Thirty Years of Light Data on the Upper Mississippi River: What is it Telling Us?

A summary of 30 years of photic zone data at Mississippi River Lock & Dams 8 & 9

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About this Report

The Wisconsin Department of Natural Resources collected the 30th consecutive year of underwater light data at Lock and Dams 8 and 9 in 2017. This photic zone dataset is one of the most robust in the nation and is providing valuable insights into ecosystem mechanisms. This report was developed by the Wisconsin Department of Natural Resources Office of Great Waters, Mississippi River Unit.

This report reflects water quality program priorities and water resources monitoring strategy goals and objectives. This monitoring report is an amendment to Wisconsin's Statewide Areawide Water Quality Management Plan and will be forwarded to USEPA for formal certification.

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Summary

Water clarity is a keystone variable in aquatic ecology. The positive relationship between water clarity and aquatic plants is well understood and the prevalence of aquatic plants drives a variety of ecological processes in aquatic ecosystems. Proliferation of aquatic plants has been shown to drive a variety of feedback mechanisms including reduced sediment resuspension, reduced phytoplankton, increased invertebrate biomass, increased refuge for zooplankton, increased denitrification, production of allelopathic substances, and increases in waterfowl abundance.

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Water clarity and aquatic plant abundance are among the major factors driving fish community characteristics across the Upper Mississippi River. Widespread landscape disturbance, resulting in increased sediment loading, has been identified as driving declines in aquatic plant abundance. This results in declines of backwater specialists and predators with plant-dependent life cycles. Clear, vegetated systems tend to be dominated by visual predators such as yellow perch (*Perca flavescens*), northern pike (*Esox lucious*), and largemouth bass (*Micropterus salmoides)*. Predatory fishes such as northern pike, bowfin (*Amia calva*), largemouth bass and longnose gar (*Lepisosteus osseus*) are often able to substantially reduce recruitment among planktivorous fishes. This reduction in planktivorous fish can alter food webs and result in further increases in aquatic vegetation and water clarity. Alternatively, benthivorous fish such as common carp (*Cyprinus carpio*) tend to be abundant in turbid systems and can keep these systems in a turbid state due to resuspension during their feeding and spawning activities. Once substantial populations of common carp and other benthivores are high, establishing aquatic plants can become difficult due to poor water transparency.

Water clarity and aquatic plant abundance are also major factors driving invertebrate and waterfowl abundance and diversity. Vegetation beds tend to be richer in invertebrate species numbers and total biomass than unvegetated areas. High food availability and reduced predation pressure from fish tend to be driving factors for invertebrate differences among vegetated and unvegetated sites. Substantial shifts in the number of migrating waterfowl observed at vegetated versus unvegetated sites is a frequent occurrence. Abundant food resources associated with vegetation beds tend to attract large numbers of migrating waterfowl that need to refuel for long flights.

LI-COR sampling equipment used to measure underwater light.

The depth of one percent of surface light is generally viewed as the delineation between the photic and aphotic zones. Figure 1 (below) provides a fascinating and valuable look into the chronology of the River downstream of Lake Pepin since 1988. A lot of valuable insight can be gained from this dataset: from the collapse of vegetation post-1988; to the nearly ten years it took the Mississippi to reset back to a clearer state; to the extreme water clarity observed in 2009 and 2010.

