



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

Vernon Project, FERC No. 1855
Bellows Falls Project, FERC No. 1904
Study Requests of Trout Unlimited

Dear Secretary Bose:

Following are Trout Unlimited's (TU) study requests for the Vernon Project and the Bellows Falls Project.

STUDY REQUESTS

**Requested Study No. 1
Shad Population Model for the Connecticut River
FERC No. 1904 & FERC No. 1855**

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. Biodiversity, 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. 1904 & FERC No. 1855**

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 River 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. 1904 & FERC No. 1855

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 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 American shad, *Alosa sapidissima*, in the Holyoke 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.
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- 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. 1904 & FERC No. 1855

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 277-291 in: 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
American Eel Survey Upstream of the Vernon and Bellows Falls dams
FERC No. 1904 & FERC No. 1855

Goals and Objectives

The goal of this study is to provide baseline data relative to the presence of American eel upstream of the Vernon, Bellows Falls, and Wilder dams.

The objective of the study is to determine the relative abundance and distribution of American eel upstream of the Vernon, Bellows Falls and Wilder dams in both riverine and lacustrine habitat.

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.

Background and Existing Information

According to the PADs, very few American eels were collected in the Fish Assemblage and Habitat Assessment of the Upper Connecticut River (Yoder et al., 2009). In the

Vernon Project area upstream of the dam, only one eel was collected; no eels were collected from the Bellows Falls pool, and none were found upstream of the Wilder Dam. However, in 2012 over 200 eels were documented using the upstream fish ladder at the Vernon Project and the New Hampshire Fish and Game Department has observed eels upstream of the Bellows Falls and Wilder dams. More recently, eels have been observed in Lake Morey, Vermont, which is located upstream of Wilder Dam (Lael Will, VDFW, personal communication). Therefore, while it is clear that some eels are passing all three dams (Vernon, Bellows Falls, and Wilder), it remains unknown how many eels may be rearing in the mainstem habitat upstream of the dams or in tributaries and lakes and ponds that feed into the mainstem river.

No targeted eel surveys have been conducted to determine the abundance and distribution of American eels in riverine and lacustrine habitat upstream of the three projects. This information gap needs to be filled so resource agencies can evaluate properly the need for, and timing of, downstream passage and protection measures for outmigrating silver phase eels.

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 configurations present problems with respect to providing safe, timely and effective passage for outmigrating eels. The intakes are deep and, while no specification for the trashracks were provided in the PADs, it is unlikely that they would prevent impingement and/or entrainment of eels. Existing anadromous downstream passage facilities at the projects also would not be expected to be effective for eels; the target anadromous species are surface-oriented, while eels tend to move much deeper in the water column. If eels are utilizing habitat upstream of the dams, then appropriate protection and downstream passage measures will be needed.

In order to understand the need for, and timing of, downstream eel passage at the projects, we are requesting that TransCanada undertake eel surveys in the Connecticut River upstream of the three dams and in tributaries feeding into the mainstem river within the project areas. Surveying tributary habitat is necessary because surveying the

mainstem alone may lead to an underestimation of eel abundance, particularly if there are relatively short tributary streams that lead to a lake or pond (where eels may accumulate, leading to true high densities).

Proposed methodology

TU requests an eel survey be conducted in the mainstem river and tributaries upstream from the three projects. The methodology should be similar to that used in the relicensing of the Saluda Hydroelectric Project, FERC No. 516 (Appendix A), the eel assessment for the Merrimack River completed by the Service's Central New England Fishery Resources Office (Appendix B), and the proposed study plan for the relicensing of the Eastman Falls Project (FERC No. 2457).

In general, a combination of electroshocking (backpack in wadeable rivers and boat-mounted in larger rivers and lakes) and eel pots should be used to collect eels and determine catch rates. Sampled habitat should include: the mainstem Connecticut River from upstream of Vernon Dam to below the Ryegate Dam; tributaries to the Connecticut within that stretch where eels have been collected previously; and lakes and ponds (such as, but not limited to, Spofford Lake and Lake Morey), where eels have been collected previously. Sampling should occur during the summer (July through September).

Level of effort and cost

The expected level of effort and anticipated costs will be comparable to that experienced on similar FERC projects of this size. A study plan recently submitted for the Eastman Falls Project (FERC No. 2457) on the Pemigewasset River in New Hampshire, which is utilizing a similar methodology, estimated that sampling a nine-mile-long impoundment with shocking and eel pots would cost \$25,000. They estimated the effort to be two nights for the electrofishing survey. Given the much larger area that will need to be sampled under this request, we estimate moderate cost and effort will be required (20 days of shocking mainstem habitat plus another 5-10 days for tributaries and associated lake/pond habitat).

