American Eel Passage Enhancement Plan for the Bronx River

Recommendations and Protocols

American eel (*Anguilla rostrada*) courtesy NYSDEC

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Summary

The effort to enhance American eel (*Anguilla rostrada*) populations in the Bronx River traces its incipient origins to the initial proposal to restore alewives (*Alosa pseudoharengus*) and build fish passage in the same system. Since eels are also plagued by many of the same dilemmas experienced by other species of diadromous fishes, it was decided that efforts should be applied to help their declining population trends that have unfortunately reached historic lows. However, a traditional fish passage is not effective to pass juvenile eels since their swimming abilities are not as capable as more athletic adult fish. Hence, a specifically designed eel pass will fill this need.

Background and Eel Conservation Efforts

Populations of American eels along the eastern coast of North America have declined drastically over the last thirty years. In 2004, the decline in eel populations prompted a petition to list the American eel under the Endangered Species Act. However NOAA and the USFWS concluded that listing was not warranted at the time. In 2006, the Atlantic States Marine Fisheries Commission (ASMFC) completed a stock assessment for American eels, and it was determined that the abundance was at or near record low levels. Due to their dual habitat usage, they are experiencing population declines caused by the same synergy of anthropogenic factors faced by other diadromous fish such as: habitat fragmentation, habitat degradation, over-harvest, and other stresses related to climate change (Richkus and Dixon 2003). Further complicating the eel's population downturn is the fact that they are a semelparous species that spawns once and perishes. Upon maturity, eels migrate back to the Sargasso Sea to spawn and die (Haro et al. 2000). Subsequently, they have a postponed reproductive effort. Some females have been aged at over 30 years prior before maturing into sexually mature silver eels and beginning their return spawning migration (ASMFC 2000). Much of the life cycle of the American eel still remains a mystery, but it is generally accepted that constituent populations drawing from both North and South America combine to form a panmictic reproductive effort that spawns in an unknown location and depth in the Sargasso Sea. Most importantly from an ecosystem perspective, eels in all stages of their life-cycle perform a valuable role as an energetic intermediary in the trophic web by converting small fish and invertebrates produced lower on the biotic scale into useful forage for larger piscivorous fish, birds, mammals on both sides of the haline barrier. Accordingly, the effects of the loss of American eels from aquatic food webs, though not quantified, may be substantial (Freeman et al. 2003).

Dams negatively impact riparian ecosystems by fragmenting rivers, resulting in widespread affects on aquatic habitat and watershed hydrology (Allen 1995; McCulley 1996**;** Rosenberg et al. 2000; Cummings 2004; Magilligan and Nislow 2004). Research in the late 1990s indicated that species that depend upon access to Atlantic coastal watersheds may be deterred from reaching up to eighty four (84) percent of upstream habitats as a result of dams (Busch et al. 1998). In many rivers, habitat loss for eels has been caused by dams restricting or eliminating access to critical upstream habitat where eels mature and grow (Schmidt et al. 2009). According to a study

conducted by Machut et al. (2007), the impact of barriers was shown to be significant to eels; within each stream the highest densities were below the first barrier, with densities dropping dramatically beyond each barrier. Furthermore, dams may disrupt the adaptive life history and population demographics of American eels since the number and proportion of females increases in upstream areas due to density dependent cues precipitating an environmental sexual determination (ESD) response (Oliveira and McCleave 2000). Experimental evidence indicates that high population density results in heightened proportions of male *Anguillids*, while low population density results in the predominance of females. According to Kruegera and Oliveira (1999), this (ESD) may be an adaptive trait resulting in higher numbers of small males in coastal habitats relatively close to the spawning areas while the larger females are spread at lower densities occupying the remainder of the available eel habitat to ensure sufficient forage to produce larger body mass which translates into high fecundity. It was proposed that crowding results in a long period of undifferentiation and the suppression of cascading hormones that induces the propagation of females. Presumably then, female morphogenesis is manifested by density dependent environmental cues that are triggered once respective eels are freed from the constraints imposed by intra-specific competition**.** Hence, in addition to passage problems for many species of fish and invertebrates, dams alter uniquely adaptive processes that have evolved by eels over eons in response to their cosmopolitan distribution and which may ultimately skew the population demographics towards the production of fewer females and a counter-gradient proportion of males. Collectively, these circumstances would synergistically act to reduce genetic diversity of the meta-population that has been experiencing consistent range-wide declines.

To counter these negative trends there are several measures proposed to protect and restore American eels to more sustainable levels ranging from broad efforts to improve overall ecosystem health to more focused projects that mitigate the passage problems posed by dams. Even though fish passages have been installed on many rivers to restore fragmented systems and improve localized ecosystem health by recharging food chain dynamics and facilitating the uninterrupted movement of fish to their natural upstream habitat, most traditional fish passages are designed for adult migratory fish with strong leaping and swimming ability. Juvenile eels, however, are hindered by these designs since they lack strong athletic abilities to surmount the vertical leaps required, nor can they generate positive rheotaxis with sufficient stamina to counter the high water velocities typically encountered **(Figure 1).** Therefore, eel specific passes should be designed and implemented to facilitate passage if uncertainty exists.

