STATE OF VERMONT
PUBLIC SERVICE BOARD

Amended Petition of Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. for amendment of their Certificate of Public Good and other approvals required under 30 V.S.A. § 231(a) for authority to continue after March 21, 2012, operation of the Vermont Yankee Nuclear Power Station, including the storage of spent nuclear fuel	)))))))	Docket No. 7862

DIRECT TESTIMONY OF JOHN SAMUELIAN
ON BEHALF OF THE
VERMONT DEPARTMENT OF PUBLIC SERVICE

October 22, 2012

Summary: Dr. Samuelian discusses the adverse impacts that heated effluent can have on species in rivers, and discusses questions concerning whether the heated effluent discharged from the Vermont Yankee Nuclear Power Station is causing such adverse impacts on species in the Connecticut River.

Dr. Samuelian sponsors the following exhibits:

Exhibit PSD-JS-01	Curriculum Vitae
Exhibit PSD-JS-02	Letter from Ken Sprankle, United States Fish and Wildlife Service, to Commissioner Deborah Markowitz, Agency of Natural Resources. March 16, 2012.
Exhibit PSD-JS-03	Castro-Santos, T. and B. Letcher. 2010. Modeling migratory energetics 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.
Exhibit PSD-JS-04	Maltais, E., G. Daigle, G. Colbeck, and J.J. Dodson. 2010. Spawning dynamics of American shad (*Alosa sapidissima*) in the St. Lawrence River, Canada–USA. *Ecology of Freshwater Fishes*. 19: 586-594.
Exhibit PSD-JS-05	Midwest Biodiversity Institute. May 25, 2012. Development of a Database for Upper Thermal Tolerances for New England Freshwater Fish Species.
Exhibit PSD-JS-06	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*). J. *Comp. Physiol. B.* 169: 287-295.

Exhibit PSD-JS-07	Marschall, E.A., M.E. Mather, D.L. Parrish, G.W. Allison, and J.R. McMenemy. 2011. Migration delays caused by anthropogenic barriers: modeling dams, temperature, and success of migrating salmon smolts. *Ecological Applications.* 21(8): 3014-3031.
Exhibit PSD-JS-08	Crecco, V., J. Benway, and T. Savoy. 2010. Report on the Future Sustainability of Connecticut River Shad Under the Current In-river Commercial and Recreational Fisheries. Report to Atlantic States Marine Fisheries Commission American Shad Technical Committee.

Q1. Please state your name, business address, and occupation.

A1. My name is John Samuelian. I am a Senior Managing Scientist at Integral Consulting, Inc. My business address is 45 Exchange Street, Suite 200, Portland, Maine.

Q2. Please state your educational and professional background.

A2. I have a B.S. in Biology from Union College, an M.S. in Ecology/Environmental Toxicology from the University of Tennessee, and a Ph.D. in Environmental Health Science from New York University. I have been employed as a Senior Managing Scientist at Integral Corporation since 2010. In this capacity, I have prepared ecological risk assessments for a number of state and federal Superfund projects, many of which included the assessment of benthic and fish communities. My roles have included oversight of the fisheries field collections, data fisheries data evaluation, and preparation of the 316(b) Demonstration. A copy of my curriculum vitae is attached as Exhibit PSD-JS-01.

Q3. Have you previously testified before the Vermont Board of Public Service?

A3. No.

Q4. On whose behalf are you presenting testimony?

A4. I am testifying on behalf of the Vermont Department of Public Service.

Q5. What is the purpose of your testimony?

A5. To discuss the adverse impact that heated effluent can have on species in rivers, and discuss questions concerning whether the heated effluent discharged from the Vermont Yankee Nuclear Power Plant (the "VY Station") is causing such adverse impacts on species in the Connecticut River.

Q6. What is the basis of your testimony?

A6. I have reviewed, among other things, (1) a March 16, 2012 letter from U.S. Fish and Wildlife Service ("USFWS"), attached as Exhibit PSD-JS-02; (2) a recent article by Theodore Castro-Santos and Benjamin H. Letcher, attached as Exhibit PSD-JS-03; (3) a recent article by E. Maltais, G. Daigle, G. Colbeck, and J. J. Dodson, Exhibit PSD-JS-04; and (4) a 2012 report by the Midwest Biodiversity Institute ("MBI"), attached as Exhibit PSD-JS-05.

Q7. Can you please summarize the USFWS letter?

