Vermont Yankee Environmental Advisory Committee Recommendations to Vermont Agency of Natural Resources on Upcoming Vermont Yankee NPDES Permit Renewal

November 12, 2013

The Vermont Yankee Environmental Advisory Committee (EAC) was informally established around 1968/1969 and at that time was called the Technical Advisory Committee. The EAC – since formally established in the National Pollutant Discharge Elimination System (NPDES) permit issued to Entergy Nuclear Vermont Yankee, LLC (Entergy) – is comprised of one individual each representing the Vermont Department of Environmental Conservation (currently, Richard Langdon); Vermont Fish and Wildlife Department (Kenneth Cox); New Hampshire Fish and Game Department (Gabriel Gries), New Hampshire Department of Environmental Services (David Neils), Massachusetts Office of Watershed Management (Robert Maietta), Massachusetts Division of Fisheries and Wildlife (Caleb Slater), and Connecticut River Atlantic Salmon Restoration Program/U. S. Fish and Wildlife Service (Kenneth Sprankle/Melissa Grader). The EAC has an advisory function in that it reviews, evaluates, and advises the Vermont Agency of Natural Resources (VANR) on matters pertaining to the permittee's environmental monitoring and studies program and NPDES permit issuance. State and federal members on the EAC represent their respective agencies which have environmental protection and natural resource management responsibilities for waters, namely the Connecticut River (the River), affected by Vermont Yankee's (VY) discharge of heated effluent to the River.

Background

Licensing and Permitting

VY was originally designed in 1967 to operate with a once-through condenser cooling water system which would have drawn water from the River through the condenser, and returned the heated water directly back to the River. However, this proposed plan was not acceptable to the regulatory agencies and resulted in the construction of two mechanical draft cooling towers. The towers were designed to dissipate heat directly to the atmosphere rather than to the River.

Vermont Yankee Nuclear Power Corporation (VYNPC) first began commercial operation of the plant in 1972. The Atomic Energy Commission issued an operating license in 1973. During the first two years of plant operation (1972-1973), VY was required to operate in closed-cycle mode (cooling towers) only.

In 1974 the State of Vermont granted VYNPC a variance to its operating license permitting the discharge of limited amounts of heat to the River during the Winter period, October 15 – May 15, while hydrothermal and biological assessments were conducted (1974-1978). In 1978, the company was issued an amended discharge permit authorizing the release of heated water to the River during the Winter period with the following limitations:

- River temperature at Monitoring Station 3 shall not exceed 65°F.
- The rate of temperature change at Station 3 shall not exceed 5°F per hour.
- The increase in temperature above ambient at Station 3 shall not exceed 13.4°F. The increase in temperature above ambient shall mean plant induced temperature increase as shown by equation 1.1 (defined on page 1-8 of VY's *316 Demonstration: Engineering, Hydrological and Biological Information and Environmental Impact Assessment* (1978)).

In 1981, VYNPC proposed evaluating the environmental effects of a limited thermal discharge to the River during the summer period (May 16-October 14) under Project SAVE (Save Available Vermont Energy). VANR approved a variance to allow experimental Summer period temperature limits in 1981. Biological studies began in 1982 to assess fish populations and whether there were possible effects caused by VY's thermal discharge. Constraints on the heated discharge conformed to the then Vermont State Water Quality Standards for warm water fisheries (see below) and on January 9, 1986 VYNPC's permit was renewed. A temperature limit of 93°F was placed on closed cycle cooling discharge to the River.

Ambient (VY Station 7) temperature	Temperature increase at VY Station 3
Above 66°F	1°F
63 – 66°F	2°F
59 – 63°F	3°F
55 – 59°F	4°F
Below 55°F	5°F

In 1990, VYNPC submitted a 316 Demonstration (Downey et al. 1990) in support of its request for alternate Summer temperature limits (see below). VANR renewed their discharge permit on December 5, 1990 authorizing the alternate limits.

Ambient (VY Station 7) temperature	Temperature increase at VY Station 3
Above 63°F	2°F
>59°F, ≤63°F	3°F
>55°F, ≤59°F	4°F
≤55°F	5°F

The 1996 permit renewal eliminated the 93°F temperature limit for closed cycle cooling. Between 1999 and 2006 the discharge permit was amended five times (1999, August 2001, 2002, 2003, 2004) and renewed once (July 2001); however, in none of these reissuances were changes made to the 1986 thermal standards.

On July 11, 2001, the VANR issued a renewal discharge permit (No. 3-1199) to Entergy which authorized the discharge of 543 million gallons per day of condenser cooling water to the River subject to temperature limitations. The permit was subsequently amended on June 20, 2003 authorizing a 1°F increase in heated water discharged to the River between May 16 and October 14 (the summer period). On March 30, 2006 the permit was once again amended authorizing an increase in the thermal discharge regime during the dates, June 16 through October 14 (see Current Thermal Discharge Periods and Temperature Limits on page 5).

On March 2, 2006, the U. S. Nuclear Regulatory Commission (NRC) approved a power uprate to increase the maximum core power level from 1,593 megawatts-thermal (MW(t)) to 1,912 MW(t).

Fish Communities Monitoring Program

Information on the baseline composition and condition of fish populations of the Connecticut River prior to VY operation, and particularly before thermal discharges to the River were permitted, are limited to basic inventories. The earliest scientific study of the fish community inhabiting the River between Vernon and Bellows Falls dams was done in 1967 by the New Hampshire Fish and Game Department. Nearly 3,000 fish were collected representing 24 species and one hybrid. This study was done independent of VYNPC.

Beginning in 1967, VYNPC contracted a biological consultant to assemble baseline water quality and aquatic biota data from the River in the vicinity of the VY plant during the pre-operational years (i.e. before 1973). Employing a variety of fish population sampling methods 26 fish species totaling about 11,000 individual fish were then documented in the project area. All specimens were measured for total length and weighed. Scales were also removed for age determination. These data also essentially constitute baseline condition of the fish populations prior to the discharge of heated water to the River. All fish species collected then continue to be represented in the fish community today. However, the number of species reported since then has increased to at least 36 which includes four native anadromous fishes (sea lamprey *Petromyzon marinus*, blueback herring *Alosa aestivalis* , American shad *Alosa sapidissima*, Atlantic salmon *Salmo salar*) to which state and federal fishery agencies have invested much time and resources into restoring self-sustaining populations to the River including that portion within VY's project area and thermal influence.

Elements of Entergy's current fish communities monitoring program are specified in its discharge permit (Amended Permit No. 3-1199) and include:

1. Larval Fish. Larval fish are collected when the plant cooling water intake is operating in open/hybrid cycle according to the following schedule and methods:
    a. Frequency/Dates: Weekly – May through July 15.
    b. Locations: Connecticut River adjacent to the plant intake.
    c. Three plankton net samples are collected on the same day of each week with the net being deployed as close as possible to the intake allowing each sample to be representative of the water column, bottom to surface. The volume sampled is measured with a flow meter mounted near the net mouth and used to calculate the density of larval fish in each tow. Larval fish are identified to the lowest distinguishable taxonomic level and enumerated.

