Shad and Eel Passage at the Conowingo Project, Susquehanna River, Conowingo, MD

By Kevin A. McCaffery, P.E., Water Resources Engineer, Gomez and Sullivan Engineers, P.C.
and Thomas J. Sullivan, P.E., Gomez and Sullivan Engineers, P.C.

ABSTRACT

As part of the Federal Energy Regulatory Commission (FERC) relicensing of the 573 megawatt (MW) Conowingo Hydroelectric Project, Gomez and Sullivan Engineers, P.C. (Gomez and Sullivan) was hired by Exelon Generation Company, LLC (Exelon) to evaluate the engineering design of existing and potential fish passage facilities for American Shad and American Eel.

The Conowingo Dam is the most downstream dam on the mainstream of the Susquehanna River. The Susquehanna River is a major tributary to the Chesapeake Bay. Conowingo is the lowest of four mainstream dams on the river and is located in the State of Maryland. Moving upstream from Conowingo Dam, diadromous fish encounter, in ascending order, the Holtwood, Safe Harbor, and York Haven Hydroelectric Projects.

FERC relicensing necessitates the review of fish passage facilities at Conowingo and an evaluation of alternatives to enhance both upstream and downstream passage. The alternatives presented in this paper represent the first set of alternatives presented by state and federal resource agencies. For each alternative considered, layouts and cost estimates were prepared and are presented in this paper. The FERC licensing process for this project is not complete as of the date of this paper. Therefore, final alternatives have not been selected.

The study plan determination required Exelon to conduct biological and engineering studies of the existing East and West fish lifts related to their ability to pass American shad. This assessment required the Licensee to conduct an engineering analysis of the remaining life cycle and maximum fish passage capacity of the two existing lifts, determine the costs and logistics of upgrading or replacing the existing fish passage facilities, and to assess the logistics and cost of utilizing one or both lifts as an interim measure to increase fish passage at the project via trap and transport methods. The alternatives evaluated ranged from simple upgrades of gates and drive motors to full replacement of the existing lifts. Therefore, costs and additional passage potential varied significantly.

This fish lift portion of the report presents an operational history of the lifts, current maintenance and operations methods, potential upgrades, modifications, or replacements to the current passage infrastructure based on the agency requests, and associated conceptual level cost opinions and drawings. Where appropriate, estimates are provided for the increased passage capacity of the various options.

The final study plan also required the Licensee to conduct biological and engineering Studies of American Eel, which included a literature review of available scientific and commercial eel information, characterizing the local eel abundance via field studies, and examining the engineering feasibility and costs of passage options.

For the eel study, conceptual layouts and cost opinions were developed for potential upstream eel passage alternatives. The alternatives ranged from eel passage facilities of limited length with a trap-and-transport program to full-length eel passage facilities that provide the opportunity for full volitional passage to Conowingo Pond.

This paper presents a summary of the alternative analyses prepared for both species and discusses the implications of attempting to satisfy the proposed restoration goals for both populations.

INTRODUCTION

As part of the Federal Energy Regulatory Commission (FERC) relicensing of the 573 megawatt (MW) Conowingo Hydroelectric Project, Gomez and Sullivan Engineers, P.C. (Gomez and Sullivan) was hired by Exelon Generation Company, LLC (Exelon) to evaluate the engineering design of existing and potential fish passage facilities for American Shad and American eel.

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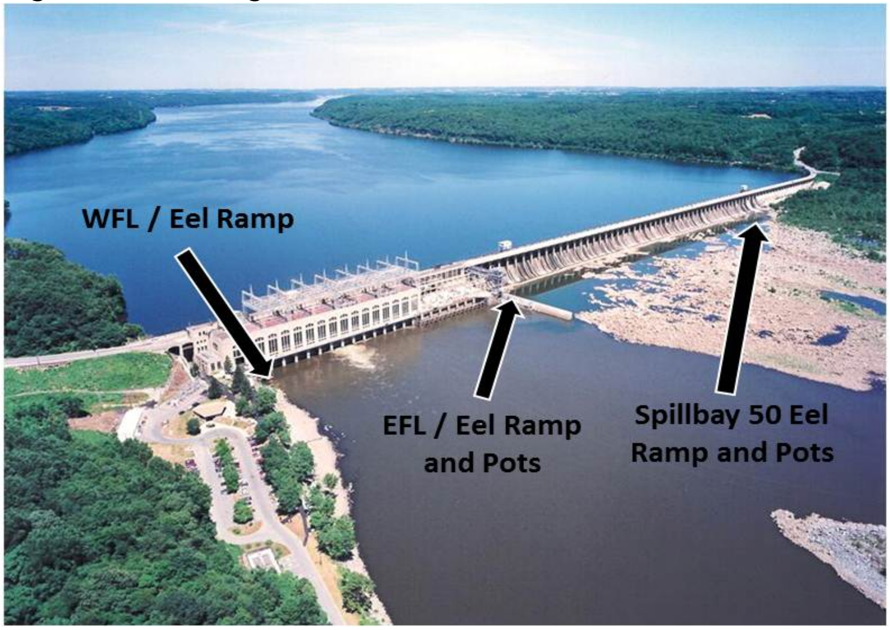
Figure 1: Conowingo Dam