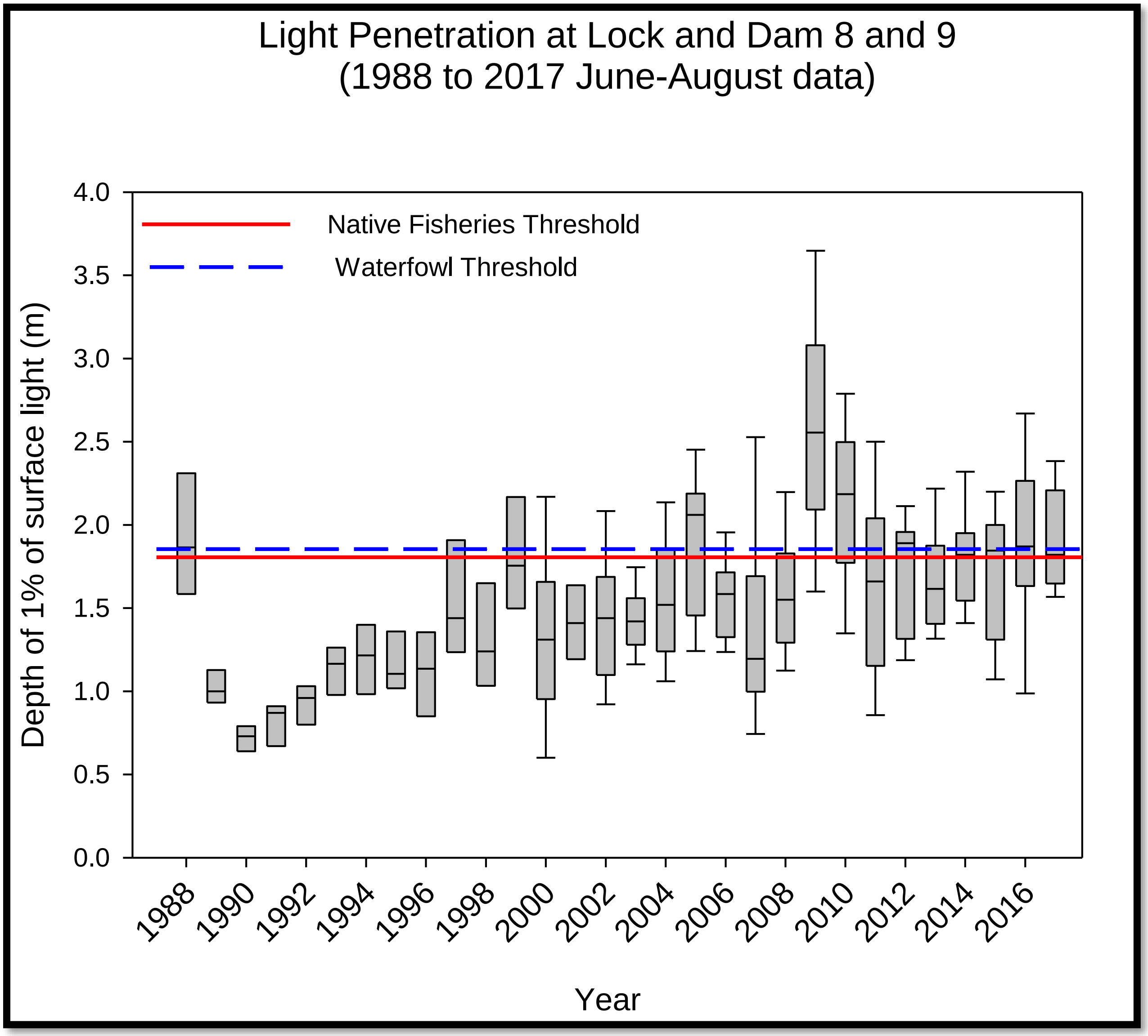

Figure 1. Long term trends in one percent of surface light at Lock and Dam 8 and 9. The red line indicates an observed threshold for native and recreational fish biomass (Giblin 2017). The blue dashed line indicates a tipping point for vegetation, waterfowl and fish for Chesapeake Bay (Kemp et al. 2004).

It appears that the fall 2010 flood was somewhat of a reset event for the River, with 2011-2017 light penetration looking similar following the unusually clear years of 2009 and 2010. The red line indicates the equivalent one percent of surface light value which corresponds to 16 mg/L TSS- a threshold we've identified where fundamental shifts in the native and recreational fish community tend to occur (Figure 2).