2. Fish. Fish are collected according to the following schedule and methods:
    a. Frequency/Dates: Monthly – May, June, September and October.
    b. Locations: Connecticut River at Rum Point, VY Station 5, VY Station 4, NH Setback, 0.1 mile south of Vernon Dam, VY Station 3, Stebbins Island, and VY Station 2.
    c. Fish are collected at each location with boat mounted electrofishing gear. All fish caught are identified, enumerated to the lowest distinguishable taxonomic level, and measured for length and weight. A representative sample of American shad and Atlantic salmon are scaled for annuli determination of age. Catch-per-unit of effort (CPUE) is calculated for each species sampled.
3. Anadromous Fish. Juvenile and adult American shad are monitored according to the following schedule:
    a. Electrofishing
        i. Frequency/Dates: Twice monthly – July through October.
        ii. Locations: Connecticut River 0.1 mile south of Vernon Dam, VY Station 3, and Stebbins Island.
        iii. Juvenile shad are collected at each location with boat mounted electrofishing gear. All captured juvenile shad are identified, enumerated and measured for length and weight. CPUE is calculated.
    b. Seining
        i. Frequency/Dates: Twice monthly – July through October.
        ii. Locations: Connecticut River between Vernon Dam and the confluence with the West River.
        iii. Twenty beach seine hauls and 12 surface trawl tows (utilizing midwater trawl tow gear) are made per sampling event. All fish caught are identified, enumerated to the lowest distinguishable taxonomic level, and measured for length and weight. CPUE is calculated.
    c. Vernon ladder fish trap
        i. Frequency/Dates: Weekly – May 15 through June.
        ii. Locations: Vernon fish ladder.
        iii. Adult shad are sampled in the fish trap and enumerated, measured for length and weight and evaluated for sex and sexual condition. Scale samples are taken from each fish and used for annuli determination of age.

4. Fish Impingement. Impingement samples are collected when the plant cooling water intake is operating in open/hybrid cycle according to the following schedule and methods:
    a. Frequency/Dates: Weekly – April 1 through June 15; August 1 through October 31.
    b. Locations: Circulating water traveling screens (CWTS).
    c. Prior to the start of each weekly sample, the three CWTS are backwashed and the debris removed. Debris is examined for shad and salmon. On the following day, the three CWTS are backwashed and debris is removed sorted to remove all fish which are then identified to the lowest distinguishable taxonomic level, enumerated, measured for length and weight.

In addition to the above task-oriented monitoring program requirements, which define a minimal data collection from fish populations residing in the vicinity of or migrating past the VY plant, additional studies (objective-specific studies) may be directed upon the EAC raising concerns about observations or findings made during the task-oriented monitoring program and/or other concerns possibly affecting the "protection and propagation of a balanced indigenous population."

Over the 40 plus years that VY has been in operation, fish community monitoring has periodically been modified, such as boat mounted electrofishing replacing gill netting; elimination of trap netting for the protection of locally nesting, federally protected bald eagles; and discontinuation of boat electrofishing to sample juvenile shad in Vernon Pool. Ramifications of these changes are discussed further on.

Additionally, after 45 years of state and federal agency cooperation toward restoration of Atlantic salmon to the Connecticut River basin, in the fall of 2012, the Connecticut River Atlantic Salmon Commission (CRASC) as well as state and federal fishery agencies decided to terminate salmon restoration due to budget cuts, loss of the White River National Fish Hatchery due to flooding during Tropical Storm Irene, and recent poor returns of adult salmon to the river. In light of this significant decision the agencies nonetheless are committed to the restoration and sustainable management of shad, river herring, lamprey, shortnose sturgeon *Acipenser brevirostrum* and American eel A*nguilla rostrata* to the Connecticut River basin.

Current Thermal Discharge Periods and Temperature Limits

Entergy's existing permit stipulates three discharge periods: (1) **Winter**, October 15 through May 15; **Spring**, May 16 through June 15; and **Summer**, June 16 through October 14. During the winter period Entergy is required to operate the plant's circulating water cooling facilities whether closed, open, or in hybrid mode in a manner where (1) the river temperature at VY Station 3 shall not exceed 65°F; (2) the rate of temperature change at VY Station 3 shall not exceed 5°F per hour; and (3) the increase in temperature above ambient at VY Station 3 shall not exceed 13.4°F. These limitations have remained unchanged since the winter discharge was authorized in 1978.

The Summer period was revised by the 2006 amended NPDES permit whereby a Spring (or early summer) period was split out for the purpose of protecting Atlantic smolts outmigrating from the River to their marine habitat. Coincidentally, the Spring period also captures a portion of the adult shad post-spawning outmigration. The Spring and Summer periods authorize the increase in river temperature above ambient at VY Station 3. Thermal discharge thresholds are summarized in Tables 1 (Spring) and 2 (Summer). Summer criteria also place a maximum limit on the increase in river temperature resulting from VY's thermal discharge. More specifically, when the average hourly temperature at Station 3 equals or exceeds 85°F, the permittee shall, as soon as possible, reduce the thermal output of the discharge such that the hourly average temperature at VY Station 3 does not exceed 85°F.

TABLE 1. Spring period (May 16-June 15) temperature discharge criteria.

Ambient (VY Station 7) temperature	Temperature increase at VY Station 3
Above 63°F	2°F
>59°F, ≤63°F	3°F
≥55°F, ≤59°F	4°F
Below 55°F	5°F

TABLE 2. Summer period (June 16-October 14) temperature discharge criteria.

Ambient (VY Station 7) temperature	Temperature increase at VY Station 3
Above 78°F	2°F
>63°F, ≤78°F	3°F
>59°F, ≤63°F	4°F
≤59°F	5°F

EAC Recommendations

In consideration of the VANR issuing a new/amended NPDES permit for the VY project, the EAC recommends Entergy be required to operate the project in closed-cycle mode year-round (i.e., reversion to the use of cooling towers) at least until the outstanding concerns regarding the effects of VY's thermal discharge on biota of the River, discussed below, have been satisfactorily assessed and accepted by the VANR and other state and federal fishery agencies with interests in and responsibilities for the wellbeing of resident and anadromous fish populations in the River.

1. *The thermal discharge periods/seasons under which VY currently operates do not correspond with the migration and spawning schedules of anadromous fish species*.

Thermal periods under which Entergy operates were discussed previously. The Winter period (October 15 – May 15) was established at least as far back as 1978. The remaining portion of the year constituted the Summer period, up until 2006,when the Summer season was further divided into two periods (Tables 1 and 2).

The EAC now recognizes that the three periods as defined above do not sufficiently protect the biological/life history requirements of anadromous and resident fishes inhabiting and/or migrating through portions of the River affected by VY's thermal discharge. Table 3 below illustrates the complexity of the seasonal needs associated with fishes occurring in the river. The table also illustrates inconsistencies between the existing seasonal periods as defined by the NPDES permit and the biological requirements of fish species inhabiting the River when they are under the influence of VY's thermal discharge. The following two cases are presented to illustrate flaws with how the current seasons are defined and implemented:

- The first shad of the 2013 run at the Vernon ladder passed on May 8 and by May 15 over 4,600 adult shad had passed into Lower Vernon Pool (LVP). However, VY is not required to change from Winter to Spring temperature limits until May 16. That year adult shad were passing into Turners Falls Pool (TFP) and the Vernon Tailwater as early as May 6. The preceding year, 2012, shad passed into TFP as early as April 20, 25 days before Spring limits go into effect. Under the currently defined Winter thermal limits adult shad in spawning condition are potentially exposed to temperatures as much as 13.4°F higher than ambient.
- During 2012, juvenile shad were still present in Vernon pool after October 14 (when VY changes from Summer to Winter temperature limits). The presence of juvenile shad in Vernon pool was demonstrated by impingement collections taken from VY's CWTS. The total number of juvenile shad collected between August 21 and November 13, 2012 was 260. Of this number 216, or 83%, were impinged after October 14, when VY's Winter temperature limits are in effect.

TABLE 3. Critical life stages and periods of the year for anadromous and resident fishes inhabiting the Connecticut River in the vicinity of Vermont Yankee.