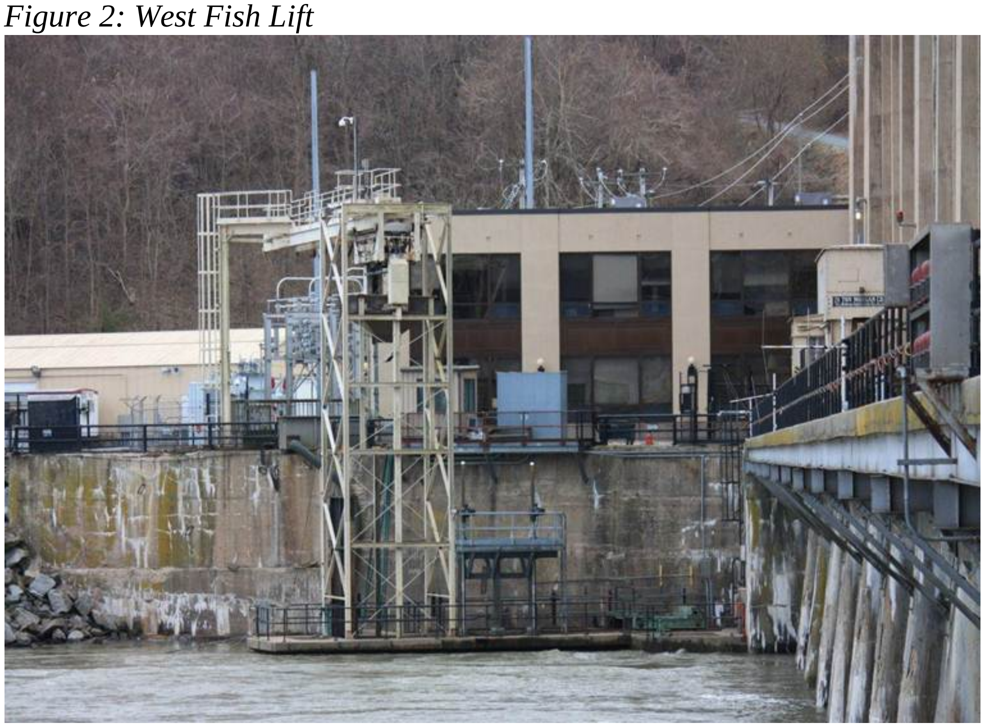


EAST AND WEST FISH LIFTS - AMERICAN SHAD PASSAGE

The objectives of the Biological and Engineering Study of the East and West Fish Lifts were: (1) determine how and to what extent the West Fish Lift and spawning tanks can be expanded to enhance biomonitoring and egg collection to promote American shad restoration; (2) to ensure that excess fish taken in the West Fish Lift can be moved upstream so as to contribute to natural spawning stock upstream; (3) conduct an engineering analysis of the remaining life cycle and maximum fish passage capacity of the existing East Fish Lift and West Fish Lift; (4) determine the costs and logistics of upgrading or replacing the existing fish passage facilities; (5) assess the logistics and cost of utilizing the West Fish Lift as an interim measure to increase fish passage at the project via trap and truck; (6) assess the need for, impact of, and logistics and costs of adding the second hopper to the East Fish Lift; (7) investigate modification or replacement of the existing West Fish Lift and a protocol for upstream transport of American shad and river herring collected in the West Fish Lift, but not needed for biomonitoring and/or egg collection programs; and (8) investigate other upstream fish passage measures or facilities, interim or permanent, which will provide safe, timely and effective upstream passage for the target species.

The West Fish Lift (Figure 2) was constructed and began operation, as a prototype facility, in 1972. The original intent was to operate the facility for a period of 5 years while larger and more permanent fish passage facilities were designed and constructed. However, it was operated through 1996 as part of a trap and transport program and in 1997 it began to operate for specific experiments conducted for resource agencies (e.g., induced spawning, transport to specific tributaries). The West Fish Lift cannot pass migrating fish directly to Conowingo Pond.