A7. Yes. USFWS submitted the letter, attached as Exhibit PSD-JS-02, to Ms. Deborah Markowitz, Secretary of the Vermont Agency of Natural Resources ("ANR"), for consideration in ANR's ongoing review of the application submitted by the owner and operator of the VY Station, Entergy Nuclear Vermont Yankee, LLC and Entergy Nuclear Operations, Inc. (collectively "Entergy") to renew its permit to discharge heated water into the Connecticut River. (The VY Station's existing permit was issued by ANR under the federal Clean Water Act in 2006.) In the letter, USFWS provided a brief summary of

the ongoing restoration efforts that USFWS and its partners have undertaken for Atlantic salmon, American shad, and blueback herring in the Connecticut River. USFWS expressed concerns about the impact of the VY Station's discharge of heated water on those species, as well as the shortnose sturgeon, in the Connecticut River. Among other things, USFWS provided a summary of (1) a Connecticut River-wide thermal study; (2) concerns about the migration and movement of American shad near the VY Station; and (3) concerns about potential impacts of the VY Station on Atlantic salmon.

Q8. Why would discharge of heated water into the Connecticut River be cause for concern?

A8. River water temperature is a physical variable that can influence fish behavior, physiology, cues for migration and movement, feeding, growth, maturation, spawning, egg and larval development, disease resistance, tolerance to "physic-chemical" conditions (e.g., dissolved oxygen), and survival. To the extent that discharge of heated effluent into the Connecticut River substantially affects river water temperature, therefore, it may result in adverse impacts on fish species. This is well documented in scientific literature. For example, Leonard et al. (1999), attached as Exhibit PSD-JS-06, shows that temperature affects the metabolic rate of American shad and explains why that is important to consider in the context of migratory species management.

Q9. What does the USFWS river-wide thermal study show?

A9. USFWS collected temperature data from 2009 through 2011 from the Moore Dam tailrace (Littleton, NH) to the river mouth (Old Lyme, CT), including the area near the

VY Station. My colleague, Dr. Marcia Greenblatt, will be testifying about this and other data which suggest that thermal discharge from the VY Station is contributing to increased water temperature in the Connecticut River.

A key point made by USFWS in its letter concerns the current permitted timing of heated effluent discharges from the VY Station and the period(s) when migratory fish (like American shad) will be in the area. For the period October 15 through May 15 (the "Winter Period"), the VY Station is permitted to increase the receiving water temperature up to 13.4°F above the ambient upstream water temperature. For the period May 16 through October 14, the VY Station is permitted to increase the river water temperature by between 2°F and 5°F, depending upon the ambient upstream water temperature. USFWS suggested that the VY Station's thermal discharge may require more stringent regulation because the period in which the most "liberal" temperature limits are imposed upon the VY Station (the Winter Period) overlaps with "fish passage windows" (i.e., the time period during which state and federal agencies have determined that fish are migrating) for Vernon Dam, which is approximately 0.5 miles downstream from the VY Station.

Q10. Can you summarize the concerns about the migration and movement of American shad that are identified in USFWS's letter?

A10. Yes. USFWS discussed a "2011 Shad Movement Study," in which adult shad were radio-tagged and monitored between two dams on the Connecticut River (Vernon Dam and Turners Falls Dam). Turners Falls Dam is approximately 22 miles downstream from

Vernon Dam. According to this study, none of the 40 radio-tagged fish that migrated upstream past a fish ladder at Turners Falls Dam (or "passed" the fish ladder) subsequently passed the Vernon Dam fish ladder. USFWS also reported that in 2011, only 0.3% of another 16,798 shad that had passed the Turners Falls Dam fish ladder successfully passed the Vernon Dam fish ladder. In general, USFWS reported that since 2002, American shad have become less able to pass the Vernon Dam fish ladder. The Vernon Dam fish ladder is on the west side of the Connecticut River–the same side as the VY Station's heated discharges–making it more difficult for migrating fish to pass the Vernon Dam fish ladder while trying to avoid the discharges from the VY Station. USFWS noted, by contrast, that a congressionally-established entity called the Connecticut River Atlantic Salmon Commission–which partners with USFWS in fish restoration efforts on the Connecticut River–has called for 40% to 60% of American shad to be able to pass each dam on the Connecticut River.[1] If American shad cannot pass Vernon Dam, they cannot access upstream habitat.

The physical features of the fish ladder at the Vernon Dam were not explored in detail in the USFWS letter, although USFWS did report that some (undefined) structural issues are being addressed in 2012. The USFWS letter also reported on a recent thermal monitoring study that showed that water temperatures in the "tailrace" near the entrance to the fish ladder (i.e., the area immediately downstream) of Vernon Dam were relatively high compared to nearby sampling points. Based on this data, USFWS suggested that the

[1] Connecticut River Atlantic Salmon Commission. 1992. A Management Plan for American Shad in the Connecticut River Basin. Available online at http://www.fws.gov/r5/crc/pdf/shad_management_plan.pdf.

higher temperatures have the potential to reduce the time that American shad have to locate and pass the fish ladder to access upstream habitat, possibly due to an avoidance response to the increased temperature relative to ambient conditions.