Pool 8 reached this threshold around 2007 and has remained above the threshold. Pool 9 is yet to meet the underwater light threshold on a consistent basis but is improving over time (Figure 3).

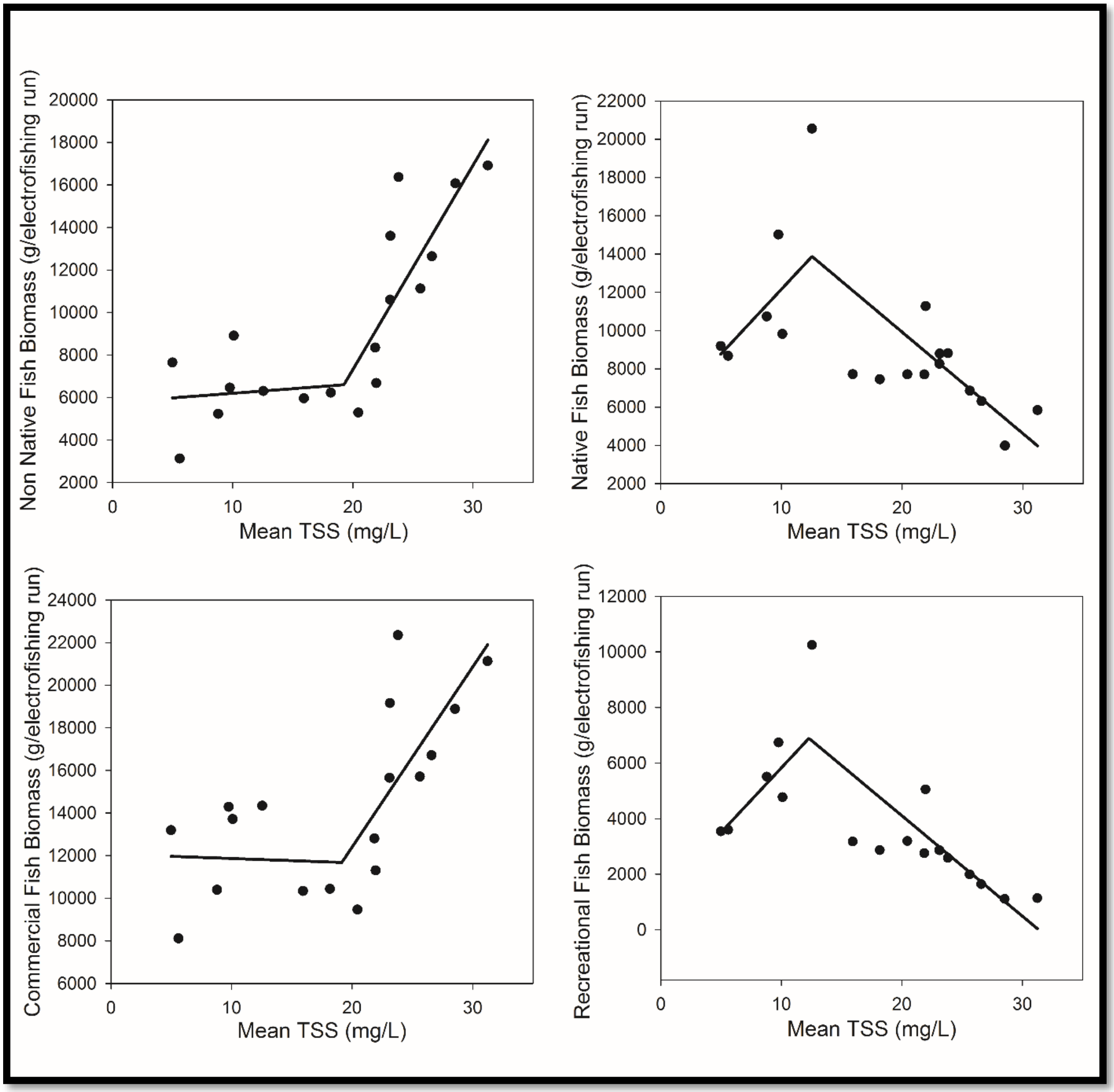

Figure 2. Relation between mean annual non-native and native fish biomass per electrofishing run and mean summer TSS in Pool 8 of the Upper Mississippi River (1993-2011). The solid line indicates the piecewise regression trend (Giblin 2017).

