Passages for fish

overcoming barriers for large migratory species

Proceeding of a workshop held at Piacenza, Italy, June 10 2006
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enriched with

a selected and partially annotated
Bibliography on dams, fish ladders, fish passes and fish lifts, including ecological and technological considerations.

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LAKE STURGEON USE OF THE EUREKA DAM FISHWAY, UPPER FOX RIVER, WISCONSIN, USA

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Summary

All of the 25 recognized species of sturgeon around the world (Family Acipenseridae) have been negatively impacted by habitat alterations, primarily the building of dams on spawning rivers, and overfishing. Most populations of the North American lake sturgeon (Acipenser fulvescens) have been severely impacted by the loss and fragmentation of habitat due to dam construction on spawning and nursery rivers. One of the largest remaining lake sturgeon populations exists in the Winnebago System in east central Wisconsin USA. Despite the robustness of the population, lake sturgeon had not been able to consistently reach upstream spawning areas on one of the Winnebago System's major spawning tributaries, the upper Fox River from 1877 – 1988, due to the presence of the low-head Eureka Dam. In 1988 a fishway was built at the dam and in 1992-93 the dam was converted into a rock rapids, which has since provided unimpeded annual upstream and downstream access to lake sturgeon and a wide range of other migratory fish species. The plunge pool fishway design uses 30 meters of fishway length to accommodate 1 meter of head at the dam. Strategic placement of the fishway in an area of optimal flow is critical to successful fish use of the structure.

Introduction

All of the 25 recognized species of sturgeon around the world (Family Acipenseridae) have been negatively impacted by habitat alterations, primarily the building of dams on spawning rivers, and overfishing (Van Winkle et al. 2002). In North America, populations of lake sturgeon (Acipenser fulvescens), once widely distributed in the US and Canada, have been substantially diminished, or in some cases eliminated, from most of their original North America range in the Great Lakes, Mississippi River and Hudson Bay drainages (Rochard et al. 1990,).

One of the most serious barriers to long-term recovery of lake sturgeon populations is the negative impacts of dams on migration and successful spawning (Holey et al. 2000). While lake sturgeon typically spend much of their life in lentic environments, successful spawning and reproduction requires a lotic environment with water velocities greater than 0.5 m·sec-1 and proper rock or cobble substrate (Bruch and Binkowski 2002). These optimal lotic conditions are typically found in higher reaches of rivers tributary to the Great Lakes and other drainages within the lake sturgeon range. Most of the historic spawning rivers within the lake sturgeon range have been dammed downstream of spawning and nursery areas resulting in the eventual loss of the population or, at best, a lower density remnant stock residing in one or more fragmented sections of the dammed river (Wisconsin DNR, 1998). Fish passage for lake sturgeon has not been thoroughly researched nor applied as a means to mitigate the impact of dams on upstream and downstream migration of lake sturgeon (Peake et al. 1997).

This paper describes the actions taken on the upper Fox River in Wisconsin, USA to successfully mitigate the impact of the Eureka Dam on lake sturgeon migration.

Study Area

The Lake Winnebago System in east central Wisconsin supports one of the largest remaining lake sturgeon populations in North America (Bruch 1999). Lake sturgeon spawn within the system in two major watersheds that flow into Lake Winnebago and its associated Upriver Lakes: the large Wolf River watershed and the smaller upper Fox River watershed (Figure 1). While both rivers have dams on them upstream of Lake Winnebago, the 1st dam on the Wolf River is 200 km upstream of the lake and the river below the dam still provides abundant spawning and nursery areas for lake sturgeon. The 1st dam on the upper Fox River at Eureka, is only 15 km upstream from the lakes and has historically prevented migration of lake sturgeon to upstream spawning areas.

History of the Eureka Dam and Lock

The 1 meter head Eureka dam was constructed on the upper Fox River in 1877 aspart of a series of locks and dams built to facilitate commercial navigation between the Lake Michigan and Mississippi River basins (Figures 2 and 3). The construction of the dam and lock system was initiated by the Green Bay and Mississippi Canal Company, but ultimately financed and completed by the US Federal government. By the time the navigation system was completed, the railroads were well established in this area of Wisconsin, and as such, likely competed with the high maintenance Fox River waterway. Commercial traffic on the waterway ceased in 1938 and the navigation system was closed in 1951 (Wisconsin Department of Natural Resources, upper Fox Waterway files, Oshkosh). On August 1, 1962, the US Army Corps of Engineers transferred ownership and management responsibility of the 9 locks and 7 dams on the upper Fox River to the state of Wisconsin Conservation Commission. As part of the agreement for transfer of ownership, the Federal government rebuilt the Eureka dam using steel sheet piling. The Eureka locks and dam at the time were the only locks still functioning on the upper Fox River, operated since 1953 by a recreational boating club located upstream of the dam in the city of Berlin. The continued operation of the Eureka locks for recreational boat-

