Panel Questions for NMPS Project Study Dispute Technical Conference
Northfield Mountain Visitor Center
April 8, 2014

1. What was FERC's basis for rejecting the larval entrainment study request? How will FERC evaluate project impacts on American shad without this study?

FERC is the appropriate responder to this question

2. How would the entrainment data be used, i.e., how would the study results inform the development of license requirements (section 5.9(b)(5))? Please give specific examples of potential recommendations or thresholds if possible. For example, what proportion of the total egg/larvae production of the population can be entrained at NMPS without negatively impacting shad (i.e., a measurable decrease of > 10 percent)?

The FWS has requested a modification of the LMS study (1993) that would allow for assessing diurnal differences in larval densities to determine if operational changes could potentially be used to minimize entrainment. In this way, study results would directly inform the development of license requirements and/or mandatory conditions (e.g., Section 18 Fishway Prescription Authority). The LMS study only sampled during the day on two occasions and on the earlier sample date they did find significantly lower larval densities in the day versus at night. The later daytime sample did not find a statistical difference, but that could have been due to a power issue (the overall numbers entrained were relatively low both at day and night). By taking paired day/night samples throughout the course of the study we will gain insight into whether, and for how long, diurnal differences in larval density occur. That information could then be used to assess whether operational changes could be used to minimize entrainment (e.g., if larval densities are lower during the day then pumping during low-market times of the day rather than at night during the early life stage period would be a potential entrainment minimization measure).

The question of what proportion of total egg/larvae can be entrained without negatively impacting shad must be more fully considered and better defined. First, juvenile shad life stages are an important part of the ecological food web in the river, estuary and marine environment. Early life stages produced by shad in the upper basin could serve a role in population resilience, in the event of different/unfavorable spawning conditions in the lower river. The impact of entrained larvae may be considered based on larval to adult

return rates documented in the Susquehanna River from 1986-2007, which reports a mean stocked hatchery larvae to adult return rate of 404:1 (Hendricks & Tryninewski 2012). This information would suggest the potential loss of over 25,000 adult shad based upon the more than 10 million post yolk sac larvae estimated entrained in 1992. The Connecticut River could have an even lower larvae to adult return ratio because on the Susquehanna River larvae are stocked above York Haven and so must negotiate four mainstem dams compared to the two that larvae rearing in Turner Falls headpond have to pass on their way to sea.

*East Coast American shad stocks are considered at "all-time low levels and did not appear to be recovering at acceptable levels" (ASMFC 2007). The current ASMFC Shad Plan (2010) states the objective "**maximize the number of juvenile recruits emigrating from freshwater stock complexes**: and restore and maintain spawning stock biomass and age structure **to achieve maximum juvenile recruitment.**" Similarly, the CRASC American Shad Plan (1992) states the objective "**maximize outmigrant survival for juvenile and spent shad**". The Connecticut River assessment measures show levels below restoration targets (CRASC), based on fish count/passage rates.*

A through- project survival goal of 95% has been used at a number of hydropower projects in New England.

3. What proportion of American shad spawning habitat is upstream and downstream of the Northfield Mountain Pumped Storage Project intake, and where is the center of spawning activity relative to the intake? If not known specifically, is there anecdotal or historical information available?