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont.
http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Requested Study No. 6
Study Request: Downstream American Eel Passage Assessment at Vernon and
Bellows Falls
FERC No. 1904 & FERC No. 1855

Goals and Objectives

The goal of this study is to determine the impact of three hydroelectric projects on the outmigration of silver eels in the Connecticut River. Entrainment at the conventional turbines at the Vernon, Bellows Falls, and Wilder projects can result in mortality or injury. It is important to understand the passage routes at each project and the potential for delay, injury, and 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. through the turbines, through the downstream bypasses; spilled at the dams, etc.).
2. Evaluate instantaneous and latent mortality and injury of eels passed via each potential route.

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 Vernon Project and the Bellows Falls Projects 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 and life history of the American eel. It also summarizes eel collection data within the Vernon and Bellows Falls project areas. Eels have been collected both upstream and downstream of the Vernon Project and also have

been counted passing the upstream anadromous fish ladder. Eels also have been documented upstream of the Bellows Falls and Wilder projects.

To date, no directed studies of eel entrainment or mortality have been conducted at any of the projects. 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.

Nexus to Project Operations and Effects

The Vernon, Bellows Falls, and Wilder projects operate as peaking facilities, except during periods when inflow exceeds the hydraulic capacities of the stations. Silver eels outmigrate during the mid- summer through late fall, a time of year when flows are generally within the operating capacities of the stations. Therefore, the projects would be expected to spill infrequently during the silver eel outmigration.

The project configurations present problems with respect to providing safe, timely and effective passage for outmigrating eels. The intakes likely are deep and, while no specification for the trashracks were provided in the PADs, it is unlikely that they would prevent impingement and/or entrainment of eels. Existing anadromous downstream passage facilities at the projects also would not be expected to be effective for eels; the target anadromous species are surface-oriented, while eels tend to move much deeper in the water column. Eels are known to occur upstream of the dams; therefore, it is necessary to understand how eels move through the projects and the level of injury or mortality caused by entrainment through the projects' turbines.

Methodology Consistent with Accepted Practice

In order to understand the movements of outmigrating silver eels as they relate to operations at the Vernon, Bellows Falls, and Wilder projects, 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 collected over both study years (especially route selection studies, which may be more significantly affected by environmental conditions during a given season than mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, that route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies has 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 21 days after capture, but preferably within seven days (particularly if the test eels are from out-of-basin).

All telemetered eels will be radio and passive integrated transponder (PIT) tagged. PIT antennas will be installed at bypasses at Vernon and Bellows Falls and monitored continuously to verify passage of eels via bypass channels.

Vernon Project 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. Tagged eels should be released at least 5 km upstream of the Vernon project. Groups of eels should be released during spill and non-spill periods if possible. Telemetry receivers and antennas should be located to assess passage via the following potential routes: Vernon spillway; Fishway attraction water intake (if operational); Vernon downstream bypasses; and Vernon Station turbines.

Eels from the Bellows Falls route studies migrating to the Vernon Dam may be used to supplement (but not serve in lieu of) these release groups.

Bellows 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 (if any) and non-spill and during periods of low, moderate, and high generation conditions, if possible. Tagged eels should be released at least 5 km upstream of the Bellows Falls Dam. If significant spillage occurs during releases, up to 50 additional eels should be released in the upper canal and allowed to

volitionally descend through the canal to assure that sufficient number of eels are exposed to canal and powerhouse intake conditions. Telemetry receivers and antennas should be located upstream and downstream of the spillway, at the canal entrance, within the canal, in the fish downstream fish bypass entrance and turbine intakes and in mainstem below Bellows Falls Station to assess passage via the following potential routes: entrainment into the canal; passage over the spillway; into the upstream fishway attraction water intake (this should be operated during the study to assess its use by eels as it may be operational in the future for riverine or eel passage as addressed in the Resident Fish Passage study request); the downstream fish bypass; and station turbines.

Eels from the Wilder route study migrating to the Bellow Falls Project may be used to supplement (but not serve in lieu of) these release groups.

Wilder Project Route Selection Study:

A minimum number of 50 telemetered eels (e.g., 5 separate groups of approximately 10 eels each) should be required to maximize the data return. Tagged eels should be released at least 5 km upstream of the Wilder Project. Groups of eels should be released during spill and non-spill periods if possible. Telemetry receivers and antennas should be located to assess passage via the following potential routes: Wilder spillway; Fishway attraction water intake (if operational); Wilder downstream bypasses; and Wilder Station turbines.