Figure 2: West Fish Lift



A 1989 Settlement Agreement with the resource agencies resulted in the construction of the East Fish Lift in 1991. The East Fish Lift (Figure 3) is much larger than the West Fish Lift and was designed to have the ability to be used either as a trap and transport facility or for direct passage to Conowingo Pond. It was used as a trap and transport facility from 1991 to 1996. Volitional passage began in 1997, with the completion of passage facilities at upstream dams, and it has been used for this sole purpose since. The facility was designed to utilize two hoppers although only one was installed when constructed. The single hopper system has a design capacity of 750,000 American shad per season.

Figure 3: East Fish Lift

The options considered for potential change at the West Fish Lift included: 1) decreased cycle time, 2) increased lift capacity, 3) direct passage to Conowingo Pond, 4) trap and transport capability, and 5) expansion of biomonitoring and shad egg production. East Fish Lift options included: 1) potential installation of a second hopper, 2) replacement of the existing lift, and 3) trap and transport capability. Table 1 presents a summary of the conceptual opinions of probable cost for the alternatives evaluated.

Table 1: Summary of Alternatives and Cost Opinions

ALTERNATIVE	BRIEF DESCRIPTION	CAPITAL COSTS (2011 DOLLARS)	INCREMENTAL ANNUAL OPERATIONS COSTS, IF APPLICABLE (2011 DOLLARS)
West Fish Lift - Decrease Hopper Rail Elevation	Lower the travel rail elevation to decrease cycle time.	$284,000	
West Fish Lift - Increase Sorting Pool Elevation	Raise the elevation of the sorting pool to decrease cycle time, also applicable if trap and transport is implemented.	$161,000	
West Fish Lift - Upgrade Crowder Gate	Replacement of the drive motors and linkage for the crowder gate to decrease cycle time.	$144,000	

ALTERNATIVE	BRIEF DESCRIPTION	CAPITAL COSTS (2011 DOLLARS)	INCREMENTAL ANNUAL OPERATIONS COSTS, IF APPLICABLE (2011 DOLLARS)
West Fish Lift - Enlarged Hopper on Existing Footings	Construct a new lift on the existing footings, with a taller hopper.	$3,058,000	
West Fish Lift - Replacement of Existing Lift	Construct a new lift on new footings with a hopper similar to the dimensions of the East Lift.	$3,665,000	
West Fish Lift - Trap and Transport Capability	Purchase and operation of transport vehicles, includes costs for raising sorting pool.	$503,000	$606,000 per year
Fish Hatchery and Spawning Facility	Construct an 8,400 square foot tank spawning and hatchery facility near the West Fish Lift.	$2,402,000	$288,000 per year
East Fish Lift - Installation of Second Hopper	Install a second hopper within the existing East Fish Lift.	$1,436,000	
East Fish Lift - Replacement of Existing Lift	Construct a new lift in the current location of the East Fish Lift.	$19,462,000	
East Fish Lift - Trap and Transport Capability	Purchase and operation of transport vehicles, includes rehabbing existing sorting pool infrastructure.	$690,000	$769,000 per year

West Fish Lift Alternatives

MODIFICATIONS TO DECREASE CYCLE TIME

This alternative considers modifying the existing lift to decrease the time between lifts. The potential number of fish raised per lift would remain unchanged with increased collection occurring by increasing the number of lifts per day. The majority of the existing infrastructure would be reused.

Modifications to the West Fish Lift to reduce cycle time include reducing structure height, raising the sorting tank, or decreasing the crowder gate closing time. If the elevation difference between the hopper rail and sorting tanks could be reduced, it would decrease cycle time.

The hopper on the West Fish Lift must be moved into the full up position before it can travel horizontally on the rail to the location of the sorting tank as it connects with a rigid support that keeps the hopper from swaying as it is moved along the rail. To decrease the hopper rail elevation, the hopper, horizontal travel rail, and all associated motors and electrical supply would need to be temporarily removed from the lift. The columns supporting the horizontal travel rail and hopper would have sections removed from the top and the existing bracing relocated. The hopper, horizontal travel rail, motors, and associated electrical systems would then be reattached at the new elevation. The cost opinion does not consider a new hopper or any other changes in operation of the lift except the lowering of the travel rail to reduce the height the hopper is lifted. The total for this potential alternative is $284,000 (Table 1). It is estimated that implementing this option would decrease cycle time by approximately two minutes.

The second option explored to reduce cycle time is to raise the elevation of the sorting tank so the hopper does not need to be lowered once it is in position above the sorting tank. Additionally, if the sorting tank is raised to a higher elevation it will allow for more efficient transfer of fish from the hopper to a transport tank if a trap and transport program was restarted. This option involves removal of the existing sorting tank, buildup of a foundation and platform to support the new sorting tanks, and installation of new sorting tanks at a higher elevation. It would not require modifications to the hopper or fish lift structure. Table 1 presents the cost opinion for this potential alternative, the total is $161,000. It is estimated that implementing this option would decrease cycle time by approximately two minutes.