Season	Critical life stage or population
Spring – Summer (April 1 – July 31)	1. Atlantic salmon smolt outmigration. 2. Adult salmon spawning migration. 3. Adult American shad & blueback herring spawning migration & outmigration. 4. Juvenile shad & blueback herring rearing. 5. Resident fishes.
Late Summer – Early Winter (August 1 – November 15)	1. Adult salmon spawning migration. 2. Juvenile shad & blueback herring rearing/outmigration (August 1 – November 15). 3. Possible adult salmon outmigration (August 1 – December 31). 4. Resident fishes.
Winter (November 16 – March 31 or January 1 – March 31)	1. Resident fishes.

Hydroelectric generation stations on the River are required to operate upstream and downstream fish passage facilities in accordance with the CRASC annual schedule for fish passage operations and as approved by the Federal Energy Regulatory Commission (Table 4). At present, VY operates independently from this schedule which is reasonably viewed as being disadvantageous to anadromous fish, and in particular to shad. The VY discharge enters the River less than a half mile upstream of Vernon Dam powerhouse/forebay. The thermal plume comes in direct contact with upstream and downstream fish passage facilities and likely has an effect on the temperature of water used to operate the fishways. Consequently, this situation could negatively affect fish passage use and efficiency. Effects of increasing temperature regimes on adult shad have been reported by Castro-Santos and Letcher 2010, Glebe and Leggett (1981), Leonard et al. (1999), and Marcy (2004). Additionally, extensive research has been conducted on temperature effects on juvenile shad (Chittenden 1972, Marcy 2004, Marcy et al. 1972, Moss 1970, Zydlewski and McCormick 1997, Zydlewski et al. 2003). The EAC has previously stated the need for empirical data to corroborate Entergy's assertion of no prior appreciable harm per previous temperature increases. The EAC has recommended in the past that Entergy conduct specific studies of temperature effects on adult and juvenile shad within that portion of the river receiving its thermal discharge. Studies have yet to be conducted. The EAC recommends VY's thermal discharge periods/seasons be changed to conform with those under which the Vernon hydroelectric project is required to operate upstream and downstream fish passage facilities.

TABLE 4. Connecticut River schedule of upstream and downstream fish passage operations prescribed for Vernon, Northfield Mountain Pump Storage, and Turners Falls hydroelectric generation projects. Source: Connecticut River Atlantic Salmon Commission, February 22, 2013. Operation of these facilities is 24 hours/ day.

Upstream Fish Passage

Location (project)	Fish passage route	Species	Life stage	Dates of operation
Vernon	Ladder	Salmon Salmon Shad & herring	Adult Adult Adult	April 15 – July 15 September 15 – November 15 April 15 – July 15
Turners Falls	Cabot, Gatehouse & Spillway ladders	Salmon Salmon Shad & herring	Adult Adult Adult	April 1 – July 15 September 15 – November 15 April 1 – July 15

Downstream Fish Passage

Location (project)	Fish passage route	Species	Life stage	Dates of operation
Vernon	Unit 10 fish bypass	Salmon Salmon Shad Shad Eel	Smolt Adult Adult Juvenile Adult	April 1 – June 15 October 15 – December 31 April 15 – July 31 August 1 – November 15 September 1 – November 15
Northfield Mountain	Barrier net	Salmon	Smolt	April 1 – July 15
Turners Falls	Log & trash sluices	Salmon Salmon Shad Shad Eel	Smolt Adult Adult Juvenile Adult	April 7 – July 15 October 15 – December 31 April 1 – July 31 August 1 – November 15 September 1 – November 15

2. *NPDES renewal coincides with the recent NRC authorization granting Entergy a license to operate another 20 years*.

This will be the first NPDES permit issued to Entergy since it was granted a license extension by the NRC in the fall of 2011. The EAC believes this provides the opportunity to recalibrate environmental metrics of the River without VY's thermal discharge thus re-establishing a baseline from which future physical, chemical and biological changes in the River, with and without a thermal discharge, can be measured over the next two decades. A baseline determination last occurred before 1974 and in the opinion of the EAC may no longer be representative of the River, with or without VY's thermal discharge, nor enables the clarity needed to assess discharge effects on the ecological health of the River within the full extent of VY's thermal influence, i.e. LVP and downstream. Since VY first began operating in 1972, a number of changes have occurred to the River itself as well as in adjacent riparian and upland areas of the watershed that may have altered its ecology, including but not limited to, a number of modifications to hydroelectric generation facilities and their operations and fish species composition, abundance and community structure. These environmental alterations, combined with changes in VY's thermal discharge, make it extremely difficult to ascribe "cause and effect" to any given factor that may be contributing to observed as well as potential changes in biological metrics associated with the nine RIS (representative important [fish] species) within LVP and downstream of Vernon Dam, and other species of management or recovery interest to fisheries agencies.[1] <u>The EAC recommends VY operate in closed cycle mode for a period of at least three to five years in order to assess the River as it is at present without a plant induced thermal influence thereby resetting a new baseline on which future thermal variances and environmental effects may be assessed</u>.

3. *The full extent of VY's thermal effect on the River from the point of discharge and downstream is not currently known or understood.*

Binkerd et al. (1978) and Luxenberg (1985) determined downstream thermal effects attributed to VY's discharge may extend as far as the Holyoke Dam. Entergy contends its influence on the River is much shorter; however, no irrefutable data have been provided to support this. The EAC recommended that Entergy revisit this issue using more current methods to identify the downstream extent and magnitude of its thermal influence. While Entergy did develop a study plan (*Predicting the Downstream Dispersion of Vermont Yankee's Thermal Plume in the Connecticut River from Vernon Dam to Holyoke Dam*, March 2008)and began implementing it, due to several factors the study was not brought to completion.

In January 2013 Entergy submitted to the VANR another study plan developed by Dr. Craig Swanson of RPS ASA: *Study Plan: Hydrothermal Modeling of the Connecticut River from the Vernon Dam to the Holyoke Dam to Evaluate Thermal effects on American Shad Migration and Residency*. Before the EAC had an opportunity to review and develop comments on the plan,

[1] The RIS include American shad, Atlantic salmon, spottail shiner *Notropis hudsonius*, fallfish *Semotilus corporalis*, white sucker *Catostomus commersoni*, smallmouth bass *Micropterus dolomieui*, largemouth bass *M. salmoides*, yellow perch *Perca flavescens*, and walleye *Sander vitreus*.

Entergy executed the study, and submitted the results as part of the recent Public Service Board proceedings (Exhibit EN-CS-7: *Modeling the Downstream Thermal Effect in Turner Falls Pool* (Swanson et al., March 14, 2013)). The analysis applied a three-dimensional computer simulation model to temperature data from the years 2001 through 2011. The dataset encompassed a portion of the upstream adult shad migration season: May 15 through June 20. The latter date was selected by the report authors without explanation of its relevance. The shad migration extends later than this date (typically to the end of the month). One finding from this analysis is that VY's thermal discharge resulted in temperature increases at VY Station 3 in the range 0.35 to 4.0°F with an average across all years of 1.75°F. By the time the river temperature attenuates to Turners Falls Dam, temperature increase is in the range of 0.27 to 2.2°F; average 1.1°F. While an increase of a few degrees may seem biologically insignificant, this is a flawed assumption unless it can be substantiated. Leonard and McCormick (1999) state, "…female American shad use a consistently higher amount of energy between Cabot Station [Turners Falls] (km 198) and Vernon Dam (km 228) than earlier in the migration…" Given all the anthropogenic challenges adult shad are faced with while migrating up river (e.g., dams, fish ladders, artificial flow regimes), small incremental temperature increases, including 4°F, that may not otherwise exist under natural conditions should not be dismissed as being inconsequential with regard to shad bioenergetics and spawning potential. <u>The EAC recommends Entergy undertake field studies employing the best technologies available to ascertain the maximum downstream effect range of its thermal influence on the River</u>.