Mobile tracking (i.e., via boat) in river reaches between release sites and several km downstream of Vernon 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 detection at radio antenna locations, and between radio antenna locations) 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 spillways, downstream bypasses, and station turbines) to maximize the data return.

For spill mortality sites (dam spillways and downstream bypasses), 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 (Vernon, Bellows Falls, and Wilder stations), 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.

If the balloon tag mortality component of the study occurs in Study Year 1 then all possible route selection sites would need to be evaluated. If the balloon tag mortality component of the study occurs in Study Year 2, then results from the route selection study (Year 1) could be used to inform which sites need to be evaluated for mortality.. Eels recovered from balloon tag studies should not be used for route selection studies.

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

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

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies will not suffice

The level of cost and effort for the downstream eel passage study would be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed at the intakes of all stations as well as at the dam spillways and Station bypasses, and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately \$75,000 for the first year of study. Costs are estimated at \$100,000 per year for the Route Selection studies and \$75,000 per year for the Spill, Bypass, and Turbine Mortality/Injury Studies, for each project.

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 277-291 in: 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.
- Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont.
http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Requested Study No. 7

Model River Flows and Water Levels Upstream and Downstream from the Wilder, Bellows Falls, and Vernon Stations and Integration of Project Modeling with Downstream Project Operations FERC No. 1904 & FERC No. 1855

Goals and Objectives

The goal of this study is to develop river flow models that permit the evaluation of the hydrologic changes to the river caused by the physical presence and operation of the Wilder, Bellows Falls, and Vernon Hydroelectric Projects and the interrelationships between the operation of all five hydroelectric projects up for relicensing and river inflows. Specific objectives of this study include:

1. Conduct quantitative hydrologic modeling of the hydrologic influences and interactions that exist between the water surface elevations of the Wilder, Bellows Falls, and Vernon project impoundments and discharges from the Wilder, Bellows Falls, and Vernon projects and the downstream hydroelectric projects including:
 - a. Inflows into the Wilder, Bellows Falls, and Vernon impoundments from the Fifteen Mile Falls Project, FERC No. 2007, and other sources;
 - b. Existing and potential discharges from the Wilder, Bellows Falls, and Vernon project generating facilities and spill flows, including existing and potential minimum flow and other operational requirements;
 - c. Existing and potential water level fluctuation restrictions (maximum and minimum pond levels) of the Wilder, Bellows Falls, and Vernon impoundments, and consequent changes in downstream project discharges; and

- d. Incorporation of the potential effects of climate-altered flows on project operations over the course of the license.
2. Assess how existing and potential operations of the Wilder, Bellows Falls, and Vernon projects affect the operations of the Northfield Mountain and Turners Falls Projects, including:
 - a. How Wilder, Bellows Falls, and Vernon flow fluctuations affect pool levels of the Turners Falls impoundment; and
 - b. How operations of the Wilder, Bellows Falls, and Vernon projects affect Turners Falls discharges.

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.

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 hydrogeneration will benefit a public resource with better information for management of flows to protect these resources.

Existing Information

Available information in the PAD does not indicate how project operations have altered the hydrology downstream from each of these facilities, 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. It is also unclear how operations at one facility affect the operations at another.

Nexus to Project Operations and Effects

The Wilder, Bellows Falls, and Vernon projects are each currently operated with required minimum flows of 675, 1,083, and 1,250 cfs (or inflows if less) for each facility, respectively, though in practice minimum flows are operated as 700, 1300, and 1600 cfs, respectively. There is presently no required minimum flow for the bypassed reach of the Bellows Falls Project. Each of the projects operates as a daily peaking facility, such that “Generation can vary during the course of any day between the required minimum flow

and full capacity if higher flows are available” (p. 2-28, p. 2-29, and p. 2-30 in the Wilder, Bellows Falls and Vernon PADs, respectively). Total hydraulic capacity of each facility is 12,700, 11,010, and 12,634 cfs, respectively. Regular daily fluctuations on the order of 9,000 cfs or greater are commonly recorded at USGS gages 01144500 (Connecticut River at West Lebanon, below Wilder Dam) and 01154500 (Connecticut River at North Walpole, NH, below Bellows Falls Dam). Daily fluctuations in headpond elevation are approximately 2.5’ (382’ to 384.5’ MSL), 1.2’ (289.9’ to 291.1’ MSL), and 1.2’ (218.6’ to 219.8’ MSL) at the Wilder, Bellows Falls, and Vernon impoundments, respectively.