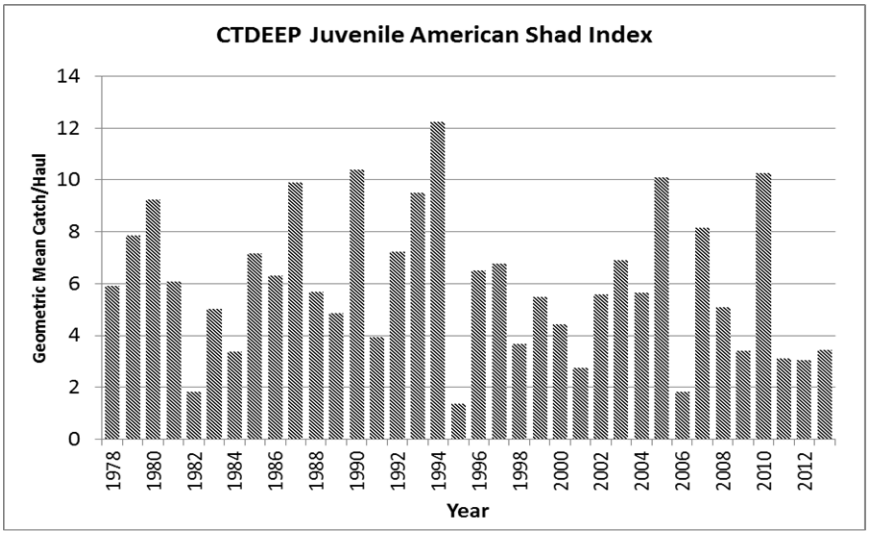
The proportion of shad spawning habitat upstream and downstream of NMPS intake is not known. In 2015 (the same year that the NMPS early life stage entrainment study would occur), FL will be undertaking Study 3.3.6 which will attempt to determine spawning locations upstream and downstream of the Turners Falls Dam as well as quantify spawning activity with surveys for eggs. The FWS is not aware of any anecdotal information on spawning locations within the Turners Falls pool.

While we do not know if shad spawn downstream of the NMPS intake, there are data supporting spawning areas upstream of the intake. A study conducted by O'Donnell and Letcher (2008) collected shad larvae from a site at river kilometer 220. Given the poor

swimming ability of shad larvae, these fish are presumed to have spawned at, or upstream of, RKm220 (NMPS is located at RKm 196).

4. Do river-wide or location-specific estimates of larval or juvenile American shad production exist for American shad in the Connecticut River? If yes, what proportion of each life stage is entrained?

CTDEEP has a long-term juvenile American shad seine index (1978-2013) that occurs below Holyoke Dam annually from July through October at seven fixed locations.



Actual data appended – end of these notes -

*The 2012 ASMFC – CTDEEP Shad Sustainability Plan (required by Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring; ASMFC 2010) was approved by ASMFC – and includes use of this juvenile abundance index (JAI) as one of three metrics to determine management action on whether fisheries can occur. I**f the geometric mean falls below 4.0 for 3 consecutive years a Plan threshold is reached**. This situation was observed **in the past 3 years** – creating a "guarded state" in the Plan, as the other two metrics remain above their threshold values.*

Monitoring of juvenile shad has also occurred as part of Vermont Yankee Nuclear Power Station's (VY) long term ecological and directed studies required by the State of Vermont through its National Pollution Discharge Elimination System (NPDES) permit. Since 2000, beach seining surveys have been conducted to develop an abundance index of

juvenile shad upstream of Vernon Dam. The seining standing crop estimates have ranged from between 723 (2003) to 31,491 (2012). In addition, monitoring of both fish impingement and ichthyoplankton entrainment at VY's cooling water intake structure has occurred annually. In some years the number of juvenile shad impinged by VY 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 lost at the VY intake. In 2010, impingement was 12% of the standing crop. Conversely, long-term ichthyoplankton sampling near VY's CWIS indicates very low entrainment of shad early life stages. For example, for the period 2000 to 2012, Clupeid (which would only be American shad upstream of the Vernon Dam)ichthyoplankton density ranged from 0.0/100m3 to 1.13/100m3, with no early lifestage detected in nine of those years, two years having no data available, and a single year (2000) having an estimated entrainment level of1.13/100m3. The reasons for the low level of ichthyoplankton entrainment at VY are unclear, but could include overall lower densities of ichthyoplankton upstream of Vernon Dam, and the fact that VY at full, "open cycle" plant cooling withdraws a maximum of 800 CFS from the Connecticut River (which represents a much lower percentage of mean monthly streamflow during May, June and July relative to NMPS project's withdrawal rate). Further, as water temperatures increase in the spring and more restrictive thermal discharge requirement activate, this level of CWIS intake becomes reduced as cooling towers (hybrid/mix to closed cycle cooling) come into increasing use (May – July). VY will cease operations in Dec 2014.