4. *NPDES renewal and NRC relicensing offer the opportunity to develop and implement a more biologically meaningful monitoring program*.

Entergy and its predecessors have conducted many studies over the past 30 or more years employing the contemporary methodologies and technologies of the time. However, advances and improvements have since been made and continue to be developed enabling better assessments of VY's potential effects on shad, other RIS, and river ecology. While the EAC believes the wealth of biological and physical information collected over the past decades has been useful, it sees a new NPDES permit as the opportunity to initiate a refocused effort to develop a more biologically relevant monitoring program coinciding as it (nearly) does with the expiration of the old license and issuance of the subsequent 20-year license.

In consideration of past NPDES permit variance requests and annual reviews of Entergy's biological monitoring data, the EAC has requested time series comparisons be made extending back before 1991. Entergy has declined such retrospective analyses on the basis of (1) changes in sampling procedures over the years do not allow for valid comparisons, and (2) their perspective that they only need to address issues extending back to the last variance and not before. The EAC acknowledges the problems with conducting meaningful analyses with data collected and/or processed differently. However, limiting evaluations to the years 1991 to present results in a more truncated dataset from which to base trends and the inability to make comparisons with baseline fish community conditions. Therefore, implementing a new environmental monitoring program with a new baseline is all the more warranted and constructive to evaluating whether future thermal discharges are having affects on aquatic communities.

The EAC also has concerns with the current practice of combining multiple age classes within fish species for calculation of CPUE and using this metric as a measure of fish abundance and ultimately as a determination of the impact of VY's operations on the River's fish species. It would be preferable to monitor individual age or at least size classes within each RIS population. To do so will require resumption of age and growth analyses.

Additionally, the current monitoring program lacks a true control, i.e. sites where similar fish populations/communities are monitored and fish are not exposed to a thermal discharge on a magnitude like that from VY. The EAC has suggested the Bellows Falls area as a possible control site. The EAC also recognizes that it has more work to do to review the current monitoring program and to develop alternate recommendations. Therefore, the EAC recommends VANR in consultation with EAC and Entergy undertake a full review of the current monitoring program and identify how it can be improved in terms of field procedures, data analyses and products such that fish populations in the River are protected and populations are sustained in accordance with ecological functions, the publics use of fishery resources, and species restoration/recovery goals are achievable.

5. *Recent scientific research document negative thermal impacts to anadromous fishes*.

Adult American Shad

Each year adult American shad ascend the River to spawn. The number of adults migrating upriver and past the hydroelectric dams at Holyoke, MA (river-mile 87); Turners Falls, MA (river-mile 122); and Vernon (river-mile 142) and Bellows Falls, VT (river-mile 174) are enumerated each year. In 2002 the number of shad passing Vernon Dam plummeted to a total of 356 fish from 1,744 the previous year. For the years 2002 through 2011 the annual number of shad passing the Vernon Dam ranged from 16 fish in 2009 to 653 in 2004. The 10-year average over this period of years was 227 fish/season. For the 15 years prior to 2002 (1987-2001), annual runs through Vernon ladder were estimated in the range of 1,370 (1988) to 37,197 (1991) with an average annual run of 10,069 fish. Table 5 presents annual passage counts for the Turners Falls Gatehouse and Vernon ladders as well as relative passage success. Significant events that did or may have affected fish passage are noted under the "Comments" column. Figure 1 illustrates trends in annual passage success based on the numbers of shad passed above Vernon Dam relative to the numbers passed through the Gatehouse ladder.

TABLE 5. Adult American shad passage through Turners Falls Gatehouse and Vernon Dam fish ladders and relative passage success, 1980-2013.

Year	Gatehouse ladder	Vernon ladder	Percent passage	Comments
1980	298			Turners Falls ladders begin operating.
1981	200	97	48.5	Vernon ladder begins operating.
1982	11	9	81.8	

TABLE 5. Continued.

Year	Gatehouse ladder	Vernon ladder	Percent passage	Comments
1983	12,705	2,597	20.4	Ladder modifications made to Turners Falls & Vernon facilities.
1984	4,333	335	7.7	Additional modifications made to Vernon ladder.
1985	3,855	833	21.6	
1986	17,858	982	5.5	NPDES permit authorizes changes to VY summer thermal limits.
1987	18,959	3,459	18.2	
1988	15,787	1,370	8.7	
1989	9,511	2,953	31.0	Additional modifications made to Vernon ladder.
1990	27,908	10,894	39.0	NPDES permit authorizes changes to VY summer thermal limits.
1991	54,656	37,197	68.1	
1992	60,089	31,155	51.8	
1993	10,221	3,652	35.7	
1994	3,729	2,681	71.9	
1995	18,369	15,771	85.9	
1996	16,192	18,844	116.4	
1997	9,216	7,384	80.1	
1998	10,527	7,289	69.2	
1999	6,751	5,097	75.5	
2000	2,590	1,548	59.8	
2001	1,540	1,744	113.2	
2002	2,870	356	12.4	
2003	?	268		
2004	2,192	653	29.8	
2005	1,581	167	10.6	
2006	1,810	133	7.3	NPDES permit authorizes changes to VY summer thermal limits.
2007	2,248	65	2.9	Fish counts at Turners Falls & Vernon ladders begin using Salmonsoft.
2008	4,000	271	6.8	
2009	3,813	16	0.4	
2010	16,422	290	1.8	Modifications are made Gatehouse ladder entrance.
2011	16,798	46	0.3	Structural problems with Vernon ladder are identified.
2012	26,727	10,386	38.9	Repairs are made to Vernon ladder.
2013	35,494	18,220	51.3	

Reasons or causes for the significant decrease in shad passed from TFP into LVP, measured both in terms of total fish numbers and percent passage success, after 2001are not fully known and continue to be of concern to the EAC. Possible causes include:

- Shad approaching the Vernon ladder entrance detect a temperature differential (i.e. higher water temperature in the ladder compared to cooler mainstem temperatures).
- Shad are bioenergetically stressed from the upriver migration and possibly river temperatures influenced by VY's thermal discharge.
- River temperatures influenced by VY's thermal discharge contribute to "premature" shad spawning in TFP and loss of migration drive to continue beyond Vernon Dam.
- Structural and/or operational issues exist with the ladder itself.
- Any combination of two or more of the above.

