the target species, suitable spawning habitats subjected to daily project operational fluctuations will be surveyed to document the type and extent of project effects on nests or spawning habitat (e.g., nests of fallfish, lamprey, bass and sunfish) and observable eggs or larvae, relative to water level and other environmental conditions, including water temperature and water velocity in noted areas.

At least one year of data collection is necessary. A second year of study may be required should environmental (e.g., river discharge, air/water temperature) or operational conditions in the first year prove to be atypical during the study period (end of March through August).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight Power does not propose any studies to meet this need. Estimated cost for the study is moderate.

FirstLight Study Request #19

Impacts of the Turners Falls and Northfield Mountain Pumped Storage Project Operations on Tributary and Backwater Area Access and Habitats

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

One goal of this study is to determine if water level fluctuations from the Turners Falls and Northfield Mountain Pumped Storage projects result in a barrier(s) to fish movement in and out of tributaries and backwaters to the impoundments and riverine reaches below dams.

A second goal is to determine if water level fluctuations in the Turners Falls and Northfield Mountain Pumped Storage project impoundments impact water levels, available fish habitat and water quality in tributaries and backwaters to the impoundments and riverine reaches below dams, and if impacts are found, to ascertain how spatially far reaching they are and develop mitigation measures.

Results of this study may also be used to help determine the adequacy of existing downstream minimum flow requirements.

Specific objectives include:

1. Conduct a field study of tributaries and backwaters, including water velocity and habitat data where appropriate, to evaluate potential impacts of impoundment fluctuation on fish access to tributaries and backwater areas. The study should also evaluate if changes in impoundment fluctuation range would mitigate for any identified impacts and if other mitigative measures would improve access.

2. Conduct a field study to examine potential impacts of impoundment fluctuations on water levels, available habitat and water quality in tributaries and backwaters. The evaluation should also evaluate if changes in impoundment fluctuation range would mitigate for identified impacts and if other mitigative measures would lessen these impacts.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide an instream flow regime that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) throughout the areas impacted by project operations.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

This requested study will facilitate the collection of information necessary to conduct effects analysis and to develop conservation measures to protect and enhance tributary and backwater access and valuable fish habitat. Maintaining connectivity between the mainstem of the Connecticut River and tributaries and backwaters is vital to the fish populations in these systems, as many fish species utilize these areas for spawning, rearing, refuge, and feeding.

Public Interest

The requestor is a natural resource agency.

Existing Information

To our knowledge, limited information exists related to this requested study.

Nexus to Project Operations and Effects

Project operations have the potential to impact fish species life history requirements, biological interactions, and habitat quantity and quality. For example, water level changes due to project operations could create conditions that could impede free movement of fish between tributaries/backwaters and the mainstem of the Connecticut River, thus limiting access to spawning habitat and/or growth opportunities. Additionally, water level changes could also alter tributary and backwater fish habitat quality, quantity, and also water quality, thus decreasing productivity and available habitat.

Methodology Consistent with Accepted Practice

Common tools to evaluate water level impacts would be used, including bathymetric mapping, substrate, depth and velocity measurements, and water quality information (dissolved oxygen, temperature, turbidity, and pH). Studies should be conducted throughout the year.

The study area for tributary and backwater fish sampling should cover all tributaries and backwaters within the project-affected areas of the Turners Falls and Northfield Mountain Pumped Storage projects. A second year of study may be required if first year data collection is

limited due to environmental or other conditions, or if river discharge in the first year proves to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

FirstLight does not propose any studies to meet this need. Estimated cost for the study is moderate.

FirstLight Study Request #20

Impacts of Water Level Fluctuations on Riparian and Aquatic Vegetation Including Invasive Species and their Associated Habitats in the Turners Falls Dam Project Impoundment

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Conduct a study to quantify impacts of reservoir fluctuation on riparian, wetland, emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), littoral zone and shallow water aquatic habitats in the Turners Falls Dam impoundment.