5. Do the parties agree that all eggs and larvae entrained at Northfield are considered lost to the population?

FirstLight has stated that all fish entrained at NMPS are lost to the CT River system. The FWS believes this is a reasonable assumption, given the pressure changes and sheer stress that entrained fish are subjected to during both pumping and generating, as well as the repeated entrainment risk that occurs throughout the rearing period.

6. How far upstream, downstream, and offshore does the intake affect flow in the lower impoundment when pumping during the period when American shad eggs and larvae are present? The LMS (1993) study assumed that all eggs in larvae in the sample area were entrained. Is this an accurate assumption?

FirstLight is the appropriate entity to respond to this question. The FWS does note that one of the studies FL will conduct is geared towards determining the geospatial extent of NMPS project's influence during pumping (Study 3.3.9). Further, strictly looking at the hydrologic data set, it can be seen that typically in the months of June and July, average flow in the Connecticut River is less than the pumping capacity of NMPS (NMPS pumps at 15,200 cfs; based on the Montague Gage – which includes the Deerfield River drainage - for the period 1992 to 2012 the average flow for May is 21,000, for June is 12,900, and for July is 8,970 cfs). While the sample stations in the LMS study encompassed areas both upstream and downstream of the intake, they still were in relatively close proximity and well within the 10 km study area proposed in Study 3.3.9. Based on this information, the FWS believes that the LMS assumption that all eggs and larvae in the sample area were entrained was reasonable.

7. Is there agreement that the LMS (1993) entrainment study accurately measured Project impacts to shad eggs, yolk-sac larvae and post yolk-sac larvae?

The FWS believes that the methodology (study design and analysis) used in the 1992 study was acceptable and does not dispute the calculated entrainment of early life stages of shad for that study year. However, as we have stated previously, that study does not provide sufficient information to either assess entrainment impacts under present-day operation/river conditions or to evaluate whether operational changes could be used to minimize entrainment. The only way to obtain that information is to conduct a new study designed to calculate entrainment during day and night (or at even finer scales).

8. Approximately how many adult female shad are required to produce the number of eggs, yolk-sac larvae and post yolk-sac larvae estimated to have been entrained in 1992 (see Table 7a, 7b and 7c of LMS (1993)).

Data that are critical to begin answering this question include (some of which are known and some that aren't known):

1) The sex ratio of adult shad passed at Turners Falls

2) The reproductive state of the females passed (% unspawned ova) above the Turners Falls Dam? LMS (1993) assumed females maintained an initial fecundity rate, regardless of shad's known batch spawning behavior, the distance travelled, and number of barriers passed (i.e., some percentage of the females entering the Turners Falls headpond may have already released some of their eggs, which would result in reduced fecundity for the purposes of calculation requested by the

panel). In addition, the % ova available/spawned likely changes as the run progresses, which also would affect the requested calculation.
3) For those females that spawn, where did they spawn? When did they spawn?
4) How were environmental (temps/flows) and/or operational conditions of power plants (i.e., VY, Vernon, NMPS, TF) influencing/interacting in favorable to unfavorable ways (with respect to spawning success, fertilization rate, egg/larvae mortality, etc.) over the course of the passage season?

There are no current published stock recruitment relationships that are viewed as scientifically acceptable for the Connecticut River and not for a specific river reach. The most recent examination of this question would be by CTDEEP for their ASMFC Shad Sustainability Plan (2012) that showed – "Using the data from the juvenile seine survey and adult passage at the lift for years 1978-2011, Beverton-Holt, Ricker and Shepard model were run to see if some sort of relationship exists between rate of recruitment and stock size. None of these stock recruitment models provided a good fit."

9. Appendix A of the LMS (1993) study describes the analysis methods that would be used to estimate short-term and long-term impacts to shad from Project operation. Was this analysis completed? What were the results? And if not completed, would this type of study provide the data necessary to determine Project effects to shad?

