DEERFIELD RIVER CHAPTER

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March 1, 2013

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

Turners Falls Project, FERC No. 1889
Northfield Mountain Project, FERC No. 2485
Study Requests of Trout Unlimited

Dear Secretary Bose:

Following are Trout Unlimited's (TU) study requests for the Turners Falls Project and the Northfield Mountain Project.

STUDY REQUESTS

Requested Study No. 1
Shad Population Model for the Connecticut River
FERC No. 1889 & FERC No. 2485

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:

- Annual projections of returns to the Connecticut River;
- A deterministic and stochastic option for model runs
- Life history inputs of Connecticut River shad
- Understanding the effect of upstream and downstream passage delay at projects

- Calibration of the model with existing data
- Analysis of the sensitivity of model inputs
- Analysis of sensitivity to different levels of up- and downstream passage efficiencies at all projects
- Multiple output formats including a spreadsheet with yearly outputs for each input and output parameter

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River.*

Public Interest

The Northfield Mountain Project and the Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American shad movement and spawning. Flow alterations caused by the cumulative effects of all projects in the Connecticut River affect the public's use of the river for recreation. Angling for shad is directly impacted by a reduced population caused by hydroelectric projects on the river.

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 passing 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 % 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.

Project Nexus

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).

TU 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.

Proposed Methodology

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 and Normandeau Associates Inc. for Exelon (FERC #405, RSP 3.4). The model is constructed in Microsoft Access and would have a 'dashboard' entry screen that allows individual entry of the parameters listed below.

Specific parameters that would be included in the model:

- Upstream passage efficiency at Holyoke, Turners Falls (Cabot, Gatehouse and Spillway Ladders), Vernon fishways, and any impacts associated with Northfield Mountain.
- Distribution of shad approaching the Turners Falls project between the Cabot Ladder and the spillway at the dam
- Downstream passage efficiencies at Vernon, Northfield Mountain, Turners Falls, and Holyoke projects for juveniles and adults
- Entrainment at Mount Tom and Vermont Yankee
- Sex ratio of returning adults
- The proportion of virgin female adults returning at 4, 5, 6, and 7 years
- The proportion of repeat spawning females at 5, 6 and 7 years
- Spawning success of females in each reach
- Fecundity
- Percent egg deposition
- Fertilization success
- Larval and juvenile in-river survival
- Calibration factor to account for unknown parameters such as at sea survival
- Options for fry stocking and trucking as enhancement measures
- Start year and model run years
- Start population
- Rates of movement to and between barriers

- Temperature, river discharge, and other variable 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 and Cost

Neither First Light 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.

Literature cited:

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. Biodiveristy, status and conservation of the world's shads. American Fisheries Society, Symposium 35, Bethesda, Maryland

Requested Study No. 2
Telemetry Study of Upstream and Downstream Migrating Adult American Shad to Assess Passage Routes, Effectiveness, Delays, and Survival
FERC No. 1889 & FERC No. 2485

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 First Light Power's Turners Falls and Northfield Mountain Pumped Storage 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 Northfield Mountain 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:

- Assessment of any migration delays resulting from the presence of the dam and peaking flow operations of the Turners Falls Project;
- 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 #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;
- Assess near field, attraction to and entrance efficiency of the Spillway Ladder by shad reaching the dam spillway, under a range of spill conditions;
- Evaluate the internal efficiency of the Turners Falls Spillway Ladder;
- 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;
- Evaluate modifications to the Cabot and/or Spillway fishways recommended by the agencies if they are implemented;
- Assess upstream migration from Turners Falls to the Vernon Dam in relation to Northfield Mountain's pumping and generating operations and Vernon Project peaking generation operations. Typical existing and proposed project operation alterations should be evaluated;
- Assess near field, attraction to and entrance efficiency of the Vernon Dam Ladder;
- Assess internal efficiency of the Vernon Dam Ladder;
- 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)
- 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;
- 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;
- Assess impacts of Northfield Mountain operations on up- and downstream adult shad migration, including delays, entrainment, and behavioral changes and migration direction shifts under existing and proposed project operations;
- 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;

- Determine downstream passage route selection, timing/delay in the canal, Cabot Station fish bypass facility effectiveness, and survival of Cabot-bypassed adult shad that enter the Turners Falls Canal system;
- 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
- Utilize available data sets and further analyze raw data (e.g., 2003- 2012 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 samples 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 First Light by U.S. Geological Survey's Conte Anadromous Fish Research Center (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, Northfield Mountain 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, CT 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 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 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 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 objectives).

Besides 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 flow releases from the project increase from the required minimum flows to peak generation flows and when flows subside from peak generation flows to minimum flows and the operation of NMPS in pumping and generation modes.