The ASMFC (2008) Fishery Management Plan (FMP) lists the following as high priority objectives: to investigate, develop, and improve technologies for American eel passage upstream and downstream at various barriers for each life stage. The FMP also requires concerned agencies to protect and enhance American eel abundance in all watersheds where eels now occur. In particular, the plan recommends investigating low-cost alternatives to traditional fishway designs for the passage of eels. Installation and operation of a temporary low-cost passage facility is recommended in any situation where there is uncertainty regarding the number and size of eels requiring passage. Low-cost eel passes comprised of synthetic materials commonly used for eel passes have included discarded trawl netting (Shotzberger and Strait 2002) and garden

netting (Knights and White 1998), and coils of burlap. The idea is to furnish a climbing substrate for the elvers and glass eels formed of netting loosely rolled into ersatz ropes to provide sufficient purchase for eels to clamber through. The simplicity of this design requires little maintenance and prevents the accumulation of debris with no adverse affects to structural integrity of the dam. In personal communication with Dr. Robert Schmidt, of Bard College, and Steve Gephard, from the Connecticut Department of Environmental Protection, CTDEP, a hanging trawl net with polyvinyl chloride (PVC) tubing passing through a face-board has been used effectively on the Mianus River and many other rivers to pass glass eels and elvers, and is commonly referred to as a Delaware-style eel pass **(Figures 2 & 3)**. By design, the bottom of the net is secured by rope firmly anchored (cement block) placed on the riverbed, and the upper portion stretches through PVC tubing and is securely affixed by rope to another cement block anchored upstream. This is a very cost effective and efficient design with few drawbacks.

Bronx River Context and Objectives

The Bronx River contains three dams. From south to north these dams are the 182nd Street Dam, the Bronx Double Zoo Dam and the Snuff Mill Dam. Respectively, they are 14, 10, and 7 feet in height. They present a successive series of obstacles hindering the upstream movement of juvenile eels, and limiting the upstream penetration of eels into an abundance of productive habitat. Optimal upstream habitat for eels includes rivers, ponds, and lakes with good to eutrophic water quality, few environmental threats, and a good prey base. Knights and White (1998) specify the following criteria as ideal eel habitat: shallow warm water, eutrophic conditions (but not excessively dystrophic), attached/emergent vegetation cover between 25-75%, and high densities of benthic invertebrate prey. In accordance with this description, the lentic ponds and lotic headwaters above the respective dams on the Bronx River meet and/or exceed these requirements and should therefore provide much needed beneficial habitat for eels.

In an effort to mitigate the range-wide decline of an historic resource, and to help conserve eel populations regionally, we propose implementing some of the FMP recommendations for enhancing eel passage at the dams on the Bronx River. Specifically, we are proposing the installation of this eel pass on the 182nd Street Dam in conjunction with the construction of the WCS/NOAA funded Bronx River Anadromous Fish Passage project. However, the eel passage enhancement methods introduced here could also be implemented independently of the anadromous fish passage, depending on the time frame of that project.

Methods

Since the eel population in the Bronx River has not been accurately assessed, we recommend a low cost approach as a preliminary method of study and effective measure to gauge the size population utilizing this river. Hence, a Delaware style eel pass provides an inexpensive option as well as an effective platform to survey usage and facilitate passage for juvenile eels. The concrete structure on the east side of the 182nd Street Dam is ideally situated to establish this structure and provides a convenient location to support and install face-boards and allow PVC tubing to pass through (**Figures 4, 5 & 6**). For a nominal cost there is an opportunity to

implement a Bronx River eel pass with little to lose and much to gain. Even though some juveniles may be able to wriggle up rocks to negotiate the dam, they stand the risk of being washed back over by the current and subsequently facing another climb, thus potentially enduring a Sisyphean task of interminable dimension. The makeshift pass has capacity to achieve greater success directing juveniles to side channels with lower velocity conditions where the face board will help prevent them from being swept back over the dam.

Materials and Costs

The following is a list of supplies required to implement a Delaware style eel pass:

Table 1. Table 1 itemizes the material and equipment required to fabricate a Delaware style eel pass. Discarded trawl netting which can be procured from the CTDEP for no cost (Brian Eltz, personal communication). Rebar can be procured internally within the Parks Department.