In response to this question, FirstLight submitted a draft report titled "Impact of the Northfield Mountain Pumped-Storage Facility on Atlantic Salmon (Salmo salar) and American Shad (Alosa sapidissima) (LMS 1993b). That report synthesized data from previous studies to estimate the impact of NMPS on the Connecticut River American shad population by relating the estimated number of individuals entrained (eggs, larvae and juveniles) to the theoretical population of juvenile shad produced in and upriver of the Turners Falls Dam.

Of the four different methods that were used to calculate impact, the one that addressed early life stage entrainment (Method 3), resulted in the highest impact (0.124). Thus, LMS (1993) estimated that 12.4% of the juvenile shad produced in and upstream of Turners Falls headpond were lost due to NMPS operation.

While the LMS (1993b) study provided insight into the impact of NMPS operations on juvenile American shad upstream of Turners Falls Dam for the study year 1992, it did not

attempt to translate those lost juveniles to future adult returns. As we've stated previously, there are at least two ways to estimate the impact to the shad population: using either the life-stage specific mortality rates developed by Savoy & Crecco (1988) or the larvae:adult ratio reported in Hendricks and Trynenewski (2012). The former represents river-specific data and the latter represents more recent and longer-term data. For example, using the Hendricks and Trynenewski (2012) ratio of 404 larvae to one adult shad, the 10,525,600 post yolk-sac larvae (PYSL) estimated to have been entrained at NMPS in '92 would have equated to 26,053 adult returns. In 1992, over 700,000 shad passed Holyoke Dam and 60,000 adults passed into the Turners Falls headpond. The adult equivalents lost to NMPS would then represent 3.7% of the shad population upstream of the Holyoke Dam but 43% of the shad population upstream of the TF Dam. If we were to use the 1996 return data (when most 1992 year class shad would be expected to return to the CT River to spawn) then those adult equivalents would represent 9.4% of shad passed upstream of Holyoke and 160% of the shad passed upstream of gatehouse.

Management plans (CRASC 1992 and ASMFC 2010) for American shad identify objectives including maximizing outmigrant survival for juvenile shad. One way to meet that objective is to minimize early life stage entrainment at NMPS Project (where entrainment mortality is assumed to be 100%). In addition, the Management Plan for American Shad in the Connecticut River (CRASC 1992) has a stated goal of 1.5 to 2 million adults to the river mouth, with 40-60% passage at each passage facility. This results in a target range of between 240,000 and 720,000 adults (using 40% and 60% rates) passed upstream of the Turners Falls Dam. Adult passage counts upstream of TF Dam for the period of available passage has averaged 12,699 adults (1980-2013), with the record high of 60,089 adults passed in 1992. The average adult number passed (12,699) is approximately 5% of the target population at its lowest level (1.5M at mouth then 40% passage at Holyoke and TF Dam). Holyoke Dam did in fact exceed its"lower" management target (based on same minimum values) in 1992 – passing an estimated 720,000 adults compared to the lower derived target value of 600,000 adults. Entrainment at NMPS and the resultant loss of recruitment could be hindering attainment of that management goal (even if the lower river population goal is being met).

The reason for requesting the study is that FWS does not know whether the 1992 data are representative of the entrainment that is occurring under present-day river conditions:

- *Vernon increased its hydraulic capacity,*

- *VY will cease discharging heated effluent this year*
- *NMPS has changed its pumping operation*
    - *The 1993a LMS study states that NMPS pumps at 14,400 cfs, while FL's PAD lists the pumping capacity of NMPS as 15,200 (an increase of 800 cfs)*
    - *With deregulation, the pumping schedule at NMPS has changed. Data provided by FL indicates that, while overall pumping may have declined between 1991 to 1993 and 2011 to 2013 for the months of May and June, the hours pumping occurs seems to have shifted (from 1991 to 1993 pumping began at 11pm or later, whereas from 2011 to 2013 pumping began as early as 9pm).*

In addition, the 1992 are not sufficient to identify whether there are certain operational periods (e.g., day pumping versus night pumping) that may minimize entrainment of early life stages of shad.

The FWS needs this information for use in developing fishway prescriptions pursuant to our mandatory conditioning authority under Section 18 of the Federal Power Act.