The last option evaluated to reduce cycle time is replacement of the drive motors and linkage for the crowder gate. The motors are removed over the winter and stored, then replaced after the tailrace stage has lowered and spill conditions have ended for the spring. Replacing these motors would not require modification to the lift structure and they could be placed in the location of the existing motors. The electronic controls would need to be reprogrammed to compensate for the faster travel of the crowder gate, with new limit switches required. The total for this potential alternative is $144,000 (Table 1). This option has the potential to decrease cycle time by approximately one minute.

These options could be combined in two different ways. Upgrading the crowder drive could be implemented for either raising the sorting tank or decreasing the elevation of the hopper travel rail. Raising the sorting tank and implementing the crowder drive upgrade appears to be the most sensible option as it would lend itself to implementing a trap and transport program if desired. The combined time savings of either of these two variations would result in the potential for approximately one to two more lifts each day; this translates to a capacity of approximately 110% of what is possible with the existing lift.

MODIFICATIONS TO INCREASE LIFT CAPACITY

The second major alternative assesses increasing the capacity of the West Fish Lift by installing a larger hopper within the existing footprint of the current lift or constructing a new enlarged system. Modifications to the West Fish Lift to increase lift capacity were evaluated and the existing structure was assessed based on its capability to support a larger hopper.

Two options were evaluated in expanding the capacity of the West Fish Lift, the first is to keep the cross section of the hopper the same but have the new hopper deeper to accommodate more fish. In this scenario the steel structure above the water would be replaced, the concrete footing structure would remain, and the new hopper would be designed to fit in the existing opening at the water surface. This enlarged hopper would have a volume of approximately 1,500 gallons, resulting in a nominal capacity of 1,150 fish per lift or approximately 165% of current capacity. Total cost for this option is estimated to be $3,058,000 (Table 1). If this or the following option were implemented, the new lift should incorporate the faster crowder drive and increased sorting pool elevation discussed above. This would result in approximately 10% (1 to 2) more lifts per day, compared to the current system.

The second option would involve complete removal of the West Fish Lift including footings; the new lift would have a similar volume as the existing hopper on the East Fish Lift. The current superstructure of the West Fish Lift does not have the capacity to support the weight of a hopper the size of that used in the East Fish Lift. If a new, larger hopper is to be installed the entire structure would need to be replaced to support the new hopper. A new hopper would have a side discharge and incorporate similar designs to that of the East Fish Lift to reduce stress on the fish. This proposed hopper would have a volume of approximately 3,300 gallons, or 3.65 times the current hopper's volume. Total cost for this option is estimated to be $3,665,000 (Table 1).

PASSAGE TO CONOWINGO POND

The third major alternative investigates modification or replacement of the existing West Fish Lift with a fully functional fishway capable of passing up to 1.5 million American shad directly into the Conowingo Pond without the need for trucking. Construction of a completely new lift capable of passing this number of fish per season is considered to be unrealistic based on site constraints, including the location of the intakes for the powerhouse.

Building a trough to provide fish passage on the west side of the Conowingo powerhouse will be challenging due to the accumulation of debris that is continuously drawn into the powerhouse intake area. Debris is a serious issue at the East Fish Lift and would be worse at the West Fish Lift. The lift design must address preventing debris from entering the facility, as well as removal of debris that does collect. Water leakage from the trough must be prevented since the Administration building is in close proximity to the current fish lift.

The lift must also address the problem of getting fish to Conowingo Pond. The two alternatives are to go over the administration building or to go under Route 1, a major thoroughfare. If the lift is to go over the administration building, the hopper would need to move up to an elevation higher than the building, move horizontally over it and Route 1, then back down to a level to discharge in the pond. Essentially, it would be comprised of two lifts: one for up and over the administration building and one back down to the pond. Logistical problems associated with this alternative include: building a structure over the administration building and over Route 1, addressing leakage problems onto the administration building and Route 1, and discharging fish too close to the turbines. Aside from the engineering and construction constraints of building over Route 1, safety of the public would also be a concern.

The alternative to go under Route 1 also has associated logistical issues as well. The lift structure would need to go around the administration building and discharge to a trough that would be constructed under Route 1. The fish would need to be discharged into the pond upstream far enough so as not to be drawn back through the turbines and to get past the debris that accumulates near the dam. Based on these significant limitations neither of these alternatives was pursued further.