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River.*

Public Interest

The Northfield Mountain Project and the Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American shad movement and spawning. Flow alterations caused by the cumulative effects of all projects in the Connecticut River affect the public's use of the river for recreation. Angling for shad is directly impacted by a reduced population caused by hydroelectric projects on the river.

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 Cabot and Spillway is poor (<10% in many years). Passage through the Gatehouse fishway is better, but still rarely exceeds 80%, despite the short length of this ladder. In addition to poor passage for fish entering the ladders, shad that ascend the Cabot 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% to over 50% 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 Gatehouse, experience similar delays in downstream passage, even after they have stopped trying to pass Gatehouse. Without spill, all outmigrating shad that have passed Gatehouse must enter the canal at the Gatehouse 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 2-dimensional array covering the canal just downstream of Gatehouse, 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 are 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 were not available at this time, but Dr. Castro-Santos stated similar patterns were noted in the data between the years on the topic of upstream delay (personal communication, Dr. Theodore Castro-Santos). Similarly, concerns relative to the downstream passage of spent shad also remain relative to delays, with existing unpublished USGS 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), the percent passage of American shad annually passed upstream of Turners Falls Dam compared to the number passed at the Holyoke Fish Lift has averaged 3.6% (1980-2012 data). The highest values for this metric has not exceed 11% and are well below the noted CRASC Management Plan target range for this objective noted earlier as 40-60% 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 Vernon compared to the number passed upstream of Turners Falls Dam (Gatehouse counts) has averaged 39.4%, ranging from 0.42% to 116.4% (> 100% due to counting error at one or both facilities, unknown).

Project Nexus

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), additional 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.

Proposed Methodology

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 U.S. Fish and Wildlife Service and U.S. Geological Survey's Conte Anadromous Fish Research Center, 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, 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 support assessment of the various operational and structural conditions in effect, to be modified in this period, and proposed conditions within the Turners Falls power canal relative to entrances to the Gatehouse fishway. A related request on CFD modeling in the Cabot Station tailrace, the upper power canal near Gatehouse, 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 Holyoke and tagged and release upstream of Turners Falls Dam, or tagged out of Gatehouse Ladder, would help to ensure an adequate sample size for evaluations in the vicinity of NMPS and to the Vernon Dam and the ability to address identified study objectives in those project areas. Additional tagged shad are expected to be required for release upstream of the Vernon Dam, which should ensure adequate sample for a separate study request, where shad spawn upstream of Vernon Dam as well as ensuring there is an adequate number of outmigrating spent adults to address related study objectives for adult outmigrants. The required number of tagged fish to address study objectives may be adjusted accordingly from area to area depending on target numbers (i.e., best information on resultant viable tagged fish and power analyses to detect effects) to account for typical passage rates, survival rates, and handling effects as examples.

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, ensuring adequate downstream adult fish sample sizes (to address project effect questions above) requires close consideration as expected losses of healthy tagged fish during upstream passage, natural mortality rates, and tagging related effects, are expected to reduce sample sizes on downstream passage objectives/questions as the season progresses. 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). This study will be coordinated with the proposed study request to evaluate ensonification as a shad behavioral deterrent at the Cabot Station tailrace which will be an additional treatment of the telemetry study.

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

Level of Effort and Cost

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 Holyoke 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 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.

Literature Cited

Atlantic States Marine Fisheries Commission. 2010. Amendment #3 to the interstate fishery management plan for shad and river herring (American shad management). Washington, D.C.

Bell, C. E. and B. Kynard. 1985. Mortality of adult American shad passing through a 17-megawatt Kaplan turbine at a low-head hydro-electric dam. North American Journal of Fisheries Management, 5:33-38.

Castro-Santos, T. 2011. Analysis of American shad passage at Vernon Dam 2011. USGS Conte Lab Internal Report

Castro-Santos, T. and A. Haro. 2005. Turners Falls fish passage studies 2005: results from PIT and radio telemetry studies. CAFRC Internal Report # 2005-04.

Castro-Santos, T. and A. Haro. 2010. Gatehouse fishway telemetry studies: progress report, 2008-2010. USGS CAFRC Internal Report.

Kieffer, M. and B. Kynard. 2012. Spawning and non-spawning migrations, spawning, and effects of river regulation on spawning success of Connecticut River shortnose sturgeon. In Life history and behavior of Connecticut Rver shortnose sturgeon and other sturgeons. B. Kynard, P. Bronzi, and H. Rosenthal Editors. World Sturgeon Conservation Society: Special Publication #4. Norderstedt, Germany.