Description	**Dimensions**	**Quantity**	**Price (approx)**	**Comments**
Trawl netting	30 Feet	1	0	Supplied by the CTDEP
Lumber	12 foot lengths of 2'X12'	2	$25.00	Purchase
Rebar	4 Feet	6	0	Procure internally
Angle iron	4 Feet	2	$20.00	Purchase
PVC	4 Feet	1	$10.00	Purchase
Cement Screws	Misc.	1 Package	$5.00	Purchase
Cement Block	Cinder Block	2	0	Procure
Misc. Tools/Supplies	Unknown	Unknown	$45.00	Purchase/Procure
TOTAL COST			**$100.00 estimated**	

Maintenance

The Delaware-style eel pass is a low-cost alternative that requires minimal maintenance. These beneficial features render this simple device a desirable option where barriers have the potential to impede and /or obstruct uninterrupted eel movements. Rolling the netting material into loose ropes provides sufficient surface for eels to climb and/or wriggle through, but it also prevents the accumulation of debris, minimizes maintenance requirements, and has no structured impact on the dam. To enhance passage, the eel pass should be installed during mid-March and remain in place through mid-October, since glass eels will start moving upstream in mid-March. Initial installation of the eel pass (and also if removed seasonally) would require the effort and labor of several persons. Maintenance would require a weekly on-site examination to ensure the pass is functional and large debris such as limbs or logs don't accumulate and impinge upon the effectiveness of its design. To further facilitate ease of maintenance, the face-boards, PVC pipe, and netting can be removed in late autumn to early March to prevent unnecessary buffeting,

weathering and winter storm damage, especially if they are not permanently affixed to the supporting structures**.**

Monitoring

The eel pass would provide a practical opportunity to evaluate and document usage, and to potentially quantify population density and seasonal recruitment of immature American eels in the Bronx River**. This would provide an ideal approach to study eel movement in the Bronx River and allow statistical analysis for stock managers, by comparing period specific numbers in successive years of monitoring.** This can be readily accomplished by installing a trap device, which consists of little more than a container attached directly to the upstream end of the PVC tubing to capture eels that successfully negotiated the dam. Subsequently, movements can be evaluated and compared with temperature, tidal fluctuation and date to create an accurate model of seasonal pulses of juvenile eels to contribute valuable data to the scientific community. In addition, monitoring of adults can be accomplished through trapping and electro-shocking methods in the non-brackish stretches of the Bronx River. This would help augment a detailed population study and would be important in the overall monitoring effort. Small-scale efforts such as these are vital to stock managers in order to effectively evaluate local cohorts as part of the larger meta-population. However, the addition of a trap attached to the eel pass would require a routine monitoring effort to prevent mortality. Accordingly, the trap can be removed once the pre-determined monitoring period is completed.

Notifications and Approvals

The 182nd Street Dam, the potential site of the proposed eel passage, is owned by NYC Parks, and forms the boundary between the Bronx Zoo (WCS), upstream, and River Park, downstream. At River Park, the river becomes more visibly accessible to the public again, making this site both an ideal site for education and outreach, and a challenge for construction and maintenance. Parks is working closely with WCS to assure that protection and safety concerns are addressed for both organizations and the public. In addition, initial discussions with NYS DEC Dam Safety have indicated that we will not be required to apply for a permit for this work, however, we will confirm with them again prior to any installation. Finally, the 182nd Street Dam is a historical structure that receives scrutiny by the State Historic Preservation (SHPO), NYC Landmarks Commission (LPC). This means that any eel passage designs will have to be submitted and reviewed by SHPO. Designs will need to take aesthetic and historical values into account.

The following organizations and individuals will need to be notified for approvals prior to eel passage installation:

1. Wildlife Conservation Society
Marla Krauss
Title: Manager of WCS/NOAA Regional Partnerships
Phone #718-741-8136

Email: mkrauss@wcs.org

2. NYC Department of Parks & Recreation
Thomas Russo
Title: Deputy Chief of Operations in the Bronx
Phone #718-430-1837
Email: thomas.russo@parks.nyc.gov

3. NYS Department of Environmental Conservation NYSDEC Dam Safety Permit
Syed Alam
Title: Environmental Engineer
Phone #518-402-0628
Email: snalam@gw.dec.state.ny.us

4. State Historic Preservation Office (SHPO) Approval
Beth Cumming
Title: Historic Preservation Specialist
Phone #518-237-8643 (ext. 3282)
Email: beth.cumming@oprhp.state.ny.us

5. Bronx River Alliance
Robin Kriesberg
Title: Ecology Director
Phone: 718- 430-4690
Email: robin.kriesberg@parks.nyc.gov

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Photos

Figure 1. Glass eels in the palm of a person's hand (Photo credit NYSDEC).

Figure 2. Close-up view of the trawl netting entering the PVC tubing on the Mianus River Dam in CT.

Figure 3. View of eel pass netting hanging over spillway on the Mianus River Dam in CT in an area of reduced flow created by the face-boards.

Figure 4. Garrison Lake elver pass in DE two years after installation.

Figure 5. Proposed site of the Delaware style eel pass on the 182nd St. Dam in the Bronx River in NY.

Figure 6. Closer view of the east side of the 182nd St. Dam in NY.

Figure 7. Cement structure located on the top of the 182nd St Dam viewed from the east retaining wall. Face-boards could be attached to the upstream façade of the structure to reduce flow and prevent juvenile eels that climb the net from being carried back over the spillway.

Figure 8. A portable eel ramp at Bard College on the Sawkill River, NY, a tributary of the Hudson River. (Photo credit Bard College)