Goals and Objectives

The goal of this study is to obtain baseline information on riparian, wetland, emergent and submerged aquatic vegetation, and associated shallow water aquatic habitats (subject to operational inundation and exposure to near exposure) known to occur in the project area. Information would be used to determine whether riparian, wetland, EAV and SAV, littoral, and shallow water (e.g., mid-river bars and shoals) habitats are impacted by current water level fluctuations permitted under the Turners Falls and Northfield Mountain Pumped Storage (NMPS) projects' licenses and whether these vegetation types and shallow water habitats can be protected and restored by modifications to project operations or other mitigation measures. This analysis needs to take into account existing and potential future limits on pond level fluctuations intended to limit recreation impacts, and the interactions of any changes in pond level fluctuation range or frequency and discharge changes under the new licenses of the Turners Falls and upstream projects. This information is needed to determine whether the project operations affect plants, habitat, and wildlife in the project area, whether aquatic vegetation and its habitats can be enhanced by modifications to project operations or other mitigative measures, and whether there is any unique or important shoreline or aquatic habitats that should be protected.

The specific objectives of the field study, at a minimum, include:

1. quantitatively describe and map wetland types within 200 feet of the shoreline, and describe associated wildlife;
2. delineate, quantitatively describe, and map all wetland types, including invasive species and wildlife observed (e.g., bald eagle nesting, water fowl nesting) within 200 feet of the shoreline, and the extent of this habitat if it extends beyond 200 feet; and
3. quantitatively describe (e.g., substrate composition, vegetation type and abundance) and map shallow water aquatic habitat types subject to project operation inundation and exposure, noting and describing additional areas where water depths at lowest operational range are wetted to a depth less than one foot (flats, near shore areas, gravel bars, with very slight bathymetric change).

A second year of study may be required should river discharge in the first year prove to be atypical (outside of 25-75th percentile of average weekly flow values) during the study period.

The field study should produce a habitat inventory report that includes:

1. the results of the field study in the form of maps and descriptions;
2. an assessment of project effects on wetland, riparian, littoral zone vegetation and shallow water habitats, invasive plant species, and wildlife habitat at the project;
3. recommendations for any necessary plant, habitat type, or wildlife, protection and/or invasive species control measures; and
4. recommendations for plant, habitat type, or wildlife protection and/or invasive species control measures, including riparian buffer restoration and protection and protection of key nest and roost trees for bald eagles.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Public Interest

The requestor is a resource agency.

Existing Information

Existing information in the PAD does not quantify EAV and SAV in this area, or other shallow aquatic habitat types and physical features (e.g., depths, substrates, wood structure) that are the environment for aquatic biota in the project area. The PAD does provide some limited monitoring data for 2012 (two locations) on water surface elevations that showed daily fluctuations, in the upper third of this impoundment, that varied over 4 feet on a daily cycling frequency, with fluctuations generally in the 2-foot range in low flow months for the data provided in the PAD. The current license does permit a greater pool elevation operational

fluctuation, up to a 9-foot change in elevation, based on the Turners Falls Dam water elevation. In the PAD, it is noted that these operational fluctuations under most circumstances at the Turners Falls Dam are within 3.5 feet.

In the PAD it is noted that FirstLight would like to expand its NMPS upper reservoir capacity (by up to 24 percent); how this may affect project operations and the habitats noted in this request is unknown. It is also noted that water is typically pumped to the upper reservoir in the evening and generation back to the river occurs once to twice daily, in daytime hours, based upon power needs and power value. Under current license conditions, provided set thresholds for minimum flow and Turners Falls Dam current license elevations are met, the NMPS may operate with no restriction in timing, frequency, or magnitude for pumping or generation. No data were provided on the operation of the NMPS plant over time relative to data on pumping and generation on an hourly basis averaged values were provided over monthly periods. It is unclear what the actual timing, frequency and magnitude of these NMPS operations are over the course of a year and how that relates to aquatic plant species establishment, growth, survival, littoral zone or other shallow water habitat fish spawning periods and their effects on these fishes (reproduction success and subsequent recruitment, e.g., bass and fall fish nests) in available and utilized habitat, and how the quantity and quality of these shallow water habitats are effected by project operational manipulation/alteration, as currently permitted or proposed.

