FLOW MANAGEMENT TO SUPPORT NATIVE FISHERIES OF THE HURON RIVER

Rationale and Recommendations for Multiuse Management of Mainstem Dams

Hydrology is the movement of water through a system. It is a master variable in rivers defining the channel shape, habitat, water temperature and species composition. The hydrologic regime is a characterization of water movement in a particular system and is generally described by the height, flow, velocity and rise and fall of water in a river. Each river system has its own unique natural flow regime or how water would behave if the watershed were not altered by humans (through dams, extraction, urban development, agricultural ditching, etc.). When we depart from the natural flow regime, we take that system out of balance which has consequences for how the river functions and the life it supports.

Hydrologic Regime of the Huron River

The Huron River has significant groundwater inputs which keeps water temperature down and flows relatively stable. The geology of the upper portion of the Huron supports greater groundwater contributions which results in higher base flows and more flow stability. The lower portion of the system occurs in till plain where more overland flow, or runoff occurs. Historically, this section of the river was characterized by more flashy (less stable) flow. On an annual basis, high flows tend to occur in March through May and baseflow conditions occur from July through October.

Factors influencing the hydrology of the Huron

Over time, as more people moved to the area and made changes to the land and river system, the Huron diverged from its natural flow regime. Several factors significantly alter the hydrology of a river. Dams, by design, are a physical barrier to water movement. Changes in flow in a natural system are gradual. Dam operations result in more dramatic changes in flow both in magnitude (how much) and frequency (how often). Development of land for agriculture and urban uses modifies hydrology. The removal of forests and filling of wetlands, channelization of tributaries, addition of drain tiles and impervious surfaces such as roads, rooftops and parking lots, all contribute to water moving to the river faster. Rainfall tends to move over land as runoff rather than infiltrating the soil into the groundwater and slowly moving toward the river. The increase in runoff dramatically alters the flow regime of a river. The rise of the river occurs more quickly creating unnatural spikes in water level and flow velocity.

In addition, climate change presents a new set of challenges to river systems and leads to further deviation from a natural flow regime. In Southeast Michigan, total precipitation has increased, the strongest storms have become stronger and more frequent, and snow has been replaced with rain. Annual precipitation totals increased by about 12% from the 1950-2014[1], but the magnitude of the change varies from location to location. Total annual precipitation in Ann Arbor has increased by 44%[2] while in other nearby areas, it has only increased slightly. Climate scientists anticipate the broader

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[1] GLISA, 2015. Great Lakes Climate Divisional Summary. Southeast Lower Michigan. Analysis using NCEI Climate Divisional Dataset. NOAA Great Lakes Integrated Sciences and Assessment. Ann Arbor, MI. http://glisa.umich.edu/climate-divisions

[2] GLISA, 2015b. Great Lakes Station Climatologies. Analysis using NCEI Global Historical Climatology Network-Daily. NOAA Great Lakes Integrated Sciences and Assessment. Ann Arbor, MI. http://glisa.umich.edu/resources/great-lakes-climate-stations

regional trend will continue or accelerate, with approximately 5-25% more precipitation falling on the region by the end of the century. The amount of precipitation falling in the most intense 1% of precipitation events increased by 37% in the Midwest from 1958 through 2012[3]. Ann Arbor has seen a 48% increase in the number of daily precipitation events that exceed 1.25” of precipitation. Further, while total annual precipitation will rise in this region, many models also suggest that summer precipitation will remain stable or decline in the future meaning less precipitation falling during the summer with higher potential for drought. Finally, winters have become shorter. The frost free season has grown by 9 days. Warmer winter temperatures means snow is melting more quickly and snow is being replaced by rain. This trend is projected to accelerate rapidly. By the end of the century, the region could see 1-2 months less of freezing temperatures, substantially altering the nature of winter precipitation in many locations.[4]

It is clear that climate change is affecting the timing, delivery and volume of precipitation moving through the Huron River system. The most significant impacts to date are less snowmelt for groundwater recharge, increased severity and frequency of spring and early summer storms leading to higher, faster flows and more extreme spikes in flow, and drier summers leading to low baseflow conditions in late summer and early fall.

When we look at the cumulative impact of these factors influencing the flow regime of the Huron River, some patterns are emerging.

How these factors have altered the hydrologic regime

We are fortunate in the Huron River to have flow data available from several long running USGS stream gages. This data has been analyzed to characterize the flow regime of the system and how it has changed over time. The data can also help identify contributing factors to changes in flow that are known to be or potentially harmful.