USFWS also stated that recent data showed 95% of American shad moving upstream through the Connecticut River had passed the Holyoke Dam (approximately 35 miles downstream from the Turners Falls Dam) before the river temperature first reached 70°F. This is noteworthy because it means those shad were between Holyoke Dam and Vernon Dam, but did not migrate further upstream, perhaps due to issues regarding the fish ladder or potential temperature impacts.

USFWS stated that it has seen no evaluations of how juvenile shad outmigration (i.e., downstream migration) may be impacted in the immediate vicinity or downstream from the VY Station's heated discharge.

Q11. Can you please summarize the concerns about Atlantic salmon identified in the USFWS letter?

A11. Yes. The Atlantic salmon fish passage window at the Vernon Dam begins on April 1. USFWS stated that Entergy has not shown how the 45 days of relatively high permitted thermal discharges (up to 13.4°F above ambient) from April 1 to May 16 can affect salmon. USFWS cites recent scientific studies, such as Marschall et al. (2011) (attached as Exhibit PSD-JS-07), providing new evidence that heated water – coupled with migration delays (which may occur when fish have problems moving through fish

passage structures) – may have adverse impacts on salmon smolt (juvenile salmon that make the transition from fresh water to salt water) survival.

Q12. Did USFWS express other concerns about the impact that the VY Station's thermal discharge may have on fish in the Connecticut River?

A12. Yes. Among other things, USFWS stated that it had seen no evaluations of how blueback herring outmigration may be impacted in the immediate vicinity or downstream from the VY Station's heated discharge, and noted that blueback herring are in formal review for protection under the Federal Endangered Species Act; expressed concern about the impacts of heated discharges on sturgeon downstream from the VY Station; and discussed how climate change could cause further uncertainty about water-temperature-related impacts on fish species in the Connecticut River. In essence, there are many unknowns identified in USFWS's letter, which are cause for concern that the VY Station's thermal discharges to the Connecticut River are having an adverse affect on fish in the river. USFWS also raised concerns about compliance with the Federal Power Act, which requires safe, timely, and effective fish passage at the hydropower dams on the Connecticut River mainstem, such as the Vernon Dam.

Q13. Have you reviewed scientific studies addressing the impact of river water temperature on fish, including studies specifically directed at such impacts on fish in the Connecticut River?

A13. Yes. For example, USFWS cited Greene et al. (2009), which is available online at http://www.umaine.edu/searunfish/recentpublications/ASMFC_Atlantic_Coast_Diadrom

ous_Fish_Habitat.pdf, in support of its concerns about the impact of river water temperature on fish. Greene et al. (2009) provides an excellent review of the life history of American shad, which includes a summary of information related to environmental conditions (e.g., waterway physical and hydrologic conditions, sediment substrate types, waterway temperature and dissolved oxygen preferences, and others). Greene et al. (2009) identifies thermal impacts as a threat to diadromous fish, including American shad and river herring, which are present in the Connecticut River.

Another recent report, Crecco (2010), attached as Exhibit PSD-JS-08, also showed that repeat spawning and age structure have declined in the Connecticut River. Two additional recent peer-reviewed journal articles, Castro-Santos and Letcher (2010) and Maltais et al. (2010), shed further light on potential impacts of heat on spawning and migration.

Q14. Can you please summarize the findings of Castro-Santos and Letcher (2010)?

A14. Yes. Castro-Santos and Letcher (2010), attached as Exhibit PSD-JS-03, developed a "bioenergetics model" to assess the migratory habits of the American shad in the Connecticut River. Bioenergetics models account for the energy requirements of the organism for processes such as growth, reproduction and migration. When characteristics of the waterway are incorporated (e.g., availability of food, temperature, velocity, and related characteristics) into the model, the potential behavior of the fish in the waterway can be predicted. That is the approach used for the model in Castro-Santos and Letcher (2010), and the article provides extensive detail on the model development and inputs.

Major conclusions of Castro-Santos and Letcher (2010) and my related recommendations for further evaluation are presented below.