Requested Study No. 3
Impact of Project Operations on Shad Spawning, Spawning Habitat, and Egg Deposition in the Project Areas of the Turners Falls, Northfield Mountain Pumped Storage and Vernon Project Areas and downstream from Bellow Falls Dam FERC No. 1889 & FERC No. 2485

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) 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 Northfield Mountain Pump Storage 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:

- Determine areas utilized by American shad for spawning by conducting night-time visual observation of spawning activity, identify and define areas geospatially, and obtain data on physical habitat conditions effected by project operations (e.g., water depth, velocity, discharge, substrate, exposure and inundation of habitats);

- Determine project operation effects on observed spawning activity, under a range of permitted or proposed project operation conditions;
- 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;
- Quantify spawning activity as measured by night-time spawning/splash surveys and egg collection in areas of spawning activity, and downstream of these areas, to further determine project operation effects (location extent of exposure from changing water levels and flows and on associated habitats from project operations).

If it is determined that the Project operations are adversely affecting the spawning activity of American shad and impacting spawning area habitat, identify operational regimes that will reduce and minimize impacts spawning habitat and spawning success within the project area. 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River.*

Public Interest

The Northfield Mountain Project and the Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American shad movement and spawning. Flow alterations caused by the cumulative effects of all projects in the Connecticut River affect the public's use of the river for recreation. Angling for shad is directly impacted by a reduced population caused by hydroelectric projects on the river.

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 (Davis et al, 1970, 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 6 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, MA. 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). TU 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).

First Light Power conducted studies in the late spring and summer of 2012, 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, MA (PAD). Similar short-term, limited monitoring in the upper Turners Falls Dam impoundment identified water level changes due to project operations that d cyclically varied several feet on a sub-daily frequency.

Project Nexus

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. TU is not aware

of any studies being conducted specifically designed to determine if a relationship between spawning behavior, habitat use, and egg deposition and project operations effects of the Turners Falls, Northfield Mountain Pump Storage and Vernon projects and downstream of Bellows Falls Dam..

TU 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.

Proposed Methodology

The first year of study should examine a sample of 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, then 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 night-time 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, night time 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.

These methods are consistent with previous studies and in the Connecticut River accepted practice.

Level of Effort and Cost

Neither First Light or 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 fieldwork labor.

Literature cited:

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

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

Kuzmeskus, D. M. 1977. Egg production and spawning site distribution of Americans had, *Alosa sapidissima*, in the Holoke Pool, Connecticut River, Massachusetts. Master's thesis. University of Massachusetts, Amherst, MA.

Layzer, J.B. 1974. Spawning Sites and Behavior of American Shad, *Alosa sapidissima* (Wilson), in the Connecticut River Between Holyoke and Turners Falls, Massachusetts, 1972. Master of Science Thesis. University of Massachusetts, Amherst, Massachusetts.

MacKenzie, C., L. Weiss-Glanz, and J. Moring. 1985. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) American shad. U. S. Fish and Wildlife Service Biological Report No. 82 (11.37), Washington, D.C.

Mansueti, R. J. and H. Kolb. 1953. A historical review of the shad fisheries of North America. Chesapeake Biological Laboratory Publication no. 97. Solomons, MD.

Marcy, B. C. Jr. 1972. Spawning of the American shad, Alosa sapidissima, in the lower Connecticut River. Chesapeake Science 13:116-119.

Ross, R. R., T. W. H. Backman, 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. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Stier, D. J. and J. H. Crance. 1985. Habitat suitability index models and instream flow suitability curves: American shad. U. S. Fish and Wildlife Service Biological Report No. 82(10.88),Washington, D.C.

Requested Study No. 4
Evaluation of Timing of Downstream Migratory Movements of American Eels on the Mainstem Connecticut River
FERC No. 1889 & FERC No. 2485

Goals and Objectives

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

The objectives of this study are:

1. 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Atlantic States Marine Fisheries Commission's management plans for 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, 2005 whose implementation would be enhanced by the results of this study.

Public Interest

The Northfield Mountain Project and the Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American eel movement and habitat use. Flow alterations and barriers at hydroelectric projects thereby affect a public fishery resource.

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 presence of "eel-sized" acoustic targets have been collected (Haro et al. 1998) 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 U.S. Fish and Wildlife 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 are issued for the projects.

Project Nexus

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.

Proposed Methodology

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, 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 common and accepted practice.

Level of Effort and Cost

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.

Literature cited:

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 277-291in: 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 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 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 Holyoke Gas and Electric Department. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 81 pp.

Requested Study No. 5
Downstream American Eel Passage Assessment at Turners Falls and Northfield Mountain
FERC No. 1889 & FERC No. 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 Station (NFMPS) 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 NFMPS, 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Atlantic States Marine Fisheries Commission's management plans for 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, 2005 whose implementation would be enhanced by the results of this study.

Public Interest

The Northfield Mountain Project and the Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American eel movement and habitat use. Flow alterations and barriers at hydroelectric projects thereby affect a public fishery resource.

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% in 2002, 100% 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 NFMPS 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 U.S. Fish and Wildlife 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 are issued for the projects.