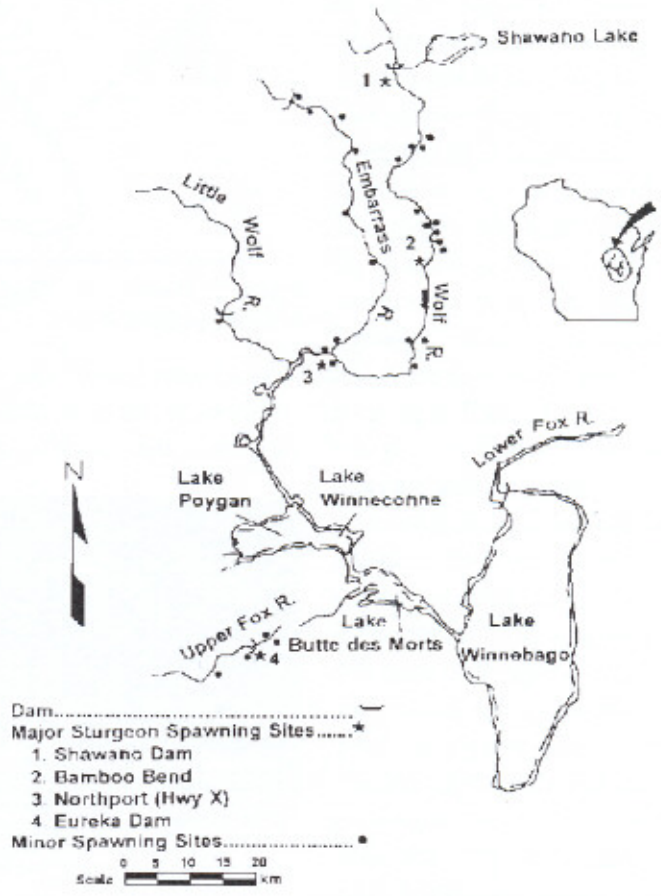

Figure 1. Overview map on the Lake Winnebago System indicationg the location of the major (*) and minor (dots) spawning sites, the position of major barriers (numbered) and the position of the study site (Eureka Dam, Upper Fox River)

ing maintained the need for the dam at the site, which in turn maintained the migration barrier in most years for sturgeon and other fish species attempting to ascend the river seasonally.

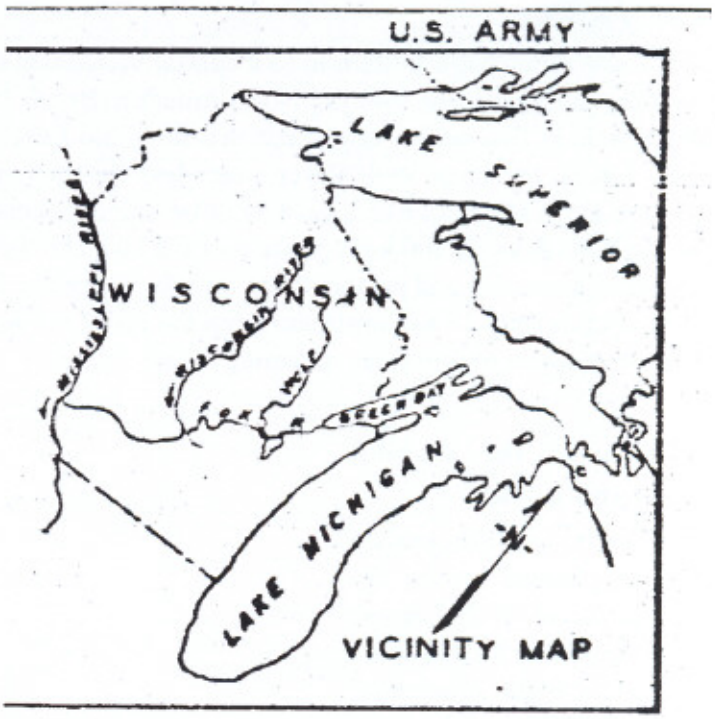

Figure 2. Historic Fox River waterway connecting the Great Lakes and Mississippi River Basins (original illustration from US War Department)

The Eureka Fishway

The first organized efforts to place an effective fishway at the Eureka dam began in May 1944. Recreational anglers upstream of the dam in the City of Berlin petitioned the Wisconsin Conservation Commission, who in turn petitioned the Federal government to install a fishway at the dam primarily to accommodate fish spring runs of walleye (Sander vitreus). The original dam was 60 meters long with 6 meters of hand operated sluice gates that provided an opening through which, it was thought at the time by the Federal government, fish could migrate if the sluice boards were removed. Although efforts by the recreational anglers and the state government in the 1940's and 1950's failed to secure the funding necessary to install a fishway specifically designed to pass fish past the dam, the sluice gate system was rebuilt in 1962 when the dam was rebuilt, with the hopes of improving fish migration past the dam. Fish passage occurred over Eureka dam following the re-construction of the sluice gates, but only during extreme flood events (Fig. 4).