- The article shows that delays to both upstream and downstream movements had dramatic effects on spawning success, determining total fecundity and spatial extent of spawning, and the likelihood of survival. Therefore, it would be beneficial to examine the current extents of the VY Station's thermal discharge (i.e., its "thermal plume") during the adult and juvenile American shad migration periods to determine whether adverse impacts are being minimized.
- The article concludes that spawning was concentrated in the immediate vicinity of dams and increased with greater migratory distance and delays to downstream migration. Therefore, it would be beneficial to examine whether changes in the thermal characteristics of these congregation areas attributable to the VY Station's thermal discharge have the potential to impact spawning success.
- The article indicates that upstream passage at dams in the absence of facilitated downstream passage may increase spawning success, but would reduce the potential for iteroparity (i.e., multiple spawning over the course of a fish's lifetime) for American shad. Because temperature is likely a cue for upstream or downstream movement, the potential role of the thermal regime is an indirect factor in this finding. This indicates that thermal discharges may compound other factors with potentially adverse impacts on the fitness and survival of fish species in the Connecticut River.

- The article concludes that thermal alterations may be partly responsible for reductions in repeat spawners on a river-wide basis. It is recommended that the Castro-Santos and Letcher (2010) model be considered in assessing whether the current VY Station is having an undue impact on American shad. Assessment of additional model scenarios (e.g., adjustments to some of the model inputs to reflect potential changes in thermal conditions) or possible refinement of the model should also be considered.

Q15. Can you please summarize the findings of Maltais et al. (2010)?

A15. Yes. Maltais et al. (2010), attached as Exhibit PSD-JS-04, examined the spawning dynamics of a far northerly population of American shad on the St. Lawrence River. Spawning activity lasted from early May to early July, which is approximately the same time window as on the Connecticut River. Maltais et al. (2010) found that juvenile American shad that were captured downstream during the summer had hatched later in the year than those captured further upstream. As a result, younger juveniles were distributed somewhat further downstream than originally presumed. The 2-month spawning period involved numerous spawning events that progressed in a downstream direction as the season advanced (i.e., the fish continued to spawn as they migrated back downstream) rather than being restricted to upstream sites for the spawning season.

For purposes of this testimony, Maltais et al. (2010) suggests that depending on where and when American shad spawn in the Vernon Pool, the American Shad may be exposed to the thermal discharge from the VY Station during sensitive life stages during

certain times of the year. To address this issue, it would be beneficial to examine the timing of the thermal gradient relative to the fish life stage monitoring data.

Q16. Are there other studies that you have reviewed assessing the impact of thermal discharges from the VY Station on fish species in the Connecticut River?

A16. Yes. The Midwest Biodiversity Institute ("MBI") prepared a recent report, entitled "Development of a Database for Upper Thermal Tolerances for New England Freshwater Fish Species" (dated May 25, 2012), that is relevant to the assessment of potential impacts of thermal discharges on certain fish species in the Connecticut River.

Q17. Can you please summarize the May 25, 2012 MBI report?

A17. Yes. This report, attached as Exhibit PSD-JS-05, provided an overview of contemporary knowledge about "thermal tolerances" of freshwater fish species found in New England waterways. This report discussed several types of "thermal tolerance metrics" or threshold temperatures at which various (lethal and sublethal) impacts on organisms may occur. The May 25, 2012 MBI report provides a compilation of upper thermal tolerances, based upon a comprehensive review of published studies and other literature, with details on sensitive life history stages. While data are not available for all categories or for all of the species presented in the report, the report provides a summary of the current state of knowledge regarding upper thermal tolerances for freshwater species in New England waterways. To better gauge whether the VY Station's thermal discharges are having an

adverse impact on these fish species, results from thermal monitoring and modeling data should be compared to these thermal tolerance metrics.

Q18. Do the information and studies you have reviewed lead you to conclude that the continued operation of the VY Station will not have an undue adverse effect on the natural environment, as described in 30 V.S.A. 248(b)(5)?

A18. No, based on the concerns raised by the USFWS, there are too many unknowns to conclude that thermal discharges are not negatively affecting fish in the Connecticut River. Recent studies and peer-reviewed articles raise serious questions concerning whether the heated effluent discharged from the VY Station is causing adverse impacts on species in the Connecticut River. In particular, there are substantial concerns about thermal discharges that coincide with sensitive life stages (e.g., spawning runs, egg hatching, larval development) of representative species. Moreover, there is a lack of scientific information on winter ecology applicable to this reach of the Connecticut River and additional concern about the compounding effect of climate change. In summary, there is significant uncertainty surrounding the impacts of the VY Station's thermal discharge on fish species, and Entergy has not provided sufficient information or data analyses to allow me to conclude that the VY Station is not adversely affecting fish species in the Connecticut River.

Q19. Does this conclude your testimony?

A19. Yes, at this time.