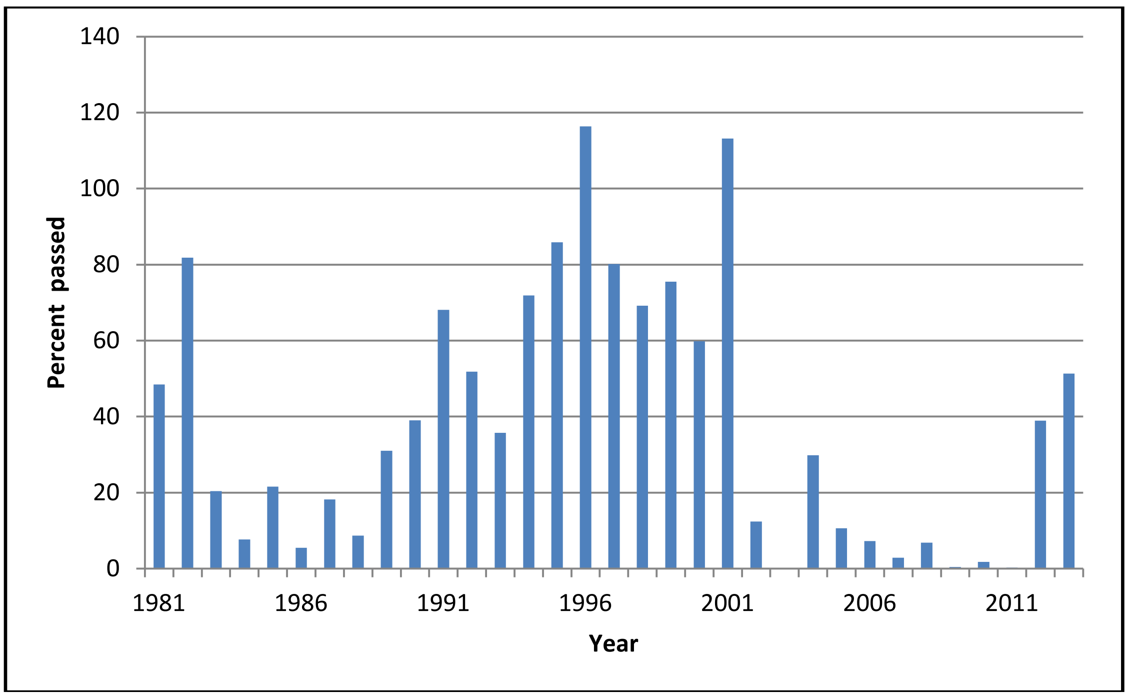

FIGURE 1. Numbers of American shad passed above Vernon Dam relative to Turners Falls Gatehouse expressed as percentages, 1981-2013.

During the 2011 and early spring 2012 fish passage season, structural issues at the Vernon ladder were discovered. These included damaged weirs in the Ice Harbor (lower) ladder section, inadequate or excessive flows over certain weirs, and problematic hydraulics within the ladder. Corrective action on the part of TransCanada (owner and operator of the Vernon project) was taken in advance of the 2012 season which clearly resulted in improved shad passage through the ladder and into LVP.

Even though improvements made to the Vernon ladder has greatly increased shad passage during the 2012 and 2013 seasons compared to the preceding 15 years (1997 – 2011), passage counts continue to be below the restoration goal and other factors having an influence on passage above Vernon dam remain understudied at this time. There is insufficient data on which to dismiss VY's thermal discharge as an effect on shad attraction to the ladder and successful passage into LVP.

Temperatures in the Vernon Tailwater and LVP could also be physiologically disadvantageous to adult shad. Glebe and Leggett's (1981) study of shad migration and bioenergetics demonstrated metabolic energy costs increase with increasing water temperature, stating overall adult mortality is "positively correlated to the thermal regime of the river during migration, being higher in years when the water temperature during migration is higher than average." Likewise, Castro-Santos and Letcher's (2010) dynamic stage model for Connecticut River shad suggests thermal alterations may be partly responsible for reduction in repeat spawners, with thermal environment being one characteristic that affected all three of their model performance variables.[2] Leggett et al. (2004) state the levels of mortality for shad migrating upstream of Holyoke Dam would be elevated at higher temperatures and/or flows due to energetic costs. From the time that adult shad enter the River and migrate upriver to Vernon Dam, they have swum a distance of 142 miles and have had to pass two dams (Holyoke and Turners Falls) and negotiate three fishways. The effects of swimming distance and migration delays are discussed in Castro-Santos and Letcher (2010). There are also temperature challenges: natural seasonal increasing water temperatures and heat from anthropogenic sources including thermal discharges and impoundments all which also tax fish energetically and physiologically. Sprankle (2013) states, "Timing, magnitude, duration of thermal exposure(s), and other related effects (e.g., energetic, physiology, movement, passage performance, rates of gonad development) of the VY thermal discharge in species such as American shad have yet to be scientifically examined in the context of current conditions for both Vermont Yankee and its most recent thermal increase, and the Vernon Dam since structural and operational improvements." <u>Therefore, until Entergy provides documentation via detailed studies that their thermal effluent is not adversely impacting adult shad, VY should operate in closed-cycle mode during the entire adult migration period (April 1 - July 15) encompassing both pre- and post-spawning runs</u>.

<u>Juvenile American Shad</u>

Successful shad reproduction has been documented upstream of Vernon Dam since 1990 (Table 6). However, long term monitoring suggests juvenile shad may be excluded from utilizing a portion of LVP as rearing habitat.

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[2] Repeat spawning occurs when virgin shad having spawned the first time (4 or 5 years of age) emigrate to the marine environment and return a subsequent year to spawn again (usually at 6 years of age) (Weiss-Glanz et al. 1986). Repeat spawning female shad are larger than virgin fish and, therefore, tend to be more fecund. Reduction in mean population fecundity has been attributed to lower annual recruitment to the shad population in the Connecticut River

Adult shad were first passed upstream of Vernon Dam in 1981, but it was not until 1990 that any juvenile shad were collected upstream of the dam (Table 6).[3] In 1990 and 1991, the only juveniles collected were those found impinged on VY's CWTS. From 1985 to 1995 VY's environmental consultant, Aquatec, Inc., studied the age and growth of juvenile shad both in LVP and the Vernon Tailwater. Table 6 also shows the numbers of shad captured by electrofishing upstream and downstream of the dam. Since 2000 beach seining has been the primary method for estimating juvenile shad abundance in Vernon Pool and is conducted at a number of index sites distributed between Brattleboro and Vernon Dam. A standing crop estimate or index is calculated from samples collected at each index site. While the number of juveniles collected at different locations with different gear types has varied substantially over the years (Table 6), it is clear that there is some level of production occurring. However, long-term collections raise several concerns with the EAC:

- Beach seining appears to show a shift in the regions where most of the juveniles are collected; from 2000 to 2006 most shad (≥78%) were seined from the Vernon region, whereas from 2007 to 2012 the general trend is a shift to upstream index regions. This more or less corresponds to when Entergy was granted the latest thermal variance (2006) allowing an additional1°F increase (raising the ΔT from 2°F to 3°F as measured at VY Station 3) when VY Station 7 temperatures are between 63°F and 78°F.
- In some years, the number of juvenile shad impinged on the CWTS is a substantial proportion of the standing crop index calculated from beach seining. For example, in 2005 the index was 2,729 juveniles and the number impinged was 576, which means potentially 21% of the estimated standing crop was killed on the CWTS. In 2010 impingement was 12% of the standing crop.
- Since 1991, juvenile shad have been sampled during the months of May, June, September and October by electrofishing upstream and downstream of Vernon Dam. Since 2006, these data (CPUE) have been used to perform trend analyses. The results of those analyses are provided in Table 7. Whereas the Kendall Tau values have been both positive in Vernon Tailwater for each of the last five years (2008-2012) of the seven years evaluated so far, LVP values have been consistently negative over the seven year period and statistically significant five out of those years.[4]

The EAC recognizes that these results could possibly be attributed to one or more factors, including the thermal regime in LVP and/or sampling method bias. Likewise, any thermal impacts in LVP may not be limited to acting directly on rearing juveniles, but also acting on them indirectly by decreasing adult spawning success and/or recruitment to the post-metamorphosed life stage. <u>The EAC recommends that rigorous directed studies like those done during project SAVE be undertaken, as none have occurred since the most recent permitted thermal limits went into effect</u>.

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[3] Since Normandeau Associates, Inc. initiated beach seining in 2000, no juvenile shad have been collected in LVP from beach sites south of the NH setback, although presumably suitable juvenile physical habitat exists in this portion of LVP.

[4] The juvenile shad abundance index employing beach seining was initiated in 2000, because electrofishing was judged to be an ineffective method for capturing young-of-year shad in Vernon Pool (NAI 2001).

The emigration of juvenile shad is dependent on declining water temperatures (and likely photoperiod), generally taking place from late September through November when water temperatures drop below 61°F (O'Leary and Kynard 1981). Water temperature threshold cues could be influenced by VY's heated discharge. For example, juveniles residing upstream of VY's discharge will experience "natural" decreasing water temperatures in the fall which in turn will initiate their downstream migration. Because outmigrating shad are surface oriented, they are prone to exposure to VY's thermal discharge. This potential exposure to warmer VY influenced water may cause shad to delay migration. Migration delays may have important negative repercussions on juvenile shad survival as late migrant fish face greater physiological challenges relative to "early" fish, both during freshwater residence and during seawater entry (Zydlewski et al. 2003).