Project Nexus

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 NFMPS 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. NFMPS has 48-foot-deep trashracks with six-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. NFMPS 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 NFMPS facility, the rack spacing is wide enough to allow for entrainment.

Proposed Methodology

In order to understand the movements of outmigrating silver eels as they relate to operations at the Northfield Mountain Pump Storage 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 that 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 Aug to mid Oct), and eels should be tagged and released within 7 days of collection.

NFMPS Route Selection Study:
A minimum number of 50 telemetered eels (e.g., 5 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 NFMPS project; releases should be timed so that there is a significant probability that migrating eels will encounter NFMPS 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 NFMPS 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., 5 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 NFMPS. 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 NFMPS route study not entrained into the NFMPS 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., 5 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 NFMPS and Turners Falls Dam Route Studies not entrained into the NFMPS 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., 5 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 NFMPS 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 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 2.

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 and Cost

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. Cost 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 it intends to rely on information from previously conducted studies and ongoing studies. TU is not aware of any previously conducted or ongoing studies related to downstream eel passage.

Literature cited:

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 277-291in: 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.

Requested Study No. 6
Model flows in the Northfield Mountain Pumped Storage Project discharge tailrace and Connecticut River 1 kilometer upstream and downstream of the discharge using two-dimensional Computational Fluid Dynamics (CFD) model techniques
FERC No. 2485

Goals and Objectives

The goal of this study is to determine the potential impacts (both project-specific and cumulative) of the Northfield Mountain Pump Storage Project operations (pumping and generating) on the zone of passage for migratory fish near the Northfield Mountain turbine discharge/pump intake, on natural flow regimes in the area of the Connecticut River immediately upstream and downstream of the project, on the potential for entrainment during pumping operations, on the potential for creating flow reversals in Connecticut River during pumping cycles that may confuse migratory fish attempting to

pass the project, and on bank erosion on both sides of the river in the vicinity of the tailrace.

Specific objectives of the study include:

- Develop a 2-dimensional CFD modeling capability for the area of the Northfield Mountain discharge and tailrace, along with the full width of the Connecticut River 1km upstream and 1 km downstream of the discharge.

- 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, recreational use, agricultural resources, and historical resources.

- Assess velocities at and in proximity to the Northfield Mountain intake/discharge structure, when pumping or generating and their potential to interfere with fish migration.

- 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.

- Assess potential for Northfield Mountain project operations to create undesirable attraction flows to the intake/discharge that may result in entrainment or delay of migratory fish.

- Assess the potential of a mainstem instream local flow reversal associated with pumping operations to impact migrating fish. The Connecticut River in the area of the Northfield Mountain tailrace has been said to flow upstream potentially confusing migratory fish keying in to flow as a directional aid to upstream or downstream migration, causing delay and additional "fish" energy expense and possible entrainment.

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

- Assess the potential for unnatural flows and eddies in the main-stem associated with pumping or generation at the Northfield Mountain Project to impact bank erosion and recreational use.

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Atlantic States Marine Fisheries Commission's management plans for 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, 2005 whose implementation would be enhanced by the results of this study.

Public Interest

The Northfield Mountain Project alters flows during pumping and generation cycles, impacting riverine and migratory aquatic species and communities most directly through entrainment during the pumping phase of operations. Fish that are entrained are for all intents and purposes extirpated from the river. Angling for shad is directly impacted by a reduced population caused by entrainment at the Northfield Project. Flow alterations and barriers at hydroelectric projects affect a public fishery resource.

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 in the Connecticut River. Preliminary results from an ongoing study of radio-tagged American shad by the USFWS and USGS Conte lab indictate 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.

As part of Field (2007; see appendix 4), a "Connecticut River Hydraulic Analysis – Vernon Dam to Turners Falls Dam" was completed by Woodlot Alternatives in July 2007. For this analysis, a 2-dimensional flow model was developed for the entire Turners Falls impoundment. This study was geared towards looking at shear stresses from high-flow events, and did not focus in detail around the tailrace or examine how pumping and generation may affect flows in the vicinity of the tailrace under a variety of flows.

As a result of the hydraulic analysis, Field (2007) on page 20 states that "While erosion does occur where high flow velocities and shear stresses approach near the bank, significant amounts of erosion also occur where flow velocitieis near the bank are low." No specific examination was done in the report on the ±1 km area near the tailrace and existing erosion sites. Banks immediately upstream and downstream and across river

have all required bank stabilization projects over the last 15 years, in some cases needing several repairs.

Project Nexus

Existing project operations have a direct impact on instream flow and aquatic habitat in the pump/discharge area of the Connecticut River. The PAD in section 3.2.2 says that the velocity 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 ≤ 20,000 cfs more than 85% 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. Project flows may also impact stream banks in ways that natural river flow (or flows affected by upstream hydropower facilities) does not, and may also impact recreational use of the river.