TRAP AND TRANSPORT CAPABILITY

Another alternative investigated at the West Fish Lift assesses what modifications and protocol would be necessary to use this lift for upstream transport of American shad and river herring that are collected but not needed for the biomonitoring and egg collection programs.

The West Fish Lift was used primarily as a trap and transport facility from 1983 to 1996. It was used on a limited basis for trap and transport from 1997 to 2000. Restarting this operation would require modification to the sorting pool configuration and purchase of new transport vehicles and associated equipment. An alternative where the elevation of the sorting pool is increased to decrease the cycle time of the lift has been discussed. Raising the sorting pool elevation would allow direct sluicing of collected fish into a tank mounted on a transport vehicle. This modification is recommended if trap and transport is pursued for the West Fish Lift; costs from that option were included in the Cost Opinion referenced above.

During previous use as a trap and transport facility, several flatbed trucks were fitted with 1,000 gallon tanks, two trash pumps for water circulation, two 2,500 pound oxygen cylinders with a regulator and hosing for aeration, and a temperature/dissolved oxygen monitor. The capacity of the transport tank was approximately 150 to 225 fish per trip. The operation used up to four trucks driven in rotating cycles; with an average round trip travel time of five hours. Fish were normally transported to waters upstream of York Haven Dam. Six loads were usually transported each day from this lift.

The personnel present during the passage season normally consisted of 1 fish biologist, 1 lift operator, 3 fish technicians, and 4 drivers. During the peak of the passage season an additional technician and driver were occasionally required. The season was an average of 52 days from 1983 to 1996 and work days were generally 12 hours.

For the West Fish Lift to be used as a trap and transport facility, a new fleet of transport vehicles would need to be purchased and equipped with the items described above. It would also require the sorting tank to be modified to allow fish to be sluiced directly into the transport tanks. A Conceptual Opinion of Probable Construction Cost (Cost Opinion) was developed. Costs for a slightly larger tank than used previously (1,500 gallon) were carried to allow for more capacity.

The Cost Opinion for this case also includes values for both capital and annual operations of the program, including predicted labor and materials needed each season. The length of season was assumed to be 50 days, although this is expected to vary each year. A project coordinator has been added to the list of personnel to facilitate an organized and monitored approach to the process. If trap and transport were implemented for the East Fish Lift, this same individual would also coordinate those activities to provide a unified approach. Initial capital costs were estimated to be $503,000, with an annual operations budget of $606,000 per year (Table 1).

EXPANSION OF BIOMONITORING AND SHAD EGG PRODUCTION

At the Conowingo West Fish Lift facility, one 10-ft diameter and one 12-ft diameter tank are currently used for hormone induced spawning trials. This method of egg production has had limited success. Some researchers have had successful viable egg production without the use of hormones when fish are placed in a facility with temperature and other climate controls.

A conceptual spawning facility schematic was developed by Mike Hendricks with the PFBC. The schematic provided details regarding the size and makeup of a potential hatchery and spawning facility at Conowingo Dam. This facility would have the potential, on an annual basis, to produce approximately 13 million viable eggs and provide incubation facilities for approximately 20 million eggs. Total costs estimated for this alternative are $2,402,000 (Table

1). This value includes design and construction of the facility but does not include annual operational and maintenance costs. It is expected that a facility of this magnitude would be staffed five months per year by a hatchery manager and assistant manager. For approximately four months per year, four seasonal hatchery technicians would also be required. Labor costs for these individuals, including an annual allowance for utilities and supplies, results in an approximate annual operations cost of $288,000 per year.

East Fish Lift Alternatives

INSTALLATION OF SECOND HOPPER

Improvement in the East Fish Lift could be accomplished by adding a second hopper to the existing structure. Installation of a second hopper was a component of the original design that was not installed during initial construction. The second hopper would be placed directly upstream of the existing hopper, closer to the spillway. In addition to the controls, motors, and lifting cables to operate a new hopper, the existing crowder gate will need to be reconfigured to allow movement past the existing hopper and full movement through the trough. The estimated total cost of this option is $1,436,000 (Table 1).

The addition of a new hopper will volumetrically double the capacity of the East Fish Lift, although it is not expected to simply double its passage potential. It is expected that fish migrating upstream would favor the second hopper as they would be seeking the most upstream point in the system. There would likely be a disparity in the relative amount of fish collected in each hopper. It is estimated that the upstream hopper would be favored approximately 3 to 1 (i.e., 75% of catch in upstream hopper, 25% in downstream hopper). It is estimated that adding the second hopper could result in a total passage capacity of approximately 150% of the existing rate for the East Fish Lift. These proportions and estimates were based on the experience of personnel familiar with the lift's operation and habits of migrating fish at the project.