Figure 3. Eureka Dam on the Upper Fox River, Winnebago County, Wisconsin, historic photograph on the original configuration as built in 1877.

Privately funded recreational boating interests continued to operate the locks at the Eureka dam through the 1960's – 1980's. Because of this use, the Wisconsin Department of Natural Resources in May 1987 allocated funds to complete an engineering study and develop a design of a fishway that would facilitate passage of sturgeon and other native fish species at the Eureka dam. Design plans were completed and in 1988 a three step plunge pool

Figure 4. Original fishway at Eureka Dam after dam repairs, 1962. Fishway only operated successfully during high water events as depicted in the photo.

Figure 5. New Eureka Dam fishway constructed in 1988.

fishway, 30 meters long, to accommodate 1 meter of head, was constructed at the site (Figures 5 and 6). The entrance of the fishway was placed at the face of the dam at the site of optimal water velocity, replacing the old sluice gate fishway.

In the spring of 1989, the first spring following construction of the new fishway, lake sturgeon and walleye were documented passing through the fishway and migrating to spawning areas up to 50 km upstream of Eureka (to the next barrier). In addition to passing through the fishway to migrate to upstream spawning areas, lake sturgeon were also observed in 1989, and in every year through 2006, spawning in the fishway taking advantage of the water velocities and substrate within the structure.

Creation of the "Eureka Rapids"

While the upstream passage problem at the Eureka dam was solved by the installation of the plunge pool fishway, downstream migration over the dam itself was believed to still be a problem. Dyed fry drift studies completed with walleye in the 1960's indicated strongly that few larval fish were able to escape from the undertow below the spillway of the dam (Figure 3) (Priegel, G. WI Dept. of Natural Resources-retired, personal communication). Small lake sturgeon are very poor swimmers (Amaral et al. 2003), and likely would also find it very difficult to escape the undertow below the dam. To address this problem, the Wisconsin Department of Natural Resources joined with numerous sport fishing organizations including Walleyes for Tomorrow, Sturgeon for Tomorrow and Otter Street Fishing Club and a local, although world-known marine engine firm, Mercury Marine, to design and finance the construction of the Eureka Rapids.

In the winter of 1992-93, barges dumped 3250 cubic meters of quarried limestone rock, 2-100 cm in diameter, below the dam to fill in the scour hole and create a "rapids". The south edge of the rapids was formed into a wing deflector to direct flow along the shore downstream of the fishway. The enhanced flow increased the movement of fish into the fishway, and ex-

panded the suitable spawning area for sturgeon to an additional 80 meters along the rip rapped shoreline downstream of the fishway. Figure 7 illustrates a group of lake sturgeon spawning along the riprap shoreline immediately below the fishway following construction of the rapids and wing deflector. The large quantity of rock used to create the rapids not only eliminated the undertow below the dam, it also created excellent spawning, nursery and/or food producing habitat for a variety of other fish species including walleye, smallmouth bass (Micropterus dolomieui) and flathead catfish (Pylodictis olivaris) (Bruch, R.M., WI Dept. of Natural Resources, Oshkosh, unpublished data).