Proposed Methodology

CFD modeling is consistent with generally accepted practice, and has been used to assess proposed modifications to the Holyoke Dam 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.

Level of Effort and Cost

This study will require a detailed elevation map of the study area upstream and downstream of the Northfield Mountain project. Information already exists in historic construction files for the project, the hydraulic analysis included in Appendix 4 of Field (2007), and possibly in conjunction with work done after the 2010 maintenance procedures that resulted a portion of the river being dredged after a large sediment dump) that are in the possession of the applicant. Additional elevation data will likely need to be collected in the field using standard survey techniques. Elevation data will then need to be entered into a CFD modeling program. The CFD computer program will need to simulate existing project operations that include all potential variations of pumping and generating, and static operation. No project specific instream flow analysis tool has been developed for the Northfield Mountain project 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.

Requested Study No. 7
Entrainment of Migratory and Riverine Fish from the Connecticut River into the Northfield Mountain Pump Storage Project.
FERC No. 2485

Goals and Objectives

The goal of the study is to determine the impact of Northfield Mountain Pump Storage Project (NFMPS) 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 NFMPS intake on an annual basis in order to evaluate potential impacts to riverine fish populations in the Turners Falls pool and diadormous 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals and more specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River* and their Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basinas well as the Atlantic States Marine Fisheries Commission's management plans for American eel.

Public Interest

The Northfield Mountain Project alters flows during pumping and generation cycles, impacting riverine and migratory aquatic species and communities most directly through entrainment during the pumping phase of operations. Fish that are entrained are for all intents and purposes extirpated from the river. Angling for shad is directly impacted by a reduced population caused by entrainment at the Northfield Project. Flow alterations and barriers at hydroelectric projects affect a public fishery resource.

Existing Information

Limited project-specific information exists regarding entrainment of fish and aquatic organisms at the NFMPS. As part of a 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 NFMPS 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 NFMPS 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% of sample time) and sometimes two (23% 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 NFMPS area. Unlike anadromous shad and river herring, , riverine species occurrence and susceptibility relative to space and time exposure windows to NFMPS 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 NFMPS operations system. As a starting point, it is necessary to obtain baseline data on project operation impacts for all species potentially impacted by NFMPS. An additional study request seeks to obtain a more accurate documentation of all fish species inhabiting or utilizing the Turners Falls impoundment.

Project Nexus

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 though 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. The unknown extent of other riverine species ichthyoplankton entrained by the NFMPS requires 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 NFMPS 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 NFMPS.

Since the previous studies were conducted, operations at the NFMPS 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% 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 NFMPS. In addition, anticipated improvements in fish passage at the Turners Falls Project will result in increased juvenile production above the NFMPS. These factors, individually or cumulatively, could increase the potential for entrainment at NFMPS station.

Proposed Methodology

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% 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.

Although a previous entrainment study was conducted, TU 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 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.

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).

These methodologies are consistent with accepted practice.

Level of Effort and Cost

We know of no other tool that will provide for this type of assessments 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.

Literature cited:

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.

Requested Study No. 8
Upstream American Eel Passage Assessment at Turners Falls
FERC No. 1889

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at 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 from 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Atlantic States Marine Fisheries Commission's management plans for 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, 2005 whose implementation would be enhanced by the results of this study.

Public Interest

The Turners Falls Project and other projects in the upper Connecticut River alter flows, impacting aquatic species and communities and specifically American eel movement and habitat use. Flow alterations and barriers at hydroelectric projects thereby affect a public fishery resource.

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, pers. comm.), 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 U.S. Fish and Wildlife 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 are issued for the projects.

Project Nexus

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.

Proposed Methodology

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 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 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 (~1May 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 2-3 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 and Cost

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. TU is not aware of any previously conducted or ongoing studies related to upstream eel passage.

Requested Study No. 9
Impacts of Turners Falls Canal Drawdown on Fish Migration and Aquatic Organism Populations
FERC No. 1889

Conduct a study to quantify impacts of the annual Turners Falls Canal drawdown on emigrating and resident fishes, freshwater mussels, odonates, 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., is fish accumulation occurring?)
2. Determine level of mortality for juvenile sea lamprey from exposure of burrow habitats;
3. Conduct surveys to determine aquatic organisms (fishes, freshwater mussels, odonates, and mudpuppies) present in the canal during the drawdown, their densities, status (stranded, dead, alive), and locations (mapping to document habitat, substrate type, wetted , at complete drawdown);
4. Evaluate measures to minimize aquatic organism population impacts of the canal drawdown.

Other submitted Study Requests compliment or directly relate to this project activity and assessing 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more specifically The Atlantic States Marine Fisheries Commission's management plans for 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, 2005 whose implementation would be enhanced by the results of this study.