REPLACEMENT OF EXISTING LIFT

A cost opinion has been prepared for the replacement of the existing East Fish Lift in its current location. The facility would resemble the existing lift, although current passage and control technologies would be incorporated into the system. It would also include a second hopper. Total costs for this option were predicted to be $19,462,000, as shown in Table 1.

TRAP AND TRANSPORT

The final alternative analyzed was the reactivation of a trap and transport operation at the East Lift. During the East Fish Lift's previous use as a trap and transport facility, several flatbed trailers were fitted with 750 gallon tanks, two trash pumps for water circulation, two 2,500 pound oxygen cylinders with a regulator and hosing for aeration, and a temperature/dissolved oxygen monitor. The capacity of the transport tank was approximately 100 to 125 fish per trip. A hy-rail truck and forklift were used to position and move the trailers to and from the sorting tank at the East Fish Lift and the West shore. The operation used up to five trucks and trailers driven in rotating cycles; with an average round trip travel time of five hours and a maximum of 10 trips per day. Fish were normally transported to waters upstream of York Haven Dam.

For the East Fish Lift to be used as a trap and transport facility, a new fleet of transport vehicles would need to be purchased and equipped with the items described above. A hy-rail truck and forklift would also be required if they are not available at the project. The existing sorting tank and support grating need to be replaced due to their age and reportedly poor condition. The gate allowing fish to be sent to the sorting tank or passed to Conowingo Pond would also need to be repaired to function as it did historically. When trap and transport was ceased at the East Fish Lift this gate was welded to the volitional setting. Costs for a slightly larger tank than used previously (1,000 gallon) have been carried to allow for more capacity. As shown in Table 1 the capital cost for this alternative is $690,000 while the operations and maintenance cost is estimated to be $769,000/yr.

Gizzard Shad

Perhaps the biggest biological concern for fish lift modifications in the context of meeting restoration goals is the dramatic increase of the gizzard shad population since the 1970s. There is ideal spawning habitat for gizzard shad above the lower Susquehanna River dams, which has contributed to the rapid expansion of the population. The construction of the dams creating suitable spawning habitat, along with increased fish passage, has caused gizzard shad to become the dominant fish in the lower river. Anecdotal evidence suggests that gizzard shad congregate at the fish lift entrances and "crowd out" the American shad attempting to pass upstream.

To meet restoration goals using non-selective volitional passage techniques, many more gizzard shad will be passed above Conowingo Dam in an effort to pass more American shad. It is likely that this will only exacerbate the current passage problem. It may be necessary to develop a method, if at all possible, to exclude gizzard shad when the new fish lift configurations are completed. This will be a difficult task and may not be determined to be feasible if it causes any undue stress to American shad. As a plan for improving fish passage at the project is being formulated and agreed to by the Licensee and the various stakeholders, it is prudent that the final plan take into account the competing gizzard shad population. A variable combination of trap and transport, spawning and release to tributaries, and volitional passage may be warranted.

AMERICAN EEL PASSAGE

The objectives of the Biological and Engineering Study of the American Eel were: (1) summarize available scientific and commercial information regarding the American eel; (2) identify suspected factors affecting American eel abundance; (3) describe the spatial distribution and size characteristics of American eels in the Conowingo tailrace; (4) examine the engineering feasibility and costs of upstream and downstream passage options, including consideration of potential fallback of eels after exiting an upstream passage device; (5) examine the potential impact of upstream and downstream passage of American eels on the Susquehanna River; (6) assess the cumulative impacts to the biodiversity of the Susquehanna River ecosystem of upstream and downstream passage of American eel; and (7) if deemed beneficial to American eel abundance, identify potential locations for an upstream passage facility.

The American eel is a catadromous fish species whose range extends from Greenland and Iceland south to Venezuela. All American eels migrate to the Sargasso Sea to spawn and disperse to coastal river basins to grow and mature. The species is panmictic and, as such, is composed of a well-mixed single breeding population where the juveniles do not necessarily return to natal streams (Wirth and Bernatchez 2003). During the maturation phase, the species utilizes a combination of freshwater, estuarine, and coastal ocean waters over a period of 4 to 24+ years coast-wide and 6 to 16 years specifically in the Chesapeake Bay region (DOI 2007). Eels' eggs and larvae (leptocephali) are dispersed across their entire range by ocean currents. Once the leptocephali reach the continental shelf, they metamorphose into glass eels. The glass eels actively migrate toward land and develop pigmentation in brackish or freshwater and are termed elvers. When elvers reach approximately age 2, they are termed yellow eels, which is their primary growth stage. Sexual differentiation occurs during the yellow eel phase. As the eels sexually mature they take on a silver pigmentation (silver eels) and begin their journey back to the Sargasso Sea to spawn.