TABLE 6. Numbers of juvenile shad collected upstream and downstream of Vernon Dam, 1981-2010. Under general electrofishing, numbers in bold type represent juveniles only; otherwise counts may include one to several adults which cannot be extracted from raw data in hand.

Year	Number of juvenile shad captured						Beach seining standing crop index	Percentage of total juvenile shad seine sample that were captured in Vernon index region[1]
	Impingement at VY intake (CWTS)	General electrofishing downstream of dam	General electrofishing upstream of dam	Electrofishing in UTP for age/growth study	Electrofishing in LVP for age/growth study	Beach seining upstream of LVP		
1981	0	a	a					
1982	1	0	**26**					
1983	0	160	14					
1984	0	**4**	3					
1985	0	**584**	0					
1986	0	156	0					
1987	0	63	0	721	0			
1988	0	110	0	1,165	0			
1989	0	162	0	948	0			
1990	9	72	0	680	0			
1991	94	171	**19**	585	0			
1992	26	37	**29**	940	51			
1993	1	84	**5**	1,576	15			
1994	6	44	**2**	996	0			
1995	210	60	**24**	489	27			

[1]Vernon index region approximately corresponds to Lower Vernon Pool; other three regions are located sequentially upriver: Cersosimo, Cersosimo Lake, and Brattleboro.
[a]No electrofishing conducted during the year.

TABLE 6. Continued.

Year	Number of juvenile shad captured						Beach seining standing crop index	Percentage of total juvenile shad seine sample that were captured in Vernon index region[1]
	Imping-ment at VY intake (CWTS)	General electro-fishing down-stream of dam	General electro-fishing up-stream of dam	Electro-fishing in UTP for age/ growth study	Electro-fishing in LVP for age/ growth study	Beach seining upstream of LVP		
1996	10	**33**	**3**					
1997	31	61	0					
1998	1	**4**	0					
1999	278	**1**	0					
2000	7	**12**	**1**			866	31,244	92
2001	25	**34**	0			62	2,433	82
2002	1	**21**	0			249	10,528	100
2003	13	**15**	0			18	723	89
2004	73	0	0			82	2,066	96
2005	577	**1**	0			120	2,729	73
2006	3	39	0			141	2,601	94
2007	51	**141**	**1**			60	1,049	10
2008	30	**48**	**6**			667	14,676	67
2009	23	115	0			398	8,153	47
2010	390	**32**	**2**			195	3,275	5
2011	60	4	0			82	1,812	54
2012	260	129	**14**			1,313	31,491	78

[1]Vernon index region approximately corresponds to Lower Vernon Pool; other three regions are located sequentially upriver: Cersosimo, Cersosimo Lake, and Brattleboro.

Temperature monitoring of the River from Wilder Dam (river-mile 217) to Turners Falls Dam conducted by the U. S. Fish & Wildlife Service (USFWS) during the fall seasons of 2009 and 2010 found that hourly temperature profiles for loggers deployed at five locations distributed between Wilder Dam downriver to 2.2 miles upstream of VY were very similar to one another and that the most downriver of the loggers agreed well with VY Station 7 hourly water temperature data (Sprankle 2013). However, water temperatures collected at a logger located in LVP at the eastern end of the dam (NH side) measured were higher and more variable than data collected at loggers upriver of VY (Sprankle 2013). It is likely that water temperatures are even warmer in Vernon forebay (same side of the River as the VY thermal discharge) than those on the NH side of the River. Loggers deployed in Vernon fish ladder and at VY Station 3 also had elevated temperature profiles.

TABLE 7. Trend analyses results for juvenile American shad sampled in the Vernon Tailwater and Lower Vernon Pool by electrofishing, 2006-2012. Trends are based on CPUE abundance.

	Lower Vernon Pool			Vernon Tailwater		
Year	Kendall tau	p-value	Trend[1]	Kendall-tau	p-value	Trend[1]
2006	-0.657	0.001	Neg.*	-0.167	0.368	Neg.
2007	-0.549	0.004	Neg.*	-0.029	0.869	Neg.
2008	-0.396	0.031	Neg.*	0.059	0.733	Pos.
2009	-0.422	0.015	Neg.*	0.146	0.382	Pos.
2010	-0.331	0.056	Neg.	0.147	0.364	Pos.
2011	-0.360	0.033	Neg.*	0.057	0.717	Pos.
2012	-0.244	0.173	Neg.	0.104	0.498	Pos.

[1]Increasing (positive) and decreasing (negative) trends are signified by Pos. or Neg., respectively. An asterisk indicates the trend is statistically significant at the p = 0.05 level.

Downstream fish passage facilities at Vernon Dam were designed and located to intercept surface oriented outmigrating juvenile shad, thereby providing an alternate route through the dam rather than passage through turbines with resulting mortality. However, juvenile shad may avoid VY heated surface water in Vernon Dam forebay and thereby be excluded/delayed from entering fishway entrances. Juvenile fish that are held back in the forebay or denied expeditious passage may experience potential physiological costs and/or increased exposure to predators.

Compounding this issue is that the juvenile shad outmigration season likely overlaps with both Summer (June 16 – October 14) and Winter (October 15 – May 15) thermal periods. Accordingly, it is possible that in years with below average temperatures, shad may migrate later than normal (i.e. after October 14), and thus would potentially have to navigate through water that is up to 13.4°F warmer than ambient at the point considered fully mixed (Station 3), and potentially warmer than that from the point of discharge down to Station 3. As a case in point, during the fall of 2012 impingement sampling (August 1 through October 31) a total of 260 juvenile shad were removed from VY's CWTS. Of this number 83% were collected between the dates of October 16 and November 13 (when Winter limits are in effect). Beyond the obvious impacts to migratory behavior/timing and physiology, this excessive temperature difference could possibly cause direct mortality via heat shock; Marcy et al. (1972) found juvenile shad exhibited heat shock when encountering water temperatures 15 - 17°F above ambient. It is clearly within the realm of possibility that juveniles located within the VY mixing zone and in particular from the point of discharge to Vernon Dam could be exposed to temperatures high enough to alter juvenile behavior, physiology and survival.

Shortnose Sturgeon

Federally endangered shortnose sturgeon (*Acipencer brevirostrum*) inhabit the River downstream of Turners Falls Dam. The upstream extent of this population is below Turners Falls Dam. Hydrothermal assessments conducted by Binkerd et al. (1978), Luxenberg (1985), and Swanson et al. (2013) modeled VY's thermal plume extending downriver at least to Turners Falls and as far as Holyoke. Dr. Boyd Kynard has undertaken a long-term study of the River's sturgeon population and study results are summarized in a recently published book (Kieffer and Kynard 2012). The authors reveal a failed upstream spawning migration of radio tagged male sturgeon in the spring of 2002 that was related to record high water temperatures for the period preceding that failed spawning migration. Dr. Kynard has relayed his concern that sturgeon may have insufficient energy for migration after wintering in warmer than usual water.[5] Pre-spawn adults experienced the highest temperatures and lowest river discharge during the foraging and winter periods preceding the failed spawning.