Public Interest

The Turners Falls Project during drawdown dewaters the power canal, impacting aquatic species and communities. Multiple aquatic species die as a result of dewatering. These deaths affect a public aquatic and fishery resource.

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 de-watering 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 FLP 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, FLP 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 six 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 bypass becomes unavailable, are through the turbines at Cabot as well as at Station 1, and eventually at the Keith Street gate located well upstream from the Cabot Staion 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 (personal communication, Boyd Kynard). In previous drawdowns, thousands to tens of thousands of dessicated ammocetes have been observed (Matt O'Donnell, personal communication, USGS Conte Lab). However, the distribution and abundance of ammocetes in the canal as well as mortality rates for ammocetes during the drawdown period has not been quantitatively determined.

Project Nexus

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 FL conduct the drawdown outside of the June through August period, FL 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.

Proposed Methodology

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 draw down. 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 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, odonates, 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 utilize 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, assess 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.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

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.

***Literature Cited*:**

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.

Requested Study No. 10
Three-dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays
FERC No. 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 maps that show color contour maps of velocity magnitude at discharges that have been agreed upon by the resource agencies and the licensee. With respect to upstream passage, the results will show approach

velocities and orientation within the approach zone of the fish 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 orientations 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 up- and downstream fishways for migrating species and to reduce impingement, entrainment and delay for downstream migrating fish. The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals and more specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River* and their Management Plan for American Eel (*Anguilla rostrata*) in the Connecticut River Basinas well as the Atlantic States Marine Fisheries Commission's management plans for American eel.

Public Interest

The Turners Falls Project poor upstream fish passage efficiency has been documented. The inability of American shad to pass the project affects a public fishery resource and angling for shad.

Existing 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 to develop a CFD model of the upper power canal and that elevation survey data from the power canal also are available. Detailed 2-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.

When designing upstream passage structures, a site assessment is critical. The development of these models gives resource agencies and other stakeholders 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.

Project Nexus

The Turners Fall Project has direct impacts to upstream and downstream migrating shad and eel. .

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, as a general rule, fish tend to follow the flow. If flow fields are directing fish towards the turbine intakes, the results from this study will indicate that. The development of a CFD model under existing conditions also informs the design of future modifications. The development of a CFD model could be used to improve the survivability of downstream migrating shad and eel.

Proposed Methodology

A 3-dimensional CFD model has become and 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). 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 and Cost

The cost of developing, running and testing a CFD model can vary tremendously; one large variable is determining the cost is based on the amount of existing bathymetric data the applicant currently has access to. We roughly estimate the cost of each CFD model could run as high as $50,000 assuming no bathymetric data currently exists. Proactive communication with resource agencies will reduce the cost and iterative effort. Given the above mentioned projects where this level of effort has occurred for other projects that have proposed to amend their license for various reasons, we see the level of effort as commensurate with the other projects given that the applicant is requesting a renewal of its existing license.

Requested Study No. 11
Determine the Fish Assemblage in the Turners Falls and Northfield Mountain Pumped Storage Project-Affected Areas

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 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 area along spatial and temporal gradients.

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

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals of protecting and conserving aquatic species and their habitats. Riverine fish species are an important component of the river's ecology and are the basis for the sport fishery.

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 Northfield Mountain Pump Storage 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 Northfield Mountain. 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

Riverine fish represent an important ecological role as well as recreational and angling opportunities. A full assessment of species composition will benefit a public resource with better information for management.

Existing Information

A thorough and comprehensive assessment of the fish assemblage present in the project-affected areas of the Turners Falls and NFMPS projects is lacking. The PAD for these projects 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 Inst. (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 projects area, 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, limits the use of these data and that synthesized 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.

Project Nexus

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 are 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.

Proposed Methodology

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 Northfield Mountain Pump Storage Project. 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 25th to 75th percentile for weekly averages. Based upon this study's results, and the additional information obtained on requests to survey aquatic habitats and littoral zone fish spawning, an additional study may be required if evidence of project operation affects on population status or habitat for identified species.

Level of Effort/Cost

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 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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Requested Study No. 12
Model River Flows and Water Levels Upstream and Downstream from the Turners Falls Project Dam Generating Stations and Integration of Project Modeling with Upstream and Downstream Project Operations
FERC No. 1889 and FERC No. 2485

Develop a river flow model(s) that are 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, 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 the Northfield Mountain Pumped Storage Project, FERC No. 2485,
    b. Discharges to the Turners Falls impoundment by the Northfield Mountain Pumped Storage Project,
    c. Discharges into the Turners Falls impoundment from the Vernon Project, FERC No. 1904 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.
    g. Minimum discharge flows ranging between 2,500 and 6,300 cfs in the bypass reach from April 15th through June 22nd 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 on the water levels on listed Puritan tiger beetle habitat at Rainbow Beach in Northampton, MA. 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 project's 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 the Turners Falls bypass reach need to be no less than 2,500 cfs during shortnose sturgeon spawning, rearing, and outmigration (April 15th – June 22nd). 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 requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals of protecting and conserving aquatic species (including the federally endangered shortnose sturgeon) and their habitats. Specifically:

- 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.