Due to their migratory behavior, eels provide an ecologic link between the marine and freshwater environments. For example, American eels serve as hosts to the larval stage (known as glochidia) of freshwater mussels, allowing for the dispersion of mussels to upstream areas. As predators of fish and invertebrates primarily, eels also tie up and remove nutrients from their prey in growth and production. Some of this freshwater/estuarine accumulated biomass is returned to the Sargasso Sea when the eels spawn and die.

TEMPORARY RAMP STRUCTURES

To better understand how American eel use the area in the immediate vicinity of the Conowingo tailrace, the United States Fish and Wildlife Service (USFWS) initiated a study in 2005. Eels have been sampled by the USFWS with ramps using Enkamat® substrate and pots near Conowingo's West Fish Lift (WFL) from 2005 to the present. In 2010, Exelon initiated eel sampling with ramps and pots in the spillway region of the project. For the 2010 Exelon sampling, one elver sampling ramp was placed adjacent to the dividing wall between the tailrace and East Fish Lift (EFL spillway ramp 2010) while the other ramp was placed on the east abutment end of the spillway at Spillbay 50, both of which used Enkamat® substrate (spillbay 50 ramp 2010 – see Figure 1). For the 2011 Exelon sampling, the ramps were placed in similar areas with the exception that tandem ramps were installed at each location with Enkamat® and AkwaDrain™ substrate fished side-by-side. Eel pots were fished adjacent to the elver ramps for both 2010 and 2011. Both gear types are similar in design and deployment to those used by the USFWS. The results of the USFWS and Exelon sampling are presented in Table 2. The Enkamat® substrate used on the ramps is reportedly size-selective for eels less than 260 mm (Solomon and Beach 2004b), and neither the ramps nor the pots captured eels between 188 and 256 mm. For the 2011 field study, AkwaDrain™ substrate was fitted to an elver ramp used in tandem with a ramp fitted with Enkamat® substrate to compare efficacy.

Table 2: Summary of eels collected at Conowingo Dam 2005 – 2010

Year/Source	Elvers Caught with Ramps	Elver Length Range (mm)	Yellow Eels Caught with Pots	Length Range of Eels Caught in Pots (mm)
2005/USFWS WFL	42	-	78	93-733 (range given for all eels caught)
2006/USFWS WFL	19	-	208	83-735 (range given for all eels caught)
2007/USFWS WFL	3,837	76-169	51	256-734
2008/USFWS WFL	44,006 (824 on east side)	90-176	38 (25 recaptures)	321-770
2009/USFWS WFL	17,437	92-162	116 (49 recaptures)	318-655
2010/USFWS WFL[1]	24,000	95-195	25 (9 recaptures)	335-696
2010/EXELON/EFL SPILLBAY RAMP 2010	8	103-148	1	525
2010/EXELON/SPILLBAY 50 RAMP 2010	158	92-154	91	115-650
2011/EXELON/EFL SPILLWAY RAMPS 2011	405/156*	88-182	59	300-689
2011/EXELON/SPILLBAY 50 RAMPS/2011	133/406*	87-188	0	NA

*: Numbers displayed for eels caught on Enkamat®/AkwaDrain™ substrate.
[1]: 2011 USFWS data was not available at the time of publication of this report

UPSTREAM PASSAGE ALTERNATIVES

A preliminary review of upstream eel passage facilities on several river systems provided background and information on the potential options for the type of upstream eel passage at Conowingo Dam. At the St. Lawrence-FDR Power Project, with a comparable civil works configuration and operating head to Conowingo Dam, a state-of-the-art eel passage facility was constructed in 2006. It is anticipated that a permanent (fixed) eel passage facility at the Conowingo Project would include similar technologies incorporated in the St. Lawrence-FDR facility. These major features include a ramp with substrate that eels can climb to a holding area, followed by a pipe containing a continuous flow that eels would swim through to a safe release point upstream of the Project in Conowingo Pond.

Based on data collected during studies from 2005 – 2010, eel passage facilities were evaluated at the east and west bank of Conowingo Dam. The west bank of the tailrace near the WFL presents challenges to direct passage because the powerhouse is also on the west side of the dam. In addition to passing eels over the dam, consideration was given to an exit location that will allow continued upstream movement. If the eels exit too close to the powerhouse, downstream currents could cause them to pass back through the turbines.

For this study, conceptual layouts and cost opinions were developed for five potential upstream eel passage alternatives. The alternatives ranged from eel passage facilities of limited length with a trap-and-transport program to full-length eel passage facilities that provide the opportunity for full volitional passage to Conowingo Pond. Table 3 presents a summary of the conceptual opinions of probable cost for the alternatives evaluated.