The PAD provides lists of plant and wildlife species whose native ranges overlap with the project area, but it does not provide any baseline information on known occurrences of these species in the wetlands, riparian, littoral and shallow water habitats, within or adjacent to the project area. Plant and wildlife occurring in these habitats may benefit from protection, mitigation, and enhancement (PMEs) measures, given the potential effects of continuing the current semiautomatic peaking operating regime. In addition, a large-scale sediment discharge from NMPS resulted in regulatory actions by FERC, the EPA and MADEP in 2010. Continuing and as yet unresolved management plan measures relative to sediment and NMPS project operations are further concerns for shallow water, littoral zone, and wetland habitats.

The Atlantic States Marine Fisheries Commission, Atlantic Coast Diadromous Fish Habitat: A Review of utilization, threats, recommendations for conservation, and research needs (ASMFC 2009), contains a review of habitat information for these species. Recommendations in this report include: Maintain water quality and suitable habitat for all life stages of diadromous species in all rivers with populations of diadromous species.

Nexus to Project Operations and Effects

Water level fluctuations due to project operations could affect EAV and SAV habitat as well as the quantity and quality of littoral and shallow water habitat. These operational water level fluctuation effects are expected to impact fish species use of these habitats and may affect spawning fishes reproductive success and subsequent population recruitment including but not limited to American shad, blueback herring, sea lamprey, fall fish, and bluegill, which spawn in mid-to-late spring through early summer in areas subject to daily or more frequent water level fluctuations.

The current operating mode, as well as the unknowns with proposed upper reservoir expansion, may affect wetland riparian, littoral and other shallow water habitats, and promote the introduction and expansion of invasive plant species through fluctuating water levels. A study that explains the relationship between the proposed mode of operation and the type and quantity of wetland, riparian, littoral, shallow water habitats, and invasive species affected would help inform a decision on the need for protection and/or control of these resources in the license.

Riparian buffers provide for river bank stability, reduction in nutrient and sediment from runoff, shading and reduced solar heating of river waters and wildlife habitat (including eagle nesting and roosting habitat) and movement corridors. Management of the project's shorelines are within the scope of project review and a Shoreline Management Plan is likely to be required. Incorporation of riparian resource protection and enhancement into this plan will require baseline information on existing conditions.

Methodology Consistent with Accepted Practice

The PAD currently contains maps portraying general wetland types from the Cabot Station tailrace upstream to the Vernon Dam. In addition, the Service understands that detailed bathymetry exists for the Turners Falls impoundment. The proposed study should utilize this existing information in conjunction with field surveys designed to describe the characteristics of each mapped wetland, riparian, littoral and shallow water habitat, including plant species composition, relative abundance/density, habitat quality, and land use. These surveys should be conducted to describe these habitats at the lowest water level operational range permitted on a daily operation schedule, under low flow conditions. Information collected should include:

1. plant species composition, and their relative abundance/density and condition/structure (e.g., seedlings);
2. structured data, including estimates of average heights and aerial cover of each vegetation layer (specifically denoting invasive species);
3. aquatic habitat substrate composition, quantity (i.e., percent types and area), wood structure (relative abundance measure applied by area), water depths (inundated, exposed, and water less than one foot);
4. predominate land use(s) associated with each cover type;
5. wildlife sightings should be noted; and
6. field-verified wetland, riparian, and littoral and shallow water habitats and invasive species occurrences should be geo-referenced as polygons and overlain on orthophoto at a suitable scale.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

In the PAD, FirstLight identified impacts of the project operations on wetlands, riparian and littoral zone habitat as a potential issue to be addressed in relicensing. FirstLight proposed wetland vegetation mapping, but additional analysis as described above is needed to understand the impacts of the project on these resources and habitats.

A wetlands, riparian, littoral/shallow water, invasive species inventory, of the scope envisioned, would likely require six to eight months to complete and cost $40,000 to $50,000.

REFERENCES

Atlantic States Marine Fisheries Commission. 2009. Atlantic coast diadromous fish habitat: A review of utilization, threats, recommendations, for conservation, and research needs. Habitat Management Series #9. Washington, D.C.

FirstLight Study Request #21

Water Quality Monitoring

(Turners Falls, P-1889; Northfield Mountain, P-2485)

Goals and Objectives

Determine the current water quality of the Connecticut River within the project area.