Potential effects of VY's thermal discharge on the Turners falls sturgeon population have only recently come to the EAC's attention and have not been investigated by Entergy. The EAC is concerned that VY's thermal release could be adversely impacting sturgeon under certain flow and temperature conditions. As mentioned previously hydrothermal modeling conducted by Swanson et al. (March 14, 2013) projected a summertime temperature increase attributed to VY's discharge as high as 2.2°F (average 1.1°F) at Turners Falls Dam. Under Winter thermal limits the increase above ambient at Station 3 could be as high as 13.4°F which in turn could result in temperatures at Turners Falls greater than that estimated by Swanson et al. (March 14, 2013). Given the species federal (and Massachusetts State) endangered status whether or not the VY discharge is affecting sturgeon within the possible range of its thermal effect cannot be dismissed. <u>Until Entergy provides documentation that its thermal effluent is not adversely affecting sturgeon, the plant should operate in closed-cycle mode</u>.

<u>Status and trends of diadromous fishes</u>.

The status and trends of diadromous fishes under active restoration management show near universal dramatic declines with identified threats including, warm water discharges and climate change (Limberg and Waldman 2009). American shad, blueback herring, and American eel are all considered to be at all-time low levels of abundance along the entire East Coast by the Atlantic States Marine Fisheries Commission.[6]

American eel is undergoing formal review for federal endangered species status, and American shad is designated as a species of greatest conservation need in the Wildlife Action Plans adopted by the states of Vermont, New Hampshire, Massachusetts and Connecticut. As previously mentioned, the River's shortnose sturgeon population is currently federally endangered.

Additionally, as mentioned above, scientific research has documented how temperature impacts the energetic, physiology, spawning potential, and behavior of migratory fishes. These temperature effects could well translate into reduced recruitment, outmigrant survival and/or adult returns which may hinder current and/or future species restoration and recovery efforts.

6. *Entrainment and impingement impacts to larval fishes.*

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[5] EAC personal communication with Dr. Kynard in March 2012.
[6] See website www.asmfc.org.

VY has cooling towers, but is only required to use them in order to meet the thermal limits specified in the NPDES permit. As part of the long-term biological monitoring that is required at the plant, weekly samples are collected to quantify impingement (CWTS, April 1 – June 15, August 1 – October 31) and entrainment (ichthyoplankton, weekly May – July 15). Under the existing NPDES permit there are no limits on impingement and entrainment rates for resident fishes, but there are limits set for shad and salmon smolts.

In 2005, Entergy undertook a more intensive impingement/entrainment sampling effort which differed from annual monitoring in that impingement samples were collected year-round (March 2005 – November 2006) and entrainment samples were collected from April through September (NAI 2011a). Results of that study showed that VY project impinged almost 30,000 fish in 2005 and nearly 10,000 in 2006. In both years, the spring months had the highest numbers of fish impinged, although in 2006 a large number were also impinged in October. Over 65% of the fish impinged were yellow perch, followed by bluegill, rock bass *Ambloplites rupestris* and black crappie *Pomoxis nigromaculatus*.

A total of 61.5 million ichthyoplankton were estimated to be entrained by the project during the April 4 to September 26, 2006 sampling period, with 58% of that total being post yolk-sac larvae (PYSL). Carp *Cyprinus carpio* and minnows were the most abundant PYSL, followed by centrarchids (bass, sunfish) and yellow perch. June was the month of highest entrainment of resident fishes. Of the yolk-sac larvae (YSL) entrained, most were yellow perch, walleye and white sucker. No life stages of migratory fishes were entrained during the sampling. Because this study was only conducted during one year, it is feasible that ichthyoplankton entrainment could be even higher during other years.

When comparing the ichthyoplankton entrained to the near field collections, it appears two of the three RIS (walleye and white sucker) are entrained disproportionate to their near field density (walleye: 25.2% of entrainment samples but only 6.6% of near field; white sucker: 18.7% of entrainment but only 0.7% of near field). These are the same two resident species that have shown declining trends in CPUE, both in LVP and Vernon Tailwater annually since 2008 (NAI 2009, 2010, 2011a, 2012, 2013). Both species spawn in early spring potentially exposing YSL and PYSL to VY's winter thermal discharge of up to 13.4°F warmer than ambient at Station 3 and may be even warmer in the mixing zone (i.e., the point of discharge down to Station 3).

The EAC is perplexed that only one shad larva has ever been documented in all the entrainment samples collected since 1981 (NAI 2011b). Annual beach seining sampling (2000 to present) shows that juveniles are rearing at sites in relatively close proximity to VY's intake (NAI 2011c), so it is unusual that younger life stages rarely become entrained. For example, 141 shad were beach seined in Vernon Pool in 2006 but none were entrained; in contrast, that same year a total of six tessellated darter *Etheostoma olmstedi* were seined from Vernon Pool, yet over a million larvae were entrained. Tessellated darter is one of several host fish species for the federally endangered dwarf wedgemussel *Alasmidonta heterodon*. The Connecticut River basin supports the largest remaining populations of dwarf wedgemussels in the United States (Wicklow 2006). Additionally, the basin contains the only populations in Vermont and New Hampshire. Although the mussel has not been collected from the River in the vicinity of VY, it has been documented in the Ashuelot River of New Hampshire (Wicklow 2006). The Ashuelot River flows into the River about two miles downstream of Vernon Dam.

The data collected indicate that VY impinges thousands of fish each year, and entrains tens of millions of larval fishes. If it were not for becoming entrained, these larval fishes would be available to the LVP trophic food web as well as upper TFP. Given that VY has had cooling towers since the 1970s, which is commonly accepted as the *best technology available* for reducing entrainment impacts, the EAC recommends that Entergy operate the plant in closed-cycle mode for the duration of time that larval fish inhabit LVP. The EAC's position is that this alternative would meet the statutory standard of "minimizing adverse environmental impact" pursuant to 316(b).

7. *Cumulative impacts*.

There are many factors that affect the successful production, outmigration, and return of anadromous fishes to a river system, including habitat quality, water quality, river flows, and how those flows are managed. On the River there are many river users, such as hydroelectric projects, irrigation withdrawals, nuclear and coal-fired plants, combined sewer overflows, and sewage treatment discharges. Each use individually, as well as cumulatively, impacts the health of the aquatic ecosystem. Uses that fall under federal, state or local regulatory jurisdiction are reviewed and conditioned to minimize its impact on the resource. Hydroelectric projects are regulated through the Federal Energy Regulatory Commission. All of the hydropower projects on the mainstem River from Wilder Dam downstream to Holyoke have been required to construct and operate upstream and downstream fishways and provide minimum flows below each project to protect water quality and aquatic habitat. These measures were based upon agency-defined time periods of biological importance (e.g., migration, upstream and downstream, for adults and juveniles; Table 4).

EAC members have also held a growing concern that the ambient thermal regime of the River may be different than what it was prior to 1978, when VY was authorized to discharge heated water to the River during the Winter period and subsequently permitted Summer thermal discharges. VY's long term (1974-2010) water temperature datasets for Stations 3 and 7 were analyzed by Massachusetts Department of Environmental Protection staff to ascertain whether temperature trends are discernible and if the trends are statistically significant. Being that Station 7 is located 3.5 miles upriver from VY's thermal discharge, it represents background (ambient) water temperature conditions in the River. A statistically significant ($p<0.05$) rise in monthly mean temperatures was observed in January, September and October (1974-2010 data). Temperature rises for these months over this time frame was 1.26°F in January; 2.88°F in September; and 2.63°F in October. A rising trend in water temperatures was also observed for April (2.38°F increase), but due to high variability in the datasets the rise in slopes were not statistically significant. Negative (falling) temperature trends occurred in the months of May, -0.32°F; June, -0.54°F; July, -1.44°F; and August, -0.29°F, but the slopes were not statistically significant. These results while not conclusive suggest the River has warmed at least in some months over a period of three plus decades.