Table 3: Summary of Upstream Eel Passage Alternatives

Alternative	Brief Description	Capital Costs (2011 Dollars)	Annual Operations Costs, If Applicable (2011 Dollars)
West Bank - Trap and Transport	Limited length eel ramp with collection facility in existing parking lot.	$639,000	$585,000
West Bank - Volitional Passage near West Fish Lift	Full eel ramp with resting pools from tailrace to pond elevation, sited near West Fish Lift superstructure.	$1,695,000	$200,000 per year (assumed personnel cost)
West Bank - Volitional Passage near Administration Building	Full eel ramp with resting pools from tailrace to pond elevation, portion buried beneath parking lot day lighting near Administration Building.	$2,230,000	$200,000 per year (assumed personnel cost)
East Bank - Trap and Transport	Limited length eel ramp with collection facility in existing access area, below non-overflow section of dam.	$622,000	$585,000
East Bank - Volitional Passage	Full eel ramp with resting pools from tailrace below spillbay 50 to pond, cored through top of dam.	$1,125,000	$200,000 per year (assumed personnel cost)

DOWNSTREAM PASSAGE ALTERNATIVES

In October 2011, a workshop was held with the relicensing stakeholders and eel experts to discuss options for the downstream passage of adult eels at hydroelectric projects generally and the Conowingo Project specifically. After discussing a variety of turbine passage, behavioral/guidance, structural, as well as trap and transport options, the group consensus was that trap and transport was the most practical alternative for the lower Susquehanna River. The capital and operations costs for a single eel weir with associated transport facilities are estimated to be $169,500 and $266,000/yr., respectively.

In order to determine the potential number of silver eels available for outmigration to the Sargasso Sea as well as the potential abundance of eels distributed via passage to upstream areas, it was necessary to construct a simple eel population model for various passage scenarios. These models include: a.) low-end estimates of upstream passage efficiency and downstream survival for volitional passage; b) high-end estimates of upstream passage efficiency and downstream survival for volitional passage; c.) trap and transport efficiency to upstream of York Haven with low-end downstream passage survival; d.) trap and transport efficiency to upstream of York Haven with high-end downstream passage survival; and e) trap and transport efficiency to upstream of York Haven with trap and transport from upstream of York Haven to downstream of Conowingo (a series of sensitivity analyses).

From a resource-management perspective, the model showed that the choice of methods for achieving upstream and downstream passage of American eel depends on the resource goals of an overall program. If the sole resource management objective is to provide the most silver eels leaving the Susquehanna River for the journey to the Sargasso Sea, volitional upstream and downstream passage is estimated to likely provide the most silver eels downstream of Conowingo Dam (92.1 percent of eels below Conowingo Dam) than options involving trap-and transportation (82.3 – 84.2 percent of eels below Conowingo). Complete volitional passage has such a high return rate of fish to the Sargasso Sea primarily because a large percentage (67%) of the eels never migrate upstream of Conowingo Dam.

If the sole resource management objective is to maximize eel abundance upstream of York Haven Dam, this goal would be accomplished with an option involving a trap-and transport program. It is estimated that a trap-and-transport option program would deliver 36 to 43 percent of the eels below Conowingo upstream of York Haven while volitional passage at the four dams would only deliver 1.3 to 25 percent of these eels above York Haven (GSE Eel 2011).

If an upstream and downstream eel-passage program sought to balance these two resource objectives, an upstream and downstream trap-and-transport program would be the best approach. If capture efficiencies for the downstream trap-and-transport program are high (approximately 75% or more), this program would also provide more silver eels leaving the river than the volitional approach.

ABOUT THE AUTHORS

Kevin A. McCaffery, P.E**.** is a licensed civil and environmental engineer with experience in the planning, analysis, and design phases of surface water projects. He holds an M.S. in Civil and Environmental Engineering from the University of Maine and a B.S. in Environmental Science from the State University of New York at Plattsburgh. He has a background in environmental sciences, engineering, and the regulatory approval process, and served as the lead engineer for fish passage for the FERC relicensing of the Conowingo and Muddy Run Hydroelectric Projects.

Thomas J. Sullivan, P.E. is a Water Resources Engineer with 32 years of experience in ecohydrology and fish passage. He holds B.S. and M.S. degrees in Environmental Engineering from the Pennsylvania State University. Tom's experience has included environmental assessment and modeling for hydrology, hydraulic, and habitat assessments as well as upstream and downstream passage of diadromous and resident species. Tom is currently the Principal in Charge for the FERC relicensing of the Conowingo and Muddy Run Hydroelectric Projects.

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