These described changes affect biotic habitat and biota upstream and downstream of each project. Project operations and potential changes to operations to mitigate impacts at each facility are influenced by inflows and operations of upstream projects. Results of river flow analyses will provide necessary information regarding changes that can be made to the Wilder, Bellows Falls, and Vernon Project flow releases and/or water level restrictions, how such changes may be constrained by inflows and upstream project operations, and how these changes potentially affect downstream resources. This information will then be used to develop flow-related license requirements and/or other mitigation measures.

Methodology Consistent with Accepted Practice

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

Level of Effort/Cost, and Why Alternative Studies will not suffice

Level of effort and cost of model development are expected to be moderate as much of the baseline modeling has already been completed, but running of various scenarios through the model(s) will be needed throughout the relicensing process to assess the implications of changes to the operations of each project on other projects and other resources. The modeling exercise will also require coordination and cooperation between TransCanada and the downstream licensee to assure that the model inputs and outputs can be accurately related.

We would anticipate that the expected level of effort and anticipated costs will be comparable to that experienced on similar FERC relicensing projects of this size.

**Requested Study No. 8
Upstream American Eel Passage Assessment at Vernon and Bellows Falls Projects
FERC No. 1904 & FERC No. 1855**

Goals and Objectives

This study has two objectives:

1. Conduct systematic surveys of eel presence/abundance at tailrace and spillway locations at the Vernon, Bellows Falls, and Wilder projects 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 Bellows Falls Project and the Vernon Projects 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 three dams, or annual numbers of eels attempting to ascend past the dams. While eels have been known to ascend the Vernon and Bellows Falls fish ladders, their efficiency for passing eels is unknown, and they are only operated during the American shad passage season (from April 15 through July 15). Eels are currently able to pass Vernon, Bellows Falls, and Wilder dams (as evidenced by documented presence of eels upstream), but the total number of eels attempting to pass all three dams and the proportion successfully passing each 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 the next dam upstream (the Turners Falls Project; FERC No. 1889) has no dedicated upstream eel passage facilities, eels have been known to ascend the Cabot Station fish ladder (A. Haro, U.S. Geological Survey, pers. comm.). Although there is rearing habitat in between the Turners Falls and Vernon 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 projects.

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 three projects generate hydropower on the head created by the Vernon, Bellows Falls, and Wilder dams. These dams create barriers 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. All three dams are high (Vernon: 58 ft. high; Bellows Falls: 30 ft. high; and Wilder: 60 ft. high), and the majority of the dam faces are dry during most of the upstream eel passage season. Design of the dams is not currently amenable to passage of eels by climbing. 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 below the dams and associated structures. These locations include: the upstream fish ladders at all three projects (dewatered state) and leakage or overflow points along the

downstream faces of all three dams, including spillways. 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 stilling basins and/or lower sections of fishways supplied with minimal attraction flow (0.5-1.0 cfs) during dewatered conditions at all three projects, as these locations may be supplemented with additional attraction flow and have high potential for being concentration points for upstream migrant eels. Similarly, traps should also be placed at spillway or bypass channel locations where eels have a potential to climb wetted (e.g., via leakage) flow zones, at the highest points where eels are able to climb to, or where otherwise feasible. Temporary trap/passes should be purpose-designed and built for each location, and operated throughout the eel upstream migratory season (~1 May to 15 October, or when river temperatures exceed 10° C). Ramp-type traps with supplementary attraction flow are preferred temporary trap/pass designs. Traps should operate daily, with catches quantified every 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 into the headponds upstream of where they were collected.

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 for each individual project (moderate for all three projects combined); a minimal number of personnel may be able to conduct the weekly surveys. The trap/pass component would require low to moderate cost and effort. We estimate \$40,000 per project to conduct this study.

TU is not aware of any previously conducted or ongoing studies related to upstream eel passage. The applicant did not propose any studies to meet this need in the PAD.

Literature Cited

Kart, J., R. Regan, S.R. Darling, C. Alexander, K. Cox, M. Ferguson, S. Parren, K. Royar, B. Popp, editors. 2005. Vermont's Wildlife Action Plan. Vermont Fish & Wildlife Department. Waterbury, Vermont.

http://www.vtfishandwildlife.com/swg_cwcs_report.cfm. (Accessed September 10, 2012).

Requested Study No. 9
Impact of Vernon Project Operations on Downstream Migration of Juvenile American Shad
FERC No. 1904

Conduct a field study of juvenile American shad outmigration at the Vernon Dam to determine if project operations negatively impact juvenile 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 operation effects of Vernon Dam on the timing, routes, migration rates, and survival of juvenile shad;
- Determine the proportion of juvenile shad that as a downstream passage route choose or are directed to existing downstream bypass structures, gate structures, or are entrained into the station turbines and assess delay, survival, timing, and related impacts with these locations under a full range of operational conditions, over the period of outmigration;
- Determine survival rates for juvenile shad entrained into Vernon Station units.