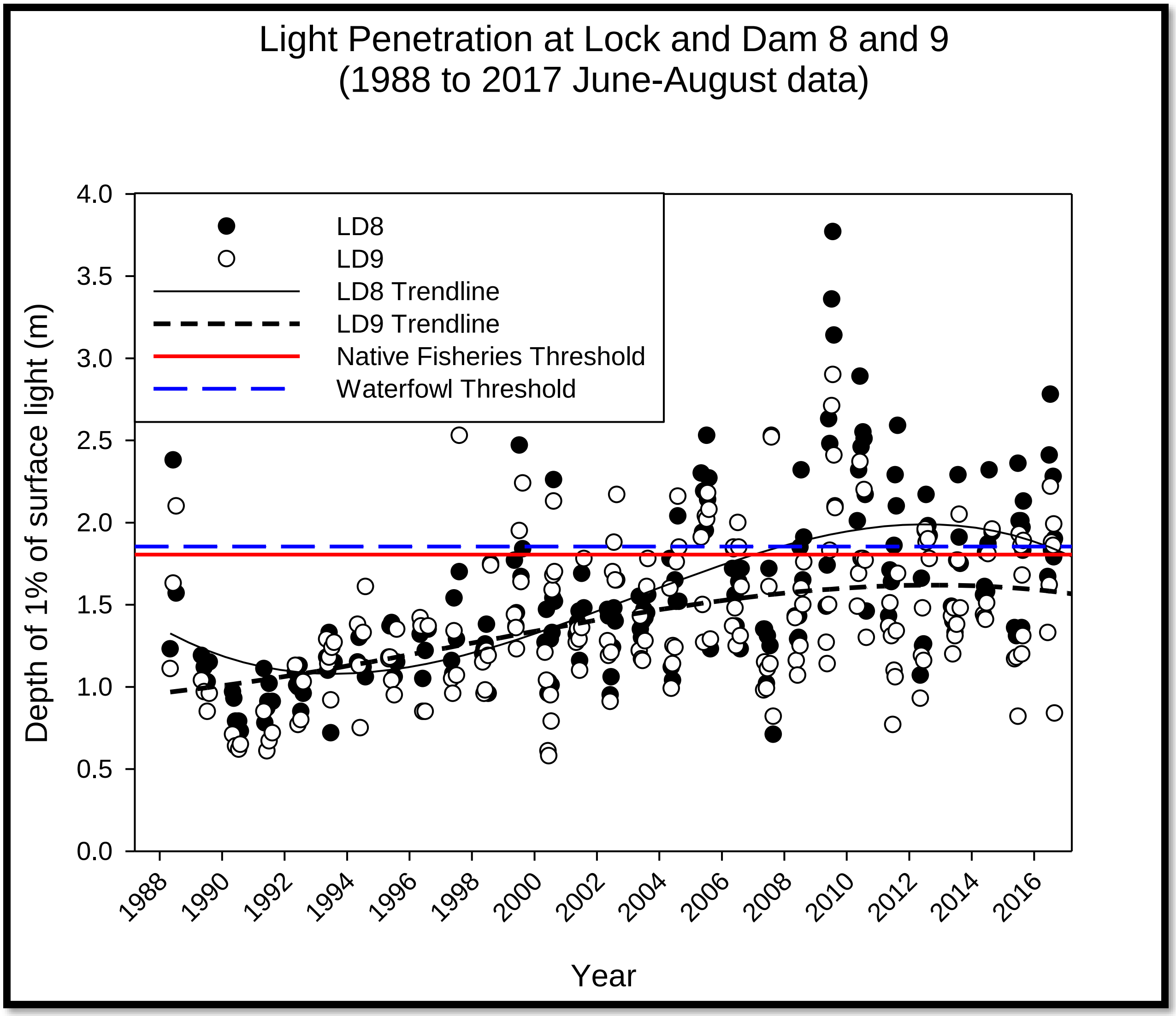

Figure 3. Long term trends in one percent of surface light at Lock and Dam 8 and 9. The red line indicates an observed threshold for native and recreational fish biomass (Giblin 2017). The blue dashed line indicates a tipping point for vegetation, waterfowl and fish for Chesapeake Bay (Kemp et al. 2004).

During the summer of 2015, WDNR Staff conducted a longitudinal survey of water clarity within Wisconsin waters (Lock and Dams 3-11; Figure 4). This method provides an efficient way to quickly assess WI waters for transparency. This approach also allows us to identify areas where water clarity is rapidly declining. Water clarity improved substantially between Lock and Dams 3 and 4, as a result of the high sediment trapping efficiency of Lake Pepin (Figure 5). This also gives a great deal of insight into what the Mississippi River, within Wisconsin waters, will look like once Lake Pepin is filled with sediment. Water clarity continued to improve from LD4 to LD6, when peak transparency was reached near Trempealeau, WI. Downstream of LD6, water clarity steadily declined to the Illinois border.