- 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.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Ensure that project operations are not likely to jeopardize the continued existence of shortnose sturgeon.
- 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).

Public Interest

Migratory and riverine fish have an important ecological role as well as recreational and angling opportunities. A full assessment of the impacts of hydrogenation will benefit a public resource with better information for management of flows to protect these resources as well as the federally endangered shortnose sturgeon.

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 22nd) (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 ELS 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 26th (Kynard et al. 2012, chapter 3), showing 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 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 indicates 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.

Project Nexus

The Turners Falls Project is currently operated with a seasonally-varying minimum bypass flow (400 cfs from 5/1 through 7/15, then 120 cfs through the winter until river temperature rises to ≥ 7°C) and year-round minimum flow below the projects 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 the Northfield Mountain Pumped Storage Project 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.

Proposed Methodology

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

Level of Effort and Cost

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 First Light 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 moderate and comparable to that experienced on similar FERC relicensing projects of this size.

Requested Study No. 13
In-stream Flow Habitat Assessment Downstream of Cabot Station
FERC No. 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: 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 Rt. 116 bridge in Sunderland, MA. Specifically, the objective of the study is to conduct an instream flow habitat study to assess the impacts of a range if flows on the wetted area and optimal habitat for key species, including the impacts of hydropeaking flow fluctuations on the quantity and location of aquatic habitat.

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: federally endangered shortnose sturgeon, American shad, fallfish, white sucker and walleye.

For shortnose sturgeon, the flow study will need to evaluate bottom velocities in shortnose sturgeon spawning and rearing areas during discharge conditions normally observed from April 15th to June 22nd. Protection of shortnose sturgeon spawning will necessitate establishment of discharges that create bottom velocities suitable for shortnose sturgeon 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 are 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. Velocity and depth data should be collected under each potential operation scenarios such that actual velocity, depth, and flow conditions occurring across the entire spawning and rearing areas including wetted shoals.

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals of protecting and conserving aquatic species (including the federally endangered shortnose sturgeon) and their habitats. Specifically:

- 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.
- 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.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

Public Interest

Migratory and riverine fish have an important ecological role as well as recreational and angling opportunities. A full assessment of the impacts of hydrogenation will benefit a public resource with better information for management of flows to protect these resources as well as the federally endangered shortnose sturgeon.

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 TU 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 the agencies and stakeholders 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 body of data represents the best available scientific information which 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 29th. 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. When peaking generation discharges cease during naturally low flow years, the tailrace shoals, likely used by shortnose ELS for rearing, were exposed (observed during years ’95, ’98-99, ’04) and may have resulted in larvae mortality due to stranding and exposure (Kynard et al 2012, chapter 3). Researchers observed that shoal exposure began when river flow below Cabot Station dropped below 7,062 cfs (Kynard and Kieffer 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 caused 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 the agencies and stakeholders to determine an appropriate flow recommendation.

Researchers have also looked at suitable depth and velocity habitat for spawning (Kynard and Kieffer 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 38 inches.

Project Nexus

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 with-in day flow fluctuations between the minimum and project capacity on 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. There are more than ten miles of free-flowing river 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% of the Aquatic Base Flow. 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 the agencies and stakeholders to determine an appropriate flow recommendation that will protect and/or enhance the aquatic resources below the Project.

Proposed Methodology

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

TU 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), and has been accepted by the Commission in other licensing proceedings.

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 1 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 2 dimensional 2D modeling to better characterize flows and velocities in this complex channel area.

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.

These methodologies are consistent with accepted practice.

Level of Effort and Cost

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-fieldwork data analysis would be a moderate cost and effort. We anticipate that the level of effort and costs will be moderate and comparable to that experienced on similar FERC relicensing projects of this size.

Requested Study No. 14
In-stream Flow Habitat Assessment of the Turners Falls Bypassed Reach
FERC No. 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: federally endangered shortnose sturgeon, American shad, fallfish, white sucker, freshwater mussels and benthic macroinvertebrates.

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals of protecting and conserving aquatic species (including the federally endangered shortnose sturgeon) and their habitats. Specifically:

- 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.
- 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.
- Minimize current and potential negative project operation effects on water quality and aquatic habitat.
- Avoid or minimize the current negative effect of project operations on shortnose sturgeon spawning and rearing at the Cabot Station spawning and rearing site.