10. Is it possible to sample near the intake or the outflow in the upper reservoir safely while the project is pumping?

FirstLight is the appropriate responder to this question.

11. Could pump samples be safely collected from the intake tunnel service port, which was mentioned by LMS (1993), during sampling?

FirstLight is the appropriate responder to this question.

12. FERC staff recommended that if "first year studies indicated high rates of juvenile shad entrainment, and/or low abundance of juveniles in relation to the adult return rate that year", then further investigation of earlier life stages of shad should be considered. In your opinion, what rate of entrainment or juvenile production would have to be observed to study entrainment of earlier life stages?

FERC is the appropriate responder to this question.

The FWS position is that, regardless of juvenile entrainment rate or production, an ichthyoplankton entrainment study still needs to be conducted because:

- *Research has shown that recruitment is set prior to the juvenile phase*
- *Mortality during the larval and juvenile stages is considered depensatory*
- *The LMS 1993b study shows that considering ichthyoplankton entrainment substantially increases the estimated impact of NMPS project on juvenile shad.*
- *The FWS believes there is a significant benefit to conducting the ichthyoplankton survey in the same year as many other associated studies are being conducted (shad spawning, adult shad telemetry, adult and juvenile shad entrainment). The results of each study will aid in interpreting the results of related studies.*
- *One problem with using juvenile entrainment rate or abundance data to determine the need for an early life stage assessment is that the results could be argued both ways. For example, if juvenile abundance (presumably based on hydroacoustic data) is low, that either could indicate that production was low OR just that few juveniles were attracted to the NMPS intake. It really does not tell us anything about ichthyoplankton entrainment and the resultant impact to recruitment, year class strength, or anticipated adult returns.*

13. The PAD stated that the Crecco and Savoy (1984) had been successful at predicting the abundance of adult shad based on juvenile indices, but the model did not predict the observed decline in the 1990s. Has the model been updated, and if so, does it capture the 1990s decline and recent patterns? What percentage of the variance does the model explain?

The model has not been updated. State of Connecticut biologists have stated that the relationship that once was shown to exist is no longer detectable.

A recent published paper on this topic is Crecco, Savoy and Marcy (2004) – American shad early life history and recruitment in the Connecticut River: A 40 Year Summary, which in the end states: "Year class strength of Connecticut River American shad appears to be established by the end of the larval period by a complex interrelationship between biotic and abiotic factors mediated by annual changes in egg production…Dominant year- classes of shad are most likely to occur when lower than normal June flows are coupled with moderate spawning stocks. The significance of determination of year-class strength during the early larval period is that all subsequent

losses during the larval and juvenile stage are DEPENSATORY[emphasis added] to subsequent adult recruits returning to natal rivers to spawn." As stated previously, normal than lower June flows in TF pool would allow NMPS to pump at levels that exceed total river discharge. Depensatory losses during the larval and juvenile stage would be additive mortality and represent sources that the FWS seeks to minimize in furtherance of published fishery management plans and overall river restoration goals.

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CTDEP	American Shad	
Year	ASD arith_Mn	ASD Gm_Cnt
1978	18.59	5.89
1979	12.81	7.84
1980	21.19	9.21
1981	12.57	6.05
1982	4.77	1.81
1983	16.57	4.99
1984	11.2	3.37
1985	15.88	7.14
1986	17.01	6.29
1987	44.73	9.89
1988	23.6	5.68
1989	61.44	4.85
1990	42.61	10.39
1991	51.24	3.92
1992	97.42	7.21
1993	79.56	9.49
1994	105.8	12.22
1995	29.42	1.34
1996	38.85	6.5
1997	59.16	6.75
1998	38.21	3.65
1999	61.45	5.47

2000	27.68	4.42
2001	53.5	2.73
2002	100.3	5.55
2003	36.86	6.88
2004	22.55	5.62
2005	50.74	10.08
2006	15.8	1.82
2007	54.97	8.15
2008	41.17	5.06
2009	18.45	3.4
2010		10.23
2011		3.08
2012		3.03
2013		3.41

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