If it is determined that the project operations or related effects are adversely affecting juvenile shad survival, migration timing, or other deleterious population effects are noted, identify operational solutions or other solutions that will reduce and minimize impacts, within the project affected area. This study will require two years of field data to capture inter-annual variability of river discharge, water temperature, and variability in run size and juvenile production (and timing of developmental stages) and variability in outmigration timing which may relate to spring, summer and fall conditions.

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 Vernon Project and other projects in the upper Connecticut River alter flows and entrain fish impacting aquatic species and communities and specifically juvenile American shad movement and survival. Flow alterations and entrainment 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

Adult shad are counted annually as they pass above the Vernon Dam. 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). A seasonal average annual index of juvenile American shad standing crop in Vernon reservoir has been calculated since 2000. Estimates of juvenile shad growth rates in the Vernon impoundment have been calculated annually beginning in 2004, and also in a study conducted in 1995 (Smith and Downey 1995).

Although there were numerous studies of downstream passage facilities at the Vernon Project for Atlantic salmon smolts, studies passage studies for American shad were limited to tests in 1991 and 1992 of a high frequency sound field to guide fish to the fish pipe, the primary downstream fishways in 1991 and 1992 (RMC 1993). Although the studies were deemed incomplete, the technology indicated some level of response by juvenile shad. However, despite that conclusion, there is no indication that this technology or other downstream passage studies with juvenile shad were subsequently pursued.

Project Nexus

Juvenile American shad production occurs in the river reach between the Vernon Dam and the Bellows Falls Dam, which is thought to be the historic upstream limit of the shad migration in the Connecticut River. Juvenile American shad require safe and timely downstream passage measures to have the opportunity to contribute to the restoration target population size.

There is little information available regarding the total impact of the Vernon project on downstream migration of juvenile shad. Migration delays, increased predation, mortality during passage over the dam or through turbines, and changes in route selection under different flow conditions are potential influences of the Vernon Dam on the juvenile shad population in the upper Connecticut River. 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, particularly in the upstream reaches. Delays in juvenile American shad outmigration may affect survival rates in the transition to the marine environment (Zydlewski et al. 2003).

Proposed Methodology

The impact to juvenile shad outmigrants would be best studied by a combination of approaches including hydroacoustics, radio telemetry (including passive integrated transponder (PIT) telemetry), and turbine balloon tags. Project discharge adjustments at the dam should be examined relative to timing, duration, and magnitude of juvenile shad migration to and through the dam, with hydroacoustic equipment for natural/wild fish information. In addition, study fish should be collected and tagged (PIT, radio, balloon)

to then empirically determine rates of survival for fish passed through the project under varied operations, from minimum flows up to full spill conditions. The release of tagged fish (radio, PIT) at a number of potential sites will provide data on delay and route selection as juvenile shad move through the Vernon project area. The number and location of release sites will depend on the availability of tagged fish.

Additional hydroacoustic assessment immediately upstream and downstream of the Vernon Dam will provide information on the timing of migration to and through this area. A more focused survival study, using balloon tags, PIT tags, or other appropriate methods, should be conducted in the second year based upon the first year of study findings relative to the frequency, magnitude, timing, and route selection of juvenile American shad through the Vernon project.

Level of Effort and Cost

TransCanada does not propose any studies to meet this need. Estimated cost for the study is expected to be up to \$150,000 with the majority of costs associated with equipment (hydroacoustic gear, radio tags, radio receivers, and PIT readers) and related fieldwork.

Literature cited:

RMC Environmental Services, Inc. 1993. Effect of ensonification on juvenile American shad movement and behavior at Vernon Hydroelectric Station, 1992 – Draft Report, March 1993.

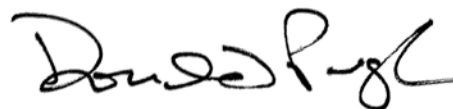
Smith, R. L., and P. C. Downey. 1995. Vermont Yankee/Connecticut River System Analytical Bulletin 69: Relative density and growth of juvenile American shad in the Connecticut River near Vernon, Vermont, 1995.

Zydlewski, J., S. D. McCormick, and J. G. Kunkel. 2003. Late migration and seawater entry is physiological disadvantageous for American shad juveniles. *Journal of Fish Biology* #63, 1521-1537.

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
10 Old Stage Rd.
Wendell, MA 01379

Sincerely,



Donald Pugh