The specific objectives of this study are as follows:

1. Characterize water quality in the Turners Falls impoundment, bypass reach, canal and below the confluence of the bypass reach and canal discharge.
2. Evaluate the potential effects of project operation on water quality parameters such as temperature and dissolved oxygen (DO) in conjunction with various other water uses.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to water quality within the Turners Falls Project area, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a natural resource agency.

Existing Information

The PAD provides a summary of existing water quality data. While a number of monitoring efforts have taken place and include sample sites within the project boundary, none of those studies were designed to comprehensively investigate whether all relevant project areas currently meet Class B standards: The Massachusetts Department of Environmental Protection's Connecticut River watershed assessment monitoring occurred in 2003, only had two stations located within the project area (both upstream of the Turners Falls Dam), and only collected five to six samples from late April to early October; the Connecticut River Watershed Council's volunteer monitoring program only had one sample site within the project area (at Barton's Cove in the Turners Falls headpond), and while those data are more recent, only three samples were collected in 2007 and only six samples in 2008 (over the course of three to four months each year); and the U.S. Geological Survey's long-term water quality monitoring station located downstream of the Cabot Station tailrace only collects information roughly once per month (and no DO data are provided).

No directed, site-specific surveys have been conducted to determine whether waters within the project area meet state standards. This information gap needs to be filled so that resource agencies can properly evaluate the potential impact of project operations on water quality.

Nexus to Project Operations and Effects

The project creates a 20-mile-long impoundment where there would naturally be a free-flowing river. It currently operates in a peaking mode, with allowable headpond fluctuations of up to 9 feet, with proposals to continue as such. Portions of the headpond are nearly 100 feet deep. There is a 2.7-mile-long reach of river bypassed by the Turners Falls power canal, with only a nominal seasonal release required (equal to 0.05 cfsm). The below-project flow requirement is equal to 0.20 cfm (1,433 cfs). Water quality can be affected by the operating mode of a hydropower project. Impoundments can stratify, resulting in a near-hypoxic hypolimnion. If the project intake draws off of these deep waters, it could cause low DO levels downstream from the project discharge.

The Service requests that the Applicant conduct a water quality survey of the impoundment, bypass reach and tailrace reach in order to determine whether state water quality standards are being met under all currently-licensed operating conditions (i.e., during periods of generation and non-generation). Results of the survey would be used, in conjunction with other studies requested herein, to determine an appropriate below-project flow prescription, bypass reach flow(s), and to recommend an appropriate water level management protocol for the headpond (e.g., limiting impoundment fluctuations to protect water quality).

Methodology Consistent with Accepted Practice

Turners Falls: Water temperature and DO measurements should be collected from a minimum of six locations: upstream in the impoundment (Route 10 bridge), at a deep location within the impoundment, in the forebay near the intake, in the bypass reach, in the canal near Cabot Station, and downstream of the confluence of the Cabot Station discharge and the bypass reach, but

upstream of the confluence with the Deerfield River. In order to ensure that data are collected during a time of important biological thresholds and anticipated "worst case" conditions for DO (low flow, high temperature, antecedent of any significant rainfall event), we recommend deploying continuous data loggers at all six locations, with biweekly vertical profiles taken at the deep impoundment location from April 1 through November 15. Results should include date, time of sampling, sunrise time, GPS location, generation status (estimated flow through canal and bypass reach), precipitation data, water temperature, DO concentration and percent saturation.

If river flow and temperature conditions are representative of an "average" or "low" water year, one year of data collection should be sufficient to perform the study. If conditions are not representative (i.e., a "wet" or cool year), a second year of data collection may be necessary.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Cost would depend on the specific methodology chosen. If continuous data loggers are installed at all six locations and biweekly vertical profiles taken at the deep impoundment location from April 1 through November 15, the estimated cost of the water quality study is moderate. It is expected to take two technicians approximately one day to deploy the loggers, twelve days to collect the vertical profiles, one day to remove the loggers, one day to download the data, and five days to write the report.