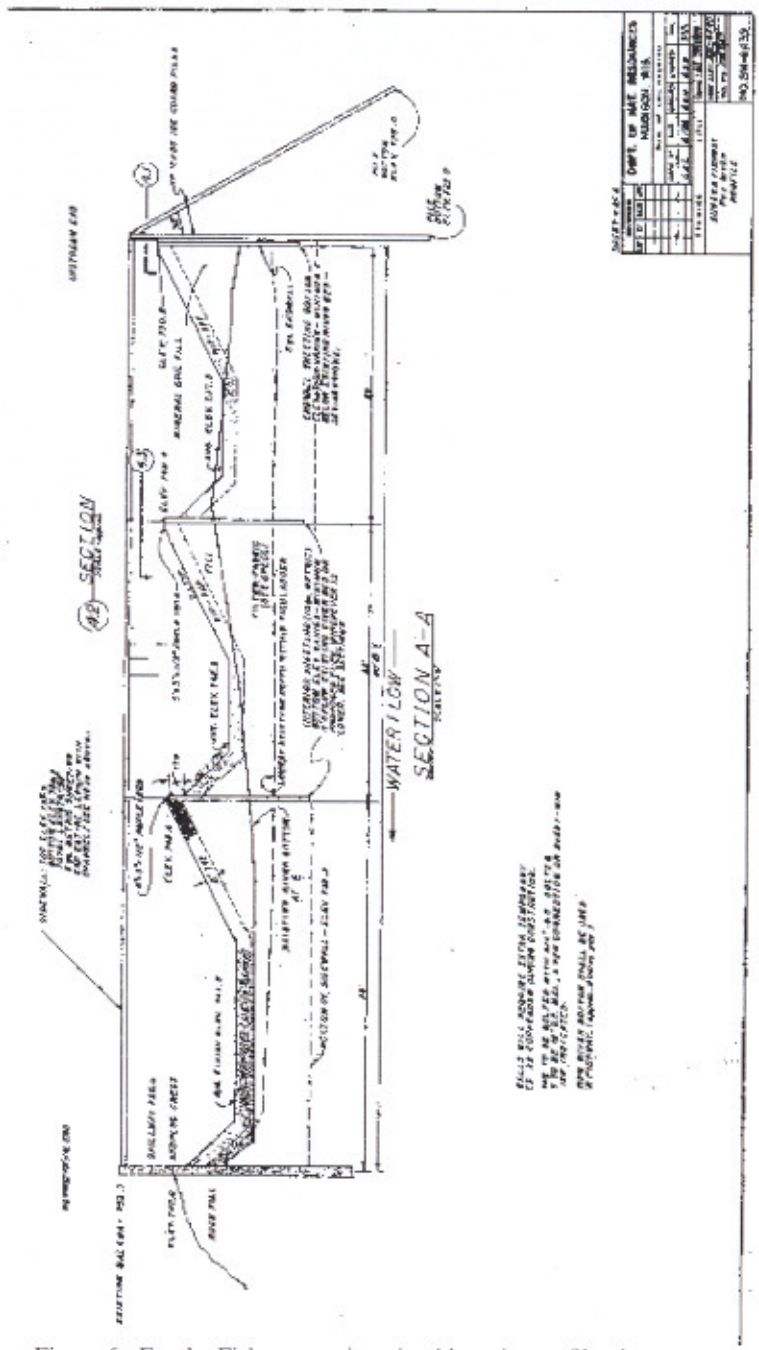

Figure 6. Eureka Fishway engineering blueprint profile view.

The final configuration of habitat created at the dam by construction of the rapids and the fishway resulted in creating some of the most diverse fish habitat on the upper Fox River in addition to providing unimpeded safe upstream and downstream migration past Eureka dam for a wide range of fish species including lake sturgeon (Figure 8). Long term monel tagging studies from 1954 – 2006, and recent radio and sonic telemetry studies on Winnebago System sturgeon have clearly shown unimpeded annual movement of sturgeon upstream and downstream of the Eureka Dam since the fishway was installed in 1989 and rapids were built in 1992-93 (Bruch, R.M., WI Dept. of Natural Resources, Oshkosh, unpublished data).

Discussion

While many of the fishways built in North America since the 1950's have been designed for salmonids (Collins et al. 1962), efforts have been made to design, evaluate, and build

Fig. 8. Eureka "Rapids" and fishway looking upstream from below the dam, 2005.

Fig.7. Spawning lake sturgeon utilizing rip rap bank downstream of fishway following the creation of the "Eureka Rapids" and associated wing deflector.

structures that accommodate the movement of other non-salmonid fish species (Schwalme et al. 1985; Katopodis et al, 1991). Much research has been done as well on the swimming performance of various sturgeon species to assist specifically in the design of fishways for sturgeon (Webb 1986; Adams et al. 1997; Chan et al. 1997; Peake et al. 1997; Liao and Lauder 2000; Kynard and Horgan 2001; Adams et al. 2003; Cheong et al. 2006). Generally, research findings indicate that, while swimming performance improves with sturgeon size, sturgeon as a rule are not as effective swimmers as salmonids due to their heterocercal tail, intermediate metabolism, and greater drag caused by their scutes. Peake (1997) suggests a range of maximum water velocities in fishways to ensure passage of lake sturgeon based on fishway length. He suggests for lake sturgeon 120 cm and larger, a maximum water velocity of 1.4 m·sec-1 for a fishway the length of the Eureka structure (30 m). While water velocities have not been measured in the Eureka fishway, it has worked exceptionally well for sturgeon passage, and spawning, every year since its construction in 1988. Plans have been made to "reverse engineer" the fishway and measure the range of water velocities and depth profiles of the fishway's three plunge pools to document these characteristics which undoubtedly have contributed to the structure's success.

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