The EAC also looked the extent that VY's discharge may have advanced the thermal regime of the River in the spring of the year. This analysis looked at datasets (1994 – 2010) for both Stations 3 and 7. Three different analyses were conducted:

- The first date on which a temperature of 65.3°F (peak "run" temperature for American shad (Stier and Crance 1985) or greater occurred at 2:00 pm;
- The difference in number of days between the date that Station 3 first reached an average temperature of 68°F (temperature endpoint for upstream migration (Stier and Crance 1985)) during the daylight of 6:00 am to 7:00 pm versus the date that Station 7 first reached 68°F (averaged over same daylight hours);
- The number of days between the date that Station 3 first reached 68°F at 2:00 pm versus the date when Station 7 hit that temperature at 2:00 pm.

Results indicate in the first scenario the thermal regime was advanced a mean of 10.5 days at Station 3 compared to Station 7; a mean of 10 days under the second scenario; and a mean of 8.6 days under the third scenario. In all cases the data illustrate the effect VY's thermal discharge is having on the thermal regime of the River which in turn has implications on adult and juvenile shad.

Addendum

On August 27, 2013 Entergy announced its plan to close and decommission VY with power production to cease by the end of 2014. Vermont Public Service Board was given a notice of intention to close the facility on the same date and the same notice was submitted to the NRC on September 23. Based on preliminary information Entergy expects that the facility will continue to have a need for service water drawn from the River, albeit only about 6% of its current usage, for some undetermined period of years until the plant is fully decommissioned.

The EAC's recommendation that VY operate in closed-cycle mode was developed prior to Entergy's announcement that it would close the plant in late 2014. Nonetheless, the EAC stands by this recommendation, and further that closed-cycle operation should be implemented as soon as possible including 2014.

Additionally, the EAC recommends Entergy continue environmental monitoring of the River's biotic community as it has been required by the VANR until the plant ceases power generation and continue to do so for a minimum of five years afterwards. This will allow assessment of any changes to the biological community.

References

Binkerd, R. C., W. D. Countryman, R. M. McNeer, and D. J. Marx. 1978. 316 demonstration engineering, hydrological & biological information and environment impact assessment. Report of Aquatec, Inc. to Vermont Yankee Nuclear Power Corporation, Vernon, Vermont.

Castro-Santos, T., and B. H. Letcher. 2010. Modeling migratory energetic of Connecticut River American shad (*Alosa sapidissima*): implications for the conservation of an iteroparous anadromous fish. Canadian Journal of Fisheries and Aquatic Sciences 67:806-830.

Chittenden, M. E., Jr. 1972. Responses of young American shad, *Alosa sapidissima*, to low temperatures. Transactions of the American Fisheries Society 101:680-685.

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

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. Pages 73-113 *in* B. Kynard, P. Bronzi and H. Rosenthal. Life history and behavior of Connecticut River shortnose sturgeon and other sturgeons. World Sturgeon Conservation Society, Special Publication No. 4, Norderstedt, Germany.

Leggett, W. C., T. F. Savoy, and C. A. Tomichek. 2004. The impacts of enhancement iniatives on the structure and dynamics of the Connecticut River population of American shad. Pages 391-405 *in* P. M. Jacobson, D. A. Dixon, W. C. Leggett, B. C. Marcy, Jr., and R. R. Massengill, editors. The Connecticut Ecological Study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. American Fisheries Society, Monograph 9, Bethesda, Maryland.

Leonard, J. B. K., J. F. Norieka, B. Kynard, and S. D. McCormick. 1999. Metabolic rates in an anadromous clupeid, the American shad (*Alosa sapidissima*). Journal of Comparative Physiology B 169:287-295.

Leonard, J. B. K., and S. D. McCormick. 1999. Effects of migration distance on whole-body and tissue-specific energy use in American shad (*Alosa sapidissima*). Canadian Journal of Fisheries and Aquatic Sciences 56:1159-1171.

Limburg, K. E., and J. R. Waldman. 2009. Dramatic declines in North Atlantic diadromous fishes. BioScience 59:955-965.

Luxenberg, R. R. 1985. Connecticut River temperature increase. Report (Analytical Bulletin 13) of Aquatec, Inc. to Vermont Yankee Nuclear Power Corporation, Vernon, Vermont.

Marcy, B. C., Jr. 2004. Early life history studies of American shad in the lower Connecticut River and the effect of the Connecticut Yankee plant. Pages 155-180 *in* P. M. Jacobson et al., editors. The Connecticut River ecological study (1965-1973) revisited: ecology of the lower Connecticut River 1973-2003. American Fisheries Society Monograph 9, Bethesda, Maryland.

Marcy, B. C., Jr., P. M. Jacobson, and R. L. Nankee. 1972. Observations on the reactions of young American shad to a heated effluent. Transactions of the American Fisheries Society 191:740-743.

Moss, S. A. 1970. The responses of young American shad to rapid temperature changes. Transactions of the American Fisheries Society 99:381-384.

NAI (Normandeau Associates, Inc.). 2001. Abundance of juvenile shad in the Vernon pool during 2000. Report of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon, Vermont.

NAI. 2008. Predicting the downstream dispersion of Vermont Yankee's thermal plume in the Connecticut River from Vernon dam to Holyoke dam. Report of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon, Vermont.

NAI. 2009. Ecological studies of the Connecticut River Vernon, Vermont Report 38 January – December 2008. Report of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon Vermont.

NAI. 2010. Ecological studies of the Connecticut River Vernon, Vermont Report 39 January – December 2009. Report of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon Vermont.

NAI. 2011a. Impingement, entrainment and nearfield ichthyoloplankton studies performed at Vermont Yankee Nuclear Power Plant from 29 March 2005 through 28 November 2006. Analytical Report 91 of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon, Vermont.

NAI. 2011b. Ecological studies of the Connecticut River Vernon, Vermont Report 40 January – December 2010. Report of NAI to Entergy Nuclear Vermont Yankee, LLC, Vernon Vermont.

NAI. 2011c. Abundance of juvenile American shad in the Vernon pool during 2010. Report of NAI to Entergy Nuclear Vermont Yankee, Vernon, Vermont.

O'Leary, J. A., and B. Kynard. 1981. Behavior, length, and sex ratio of seward-migrating juvenile American shad and blueback herring in the Connecticut River. Transactions of the American Fisheries Society 115:529-536.

Sprankle, K. 2013. Water temperature monitoring and diadromous fishes temperature concerns in the Connecticut River upstream and downstream of Vernon dam, Vernon, Vermont fall 2009 through fall 2012. U. S. Fish and Wildlife Service, Sunderland, Massachusetts.

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 82(10.88), Washington, D.C.

Swanson, J. C. 2013. Study plan: hydrothermal modeling of the Connecticut River from the Vernon dam to the Holyoke dam to evaluate thermal effects on American shad migration and residency. RPS ASA Project Number 2011-263, South Kingstown, Rhode Island.

Swanson, C., D. Crowley, D. Mendelsohn, and L. Decker. 2013. Final report modeling the downstream thermal effect in the Turners Falls pool of the Connecticut River from Vermont Yankee discharge. Report of RPS ASA to Goodwin Procter, Boston.

Weiss-Glanz, L. S., J. G. Stanley, and J. R. Moring. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (North America) American shad. U. S. Fish and Wildlife Service Biological Report 82(11.59), Washington, D. C.

Wicklow, B. J. 2006. Species profile: dwarf wedgemussel Alasmidonta heterodon. Pages A-26 – A-36 *in* J. Kanter et al. New Hampshire wildlife action plan. New Hampshire Fish and Game Department, Concord.

Zydlewski, J., and S. D. McCormick. 1997. The loss of hyperosmoregulatory ability in migrating juvenile American shad, *Alosa sapidissima*. Canadian Journal of Fisheries and Aquatic Sciences 54:2377-2387.

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