In the PAD, the Applicant proposes to assess the effects of the Turners Falls and the Northfield Mountain Pumped Storage (NMPS) project operations on DO and temperature by continuously monitoring DO and temperature at locations within the project areas and gathering vertical profiles within the Turners Falls impoundment and NMPS upper reservoir.

FirstLight Study Request #22

Climate Change as it Relates to Continued Operation of the Vernon, Bellows Falls, Wilder, Northfield Mountain Pumped Storage, and Turners Falls Projects

(Turners Falls, P-1889; Northfield Mountain, P-2485; Bellows Falls, P-1855; Wilder, P-1892; Vernon, P-1904)

Goals and Objectives

The goal of this study is to determine how climate change relates to the continued operation of the Vernon, Bellows Falls, Wilder, Northfield Mountain Pumped Storage (NMPS), and Turners Falls projects.

The objectives of this study are:

1. Quantify the amount of thermal loading contributed by each respective impoundment (including the NMPS upper reservoir).
2. Using climate change prediction models, calculate how much warmer the project impoundments are projected to get in the next 30-50 years.
3. Model the effect of various project modifications on river temperature under current conditions and climate change predictions (e.g., converting to run-of-river, deep-water releases, dam removal, large-scale riparian revegetation, etc.).
4. Using climate change prediction models, determine if the projects actually provide an environmental benefit with respect to mitigating against climate change impacts (vis a vis warming of air and water temperatures) by producing low greenhouse gas emitting energy. The NMPS assessment must be based on net energy production (i.e., NMPS generates 1,143,038 MWh annually, but consumes 1,567,506 in its pumping operations, for a net consumption of 424,468 MWh annually).
5. Determine how climate change predictions will impact management of high flow events at the three projects and evaluate if changes to dam structures would mitigate adverse impacts of the existing flood management protocols.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the projects.

Specific to climate change, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize deep headpond drawdowns associated with the loss of stanchion logs during high flow events, which are predicted to increase due to climate change.
3. Minimize project-related sources of thermal increases to Connecticut River waters to mitigate against predicted climate change impacts.

The Service, along with the National Oceanic and Atmospheric Administration (NOAA) and the Association of Fish and Wildlife Agencies, developed a draft *National Fish, Wildlife and Plants Climate Adaptation Strategy* (Strategy) in 2012. The public comment period closed on March 5, 2012, and the agencies are working to finalize the document. Goal #7 of the Strategy calls for reducing non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate. The Strategy notes that some stressors (such as habitat loss and fragmentation and pollution) "are not only some of the things decision makers can control, they are also likely to interact with climate change to magnify negative impacts on fish, wildlife, and plants."

Goal #7 contains a number of strategies and associated actions, including:

Strategy 7.1: Slow and reverse habitat loss and fragmentation

Actions:

1. Consider application of offsite habitat banking linked to climate change habitat priorities as a tool to compensate for unavoidable onsite impacts and to promote habitat conservation or restoration in desirable locations.
2. Identify options for redesign and removal of existing structures/barriers where there is the greatest potential to restore natural processes.

Strategy 7.2: Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through…water resource planning, pollution abatement…

Actions:

1. Work with….water resource…planners to identify potentially conflicting needs and opportunities to minimize ecosystem degradation resulting from development and land and water use.
2. Reduce existing pollution and contaminants and increase monitoring of air and water pollution.
3. Increase restoration, enhancement, and conservation of riparian zones and buffers in agricultural and urban areas to minimize non-point source pollution.

Our study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Endangered Species Act of 1973, as amended (16 U.S.C. §1531 *et seq*.), the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661 *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a resource agency.

Existing Information

The PAD contains no information relative to climate change and how climate change predictions may impact future operation of the hydroelectric plants, nor of how the projects either mitigate for or exacerbate predicted climate change impacts to freshwater ecosystems.

TransCanada's PAD provides a summary of water quality data collected in 2012. Table 1 below is a synthesis of the temperature data collected by TransCanada. It should be noted that the upper and mid-impoundment stations at each project represent the average of temperature readings taken over the entire water column, while the continuous loggers (Lower Cont. and TR) were located near the water surface. These data indicate that from the upstream end of the Wilder headpond to the Vernon tailrace, water temperature increased approximately 6°C.