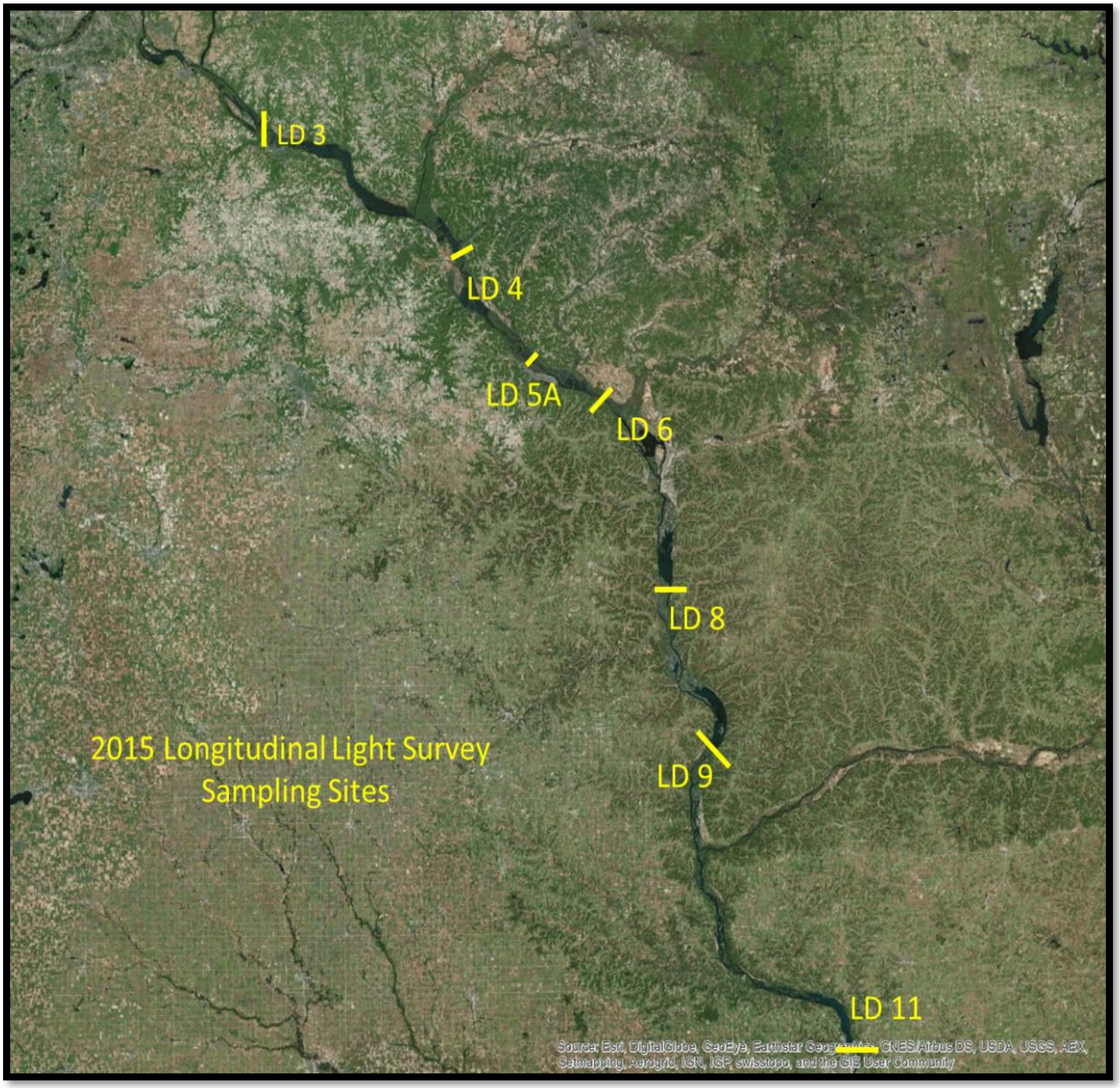

Figure 4. Location of underwater light sampling sites at lock and dams (LD 3-11) during 2015.

This photo shows a researcher lowering an underwater light sensor into the water at Lock and Dam 8.