Public Interest

Migratory and riverine fish have an important ecological role as well as recreational and angling opportunities. A full assessment of the impacts of hydrogenation will benefit a public resource with better information for management of flows to protect these resources as well as the federally endangered shortnose sturgeon.

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 miles 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 miles 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 27th 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 ELS 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 26th (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 does 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 the agencies and stakeholders to use in determining a flow recommendation.

Project Nexus

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 the agencies and stakeholders 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 Commission.

Proposed Methodology

TU 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), and has been accepted by the Commission in other licensing proceedings.

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 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 1 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 2 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.

The methodologies are consistent with accepted practice.

Level of Effort and Cost

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-fieldwork data analysis would be a moderate cost and effort. Field work associated with this study could be done in conjunction with the project instream flow study request. We anticipate that the level of effort and costs will be comparable to that experienced on similar FERC relicensing projects (e.g., the Glendale Project, FERC No. 2801).

Requested Study No. 15
Impact of Project Operations on Downstream Migration of Juvenile American Shad
FERC No. 1889

Conduct a field study of juvenile American shad outmigration in the Turners Falls impoundment and the power canal and at Turners Falls Dam,t, 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:

- Assess project operations effects of NMPS and Turners Falls Dam on the timing, orientation, routes, migration rates, and survival of juvenile shad;
- 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;
- 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);
- 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;
- 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);
- Based upon year 1 study results on route selection, determine the survival rate for juvenile shad entrained into Station 1; and
- 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 compliment the NMPS Fish Entrainment Study Request which includes assessment of impacts to juvenile shad.

Resource Management Goals

The requestor is not a public agency. However, we believe the information gathered as a result of this study would further regional resource management goals, and more

specifically The Connecticut River Atlantic Salmon Commission's *Management Plan for American Shad in the Connecticut River.*

Public Interest

The Turners Falls Project alters flows, impacting aquatic species and communities and specifically juvenile American shad outmigration. Mortality and delay of outmigrating juveniles affect the public's use of the river for recreation. Angling for shad is directly impacted by a reduced population caused by hydroelectric projects on the river.

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 Dam. A number of modifications to the Turners Falls fishways have occurred since that time, with the numbers of adult shad passed at 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 % of the adult shad passed upstream of Holyoke Dam subsequently have passed upstream of Turners Falls Dam, and this value has never exceeded 11%. This value is well below the CRASC 1992 Shad Plan objective of 40-60% 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 suggests 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 an MOA on downstream fish passage to address both juvenile and adults at the Turners Falls Project and Northfield Mountain Pumped Storage Project.

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 seems 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 (Creeco 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 19C and peaked at 16C (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% (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%, 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%). 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%, based on tagged and recaptured fish (held for up to 48 hours). Scale loss (<20%) (22 of treatment fish) compared with scale loss of >20% (5 of treatment fish) was examined and determined to occur in an overall total of 10% of study fish (adjusted by control fish data).

Project Nexus

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.

TUis not aware of any studies being conducted specifically designed to determine:

- When spill gates are open at the Turners Falls Dam?;
- What proportion of juvenile outmigrant shad take that route of passage?;
- What is the rate of survival under a range of spill and gate configurations?
- What is the timing, duration, and magnitude of juvenile shad outmigrants in summer and fall to the Turners Falls Dam and Gatehouse?

- Are there delays in migration/movement at the dam, Gatehouse, Cabot Station, or Station 1?
- For juveniles that enter the power canal, what proportion subsequently enter the Station 1 power canal?
- As there is 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?
- What is the rate of movement through the Turners Power Canal, relative to r delay to outmigrant juvenile shad and the potential accumulation of juveniles (e.g., prior to the canal drawdown in September)?
- 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)?
- 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)?

TU is concerned that project operations may impact juvenile shad outmigration survival and be contributing to the failure of the Connecticut River shad population to meet management targets. In the PAD, proposed modification 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.

Proposed Methodology

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 fall with canal outage period. The understanding of the timing, magnitude, duration of the wild fish outmigration will help inform the design, data/results, and assessment of tagged study fish. 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 Cabot Station forebay will provide information on wild/natural juvenile fish timing, magnitude, and duration to and through this area. Based upon Year 1 study findings relative to the frequency, magnitude, 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.

These methodologies are consistent with common and accepted practice.

Level of Effort and Cost

First Light does not propose any studies to meet this need. Estimated cost for the study is 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 fieldwork labor.

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Trout Unlimited respectfully requests the Commission consider these proposed study requests. We also request that the Commission add the following representative to the official service list for this project:

Donald Pugh
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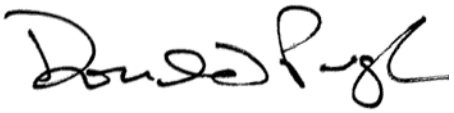
Sincerely,



Donald Pugh