Table 1. Median water temperature at monitoring stations located within the impoundments and tailraces of the three hydropower projects.

	Median Water Temperature °C			
Project	Upper Imp.	Mid-Imp.	Lower Cont.	TR
Wilder	20.86	21.83	24.08	23.59
Bellows Falls	22.43	23.67	24.86	24.38
Vernon	23.81	24.49	26.73	26.35

Relative to existing flood management protocols at each station, TransCanada's PAD identifies that all three dams utilize stanchion bays (two at Vernon, three at Bellows Falls, and four at Wilder). When inflows to each dam reach certain levels, the stanchion bays are removed, and cannot be replaced until inflows subside. The depth of these bays and the flows at which they are removed are outlined in Table 2 below.

Table 2. Summary of pertinent stanchion bay information for the Vernon, Bellows Falls, and Wilder projects.

Project	Stanchion Height (feet)	Flow Complete Removal	Triggering Stanchion
Wilder	17	145,000 cfs	
Bellow Falls	13	50,000 cfs	
Vernon	10	105,000 cfs	

The PAD provides no information on the history of stanchion removal at any of the projects (frequency, duration, timing), nor a discussion of how predicted climate change might alter management of the stanchion bays in the future (with respect to the frequency and seasonality of occurrence). There also is no discussion of potential impacts to headpond resources that occur as a result of stanchion bay removal. These information gaps need to be filled so resource agencies can assess the relative and cumulative impact of project operations with respect to the Service's management goals and objectives, including those identified in the Strategy.

Data provided by NOAA, Climate Data Center, illustrates long-term increasing air temperatures in the Northeast (Figure 1). Long-term, monthly mean water temperature data for the Vernon Dam impoundment, monitored by Vermont Yankee, has shown significant differences over time (ANOVA analyses, $P < 0.05$) that when plotted and further analyzed by linear regression, show a significant increasing trend for the period 1974–2010 for the months of January, September, and October (Figure 2). These analyses were performed with data from Vermont Yankee, analyzed by the Massachusetts Department of Environmental Protection.

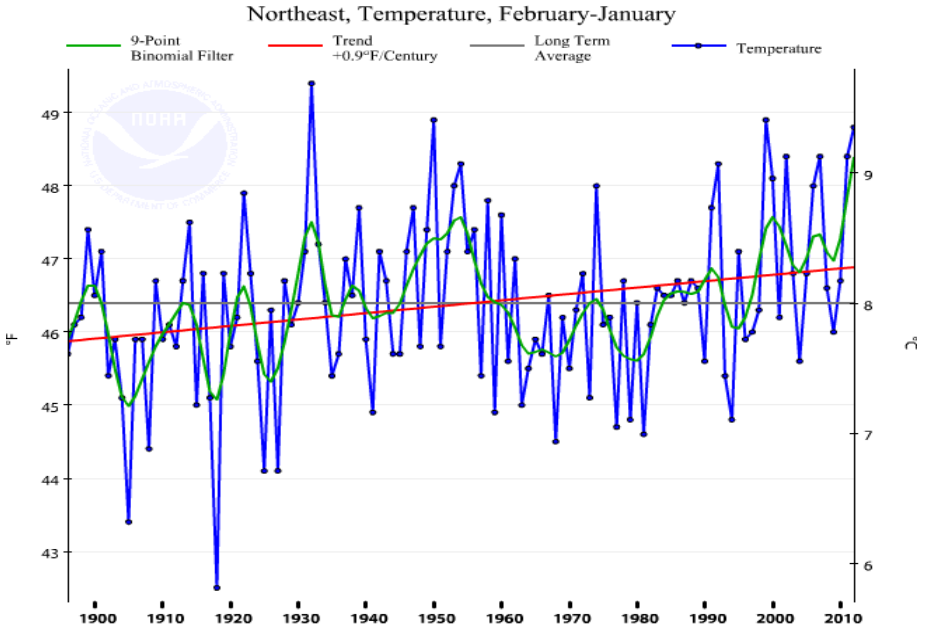

Figure 1. NOAA National Climate Data Center, Northeast 12-month average temperature for the period 1896 through 2012.