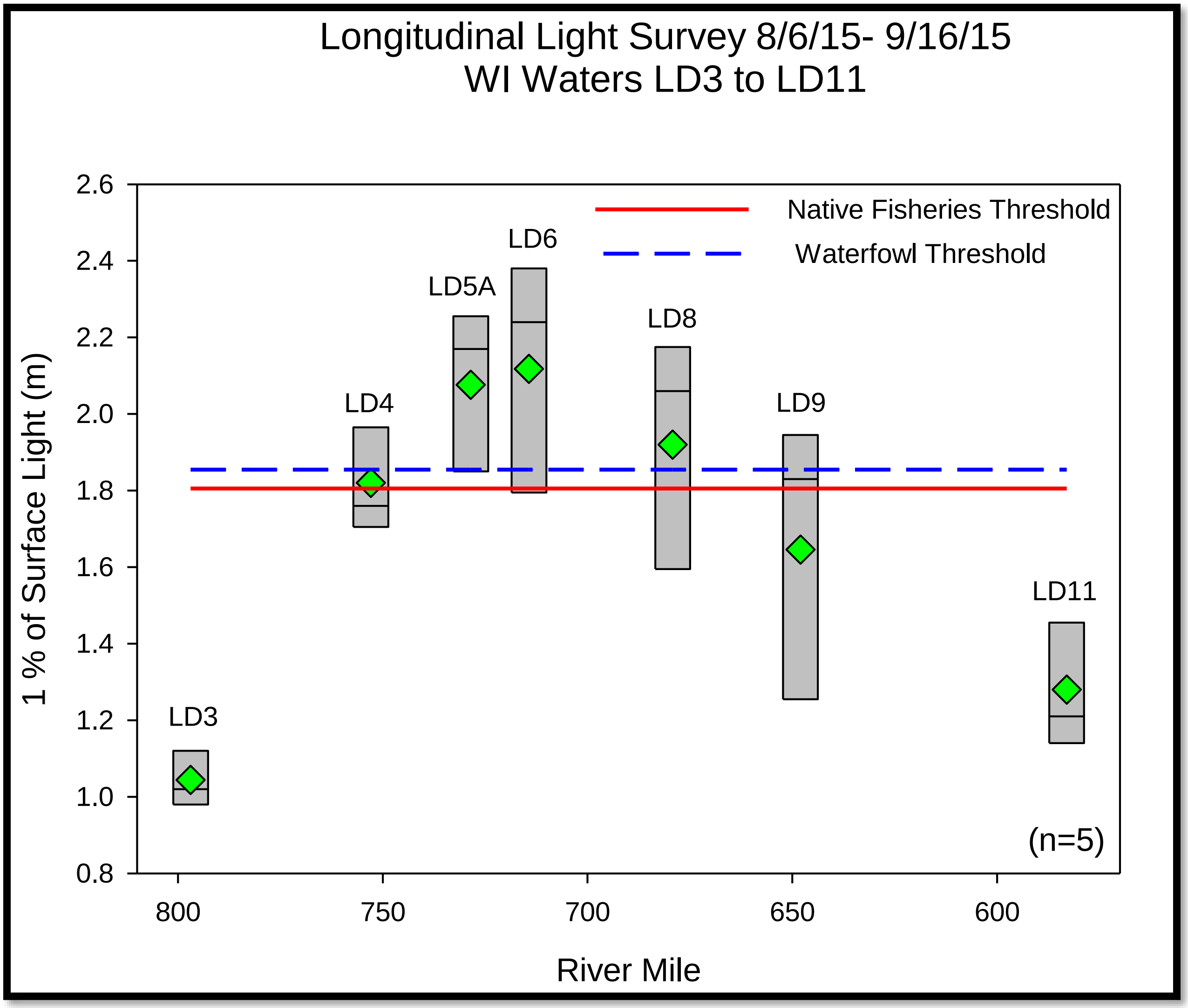

Figure 5. Longitudinal depth of one percent of surface light data collected from Lock and Dams 3-11 during the summer of 2015. The red line indicates an observed threshold for native and recreational fish biomass (Giblin 2017). The blue dashed line indicates a tipping point for vegetation, waterfowl and fish for Chesapeake Bay (Kemp et al. 2004).

In relation to meeting the light threshold of 16 mg/L TSS to move the fish community to a more robust native species assemblage, we have not yet met our light goal upstream of Lake Pepin (Pools 3 and Upper 4) and again in Pools 9-11. This speaks to the need for projects to improve water clarity in these reaches of river through habitat projects (e.g. island building in windswept impounded areas of Pools 9- 11) and watershed improvements. The recently completed Harper's Slough HREP and the future Lower Pool 10 Islands HREP should help to improve water clarity in this reach.

In areas where we are meeting our water clarity goals (Pools Lower 4-8), projects to improve water clarity do not appear to be needed at this time and we should consider directing our habitat activities toward other projects, like backwater dredging, to increase off-channel depth lost due to sedimentation. Using backwater sediments to achieve forestry objectives provides abundant opportunities to achieve both aquatic and terrestrial ecosystem goals. Projects that optimize the connectivity of off-channel areas to the main channel would also be good projects to pursue in this reach. This can involve moving more or less water into particular backwaters depending on site-specific water quality characteristics. We should still strive to implement watershed improvements in the entire reach to extend the geographic extent of areas meeting our water clarity goals.

References

Giblin, S. M. (2017). Identifying and quantifying environmental thresholds for ecological shifts in a large semi-regulated river. *Journal of Freshwater Ecology*, *32*(1), 433-453.

Kemp, W. M., Batleson, R., Bergstrom, P., Carter, V., Gallegos, C. L., Hunley, W., ... & Murray, L. (2004). Habitat requirements for submerged aquatic vegetation in Chesapeake Bay: Water quality, light regime, and physical-chemical factors. *Estuaries*, *27*(3), 363-377.

A submersed plant community in a typical Mississippi River backwater.