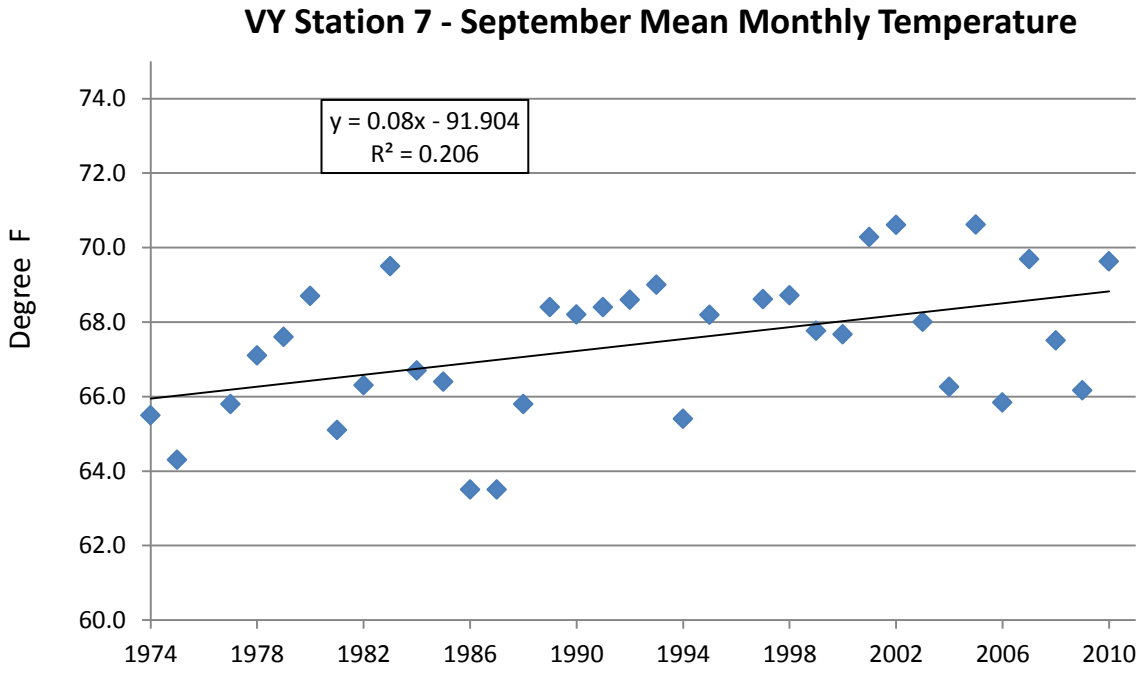

Figure 2. A plot of September's mean temperatures for Vermont Yankee's Station 7 (excludes outlier 1996 data point) for the period 1974 through 2010.

The PAD for the Turners Falls and NMPS projects provides a summary of existing water quality data compiled by FirstLight, including water temperature data obtained from the Service. The PAD also notes a 1991 study by the former licensee that modeled thermal effects of pumping to the upper reservoir. That model reported a maximum temperature difference attributable to NMPS operation of 0.21°C in the Turners Falls reach of the Connecticut River in low flow (4,000 CFS) simulation.

Nexus to Project Operations and Effects

The four mainstem projects have very long impoundments capable of storing large volumes of water (Table 3 below). These impoundments effectively have converted large portions of the Connecticut River into a series of in-river "lakes." Because water velocities slow in these impounded sections of the river, it allows for increased thermal loading and resultant higher water surface temperatures than in free-flowing sections of the river.

Table 3. Relevant characteristics of the reservoirs behind the Wilder, Bellows Falls, Vernon, Turners Falls dams and NMPS.

Project	Headpond Length (miles)	Gross Storage Volume (acre-ft.)	Average Depth (ft.)	Surface Area (acres)	Flushing Rate (days)
Wilder	45	34,350	11	3,100	3
Bellows Falls	26	26,900	10	2,804	<2
Vernon	26	40,000	16	2,550	2
Turners	20	21,500		2,110	
NMPS	n.a.	17,,050		246	n.a.

Depending on where the hydropower intakes withdraw water, these warmer surface waters may be discharged downstream, raising the temperature of those waters as well (the data in Table 1 above suggest that the projects do draw water from the upper levels of the reservoirs). This effect may be felt for miles downstream. If there are a series of impoundments (like on the Connecticut River), the cumulative impact is an overall warming of the river. Even small run-of-river dams have been shown to elevate downstream water temperature (Lessard and Hayes 2003; Saila *et al.* 2005). The most recent climate change prediction models specific to the Northeast forecast warmer air temperatures, more frequent high precipitation events, more heat waves, and an increase in the incidence of short-term droughts (Karl *et al.* 2009).

Resource concerns related to this project effect include the potential impacts to populations (reductions in abundance, structure, condition) or loss of species not tolerant of increases in temperature and other effects related to physiology such as energetic costs with warmer temperatures (Leggett 2004). As one example, American shad restoration target numbers for fish passage at mainstem dams into upstream historic habitat could be negatively impacted from artificially increased water temperatures. Water temperature has been identified as a factor in the timing (i.e., duration) of this species migration, as well as its role in gonad development and spawning (Glebe and Leggett 1981; Leggett 2004). These factors can be logically reasoned to result in accelerated rates of energy reserve use and a reduced migration window, possibly reducing the ability of fish to reach up-river habitats and further reducing the ability to survive downstream outmigration.

With respect to project operations during high flow events, all TransCanada projects have stanchion bays that are used to manage water during high flow events. Each time these stanchion bays are removed, the headponds are lowered substantially (from 10 to 17 feet, depending on the project) and must remain lowered until inflows subside. Depending on the timing and duration of these deep drawdowns, headpond resources could be negatively impacted.

All of the dams also contain other mechanisms for managing flows, such as tainter gates, sluice gates, roller gates, skimmer gates and hydraulic flood gates. All of these gates have an advantage over stanchion bays in that they do not require flows to subside significantly before they can be closed to return impoundment levels back to normal. One climate change prediction for the

Northeast is that we will see more frequent high precipitation events which will result in high flow conditions on rivers. Therefore, it is likely that the stanchion bay removal protocol will have to be employed more frequently in the future.

Methodology Consistent with Accepted Practice

1. In order to quantify the amount of thermal loading contributed by each respective impoundment, detailed bathymetry will need to be collected. This bathymetry, combined with storage volume, tributary hydrology, and project operations, should be used to calculate the thermal loading of each headpond. The individual and cumulative increase in surface water temperature due to the impoundments should then be used to predict future warming based on climate change models.

2. Analyze different mitigation strategies to understand which have the greatest benefit in terms of building resilience against the impacts of climate change on water temperature. Potential scenarios to analyze include converting the projects to run-of-river, implementing deep-water releases, removing one or more dams, conducting large-scale riparian revegetation, etc.).

3. Input to climate change models the amount of GHG emissions that would be generated if fossil fuel plants were producing the equivalent amount of net energy as the five hydropower projects to determine the impact on air and surface water temperatures.

4. Climate change prediction model output should be assessed to determine if the frequency and timing of high flow events are likely to change in the future. If high flow events that necessitate initiating the stanchion bay removal protocol are predicted to increase in frequency and/or shift in timing, the Applicant should evaluate structural and/or operational alternatives that would mitigate adverse impacts of the existing flood management protocols.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the thermal loading analysis would be low to moderate. Collecting bathymetry in the three TransCanada headponds would take two staff members less than one week to collect (it took the Kansas Biological Survey two days to collect bathymetry at a 3,500-acre lake; Jakubauskas *et al.* 2011). Bathymetry for the Turners Falls pool and NMPS upper reservoir already exist. The remaining work would be desk-based, loading relevant information into an appropriate thermal loading model to compute the estimated thermal loading of each headpond and then comparing this information to surface water data from climate change prediction models.

The high flow flood protocol study is a desktop analysis that should require low cost and effort. Climate change models already exist and that output would be downloaded and analyzed. The remaining analysis requires a review of alternative means of managing flows without the use of stanchion bays.

The Applicant did not propose any studies to meet this need in the PAD.

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