Over the past 100 years, average annual flow has increased and corresponds with a similar increase in average annual precipitation over the same period of time. Minimum and maximum flow magnitudes have also increased. The Huron has seen a similar increase in average monthly flow for all months except March and April with the greatest increases in flow occurring in October and November. An analysis of daily flow data reveal differences among gage locations. Gages at Ann Arbor and Ford Lake dam have higher flashiness (rapid changes in flow) when compared to other gages. The New Hudson gage shows high flashiness in April and November which are the months when Kent Lake Dam, located just above the gage, adjusts lake levels. The Hamburg gage shows the lowest flashiness and likely resembles the natural flow regime more than any other gage. The stability of flow on a sub daily basis was also examined. The Ann Arbor gage showed high sub daily fluctuations in flow throughout the year. While some of this variability can be attributed to the Allen Creek outfall during rainfall events, it does

[3] Pryor, S. C., D. Scavia, C. Downer, M. Gaden, L. Iverson, R. Nordstrom, J. Patz, and G. P. Robertson, 2014: Ch. 18: Midwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 418-440. doi:10.7930/J0J1012N.
[4] Pryor, et al. 2014.

not account for all of the variability in flow. Argo dam operations and the diversion of water to the Cascades also contribute to the instability of flow in this stretch of river.[5]

Additionally, with land conversion and the increase in impervious surface over time, runoff has increased which also alters the natural flow regime. The Runoff Curve Number (estimate of the amount of direct runoff from a rainfall event) increased 18% when comparing the pre-settlement landscape with 1992[6]. This increase in runoff following precipitation events results in increased overall flashiness of the system, increasing peak flows and decreasing low flows during drought.

In summary, the Huron has higher average flows today than it had historically, urban and agricultural development led to a more flashy system in general, and in several places on the river where we have data, spikes in flow are more dramatic and far more frequent. So, what does this mean for the ecology of the Huron River and the many services a healthy river provides? Rivers where runoff leads to faster, steeper spikes in flow experience alterations to sediment transport. Erosion of banks and scour of the river bed impacts water quality and habitat quality. Runoff also delivers pollutants and nutrients to the river contributing to declines in water quality and eutrophication. Slow flow in impoundments behind dams interrupts the movement of water, sediment and organisms. The entire biological community changes to species that prefer warmer, deeper, slower water. Rapid change in flow or overall high flows displace aquatic insects and fish eggs, and can sweep adult fish guarding nests making eggs and fry vulnerable to predation. The slow steady increase in the average annual flow of the river can lead to more frequent flooding.

Implications for the ecology of the system – a look at smallmouth bass

Smallmouth bass are a critical component of the Huron River system. The species is both a top predator important to the balance of the entire community of aquatic organisms and a prized game fish. By looking at flow requirements for this species, we can explore what aspects of the natural flow regime are most critical and which aspects of the altered flow regime are most detrimental. Smallmouth bass reproduce in the spring. Spawning behavior begins at 59 F. In the Huron, this occurs as early as mid-April or as late as mid-May but most commonly occurs in the first week of May.[7] Once water temperatures reach this level adults build nest, deposit eggs, and guard eggs and young. The entire process takes about six weeks. Many other native fish in the Huron River system are also spawning during the same period of time. Bass select nesting sites to avoid high velocity water. They need cover, depth or slower moving water. Bass select their site based on flow at the time of nest selection. So if flow is slow at the time of selection, individuals may select a nest location that has a high degree of exposure to high flows should flow change during the spawning period.[8]

A study of spawning success of smallmouth bass concluded that the species is reliant on stable flows for successful spawning. Specifically, this research found that a 100-150% change in flow within a 12 hour

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[5] Duan, Z., C. McDowell, S. Roberts, Y. Wang, X. Xu. 2014. Environmental Flows for the Huron River System. School of Natural Resources and Environment, University of Michigan.
[6] Duan, Z. et al. 2014.
[7] Bovee KD, Newcomb TJ, Coon TG, 1994. Relations between habitat variability and population dynamics of bass in the Huron River, Michigan. *National Biological Survey*. Report 21.
[8] Elliott, Austin, 2015. Spawning Habits of Smallmouth Bass and the Relation to Localized Flow: A study of the Huron River. Literature Review for the Huron River Watershed Council.

period resulted in failure of 40% of nests and damage to an additional twenty percent.[9] Research to date indicates that flow variability is more important than magnitude (volumetric rate of flow, e.g. cubic feet per second) for spawning success. In other words, it is not how much flow that matters but rather that the flow does not fluctuate rapidly. However, low velocity microhabitats (fallen trees, boulders, deeper pools) are essential in high flow conditions. A high flow, uniform channel with little or no habitat will not support strong smallmouth bass reproduction with implications for bass populations in the future. Survival of juvenile bass is also negatively affected by erratic flows. Years with the strongest birth rate and survival for smallmouth bass are years where June flows are within 40% of the average flow and are stable.[10]

The Huron River is extensively dammed with nearly 100 known dams throughout the system and 17 on the mainstem. Typically dams are operated for a designated purpose – hydropower and recreation are the primary roles of Huron River dams. Dams are flow regulators and while the impacts of dams on aquatic communities are mostly negative, there is potential to manage dams as a multi-use system achieving multiple goals including ecosystem health which can lessen the negative impacts of these dams. Further, as climate change continues to result in increasing annual precipitation and more frequent extreme rainfall events, dams can be employed to mitigate some of the impacts of climate change such as flooding, high flows and drought.

Recommendations

Multi-use dam management encourages the management of river flow for multiple purposes. The Huron River and its communities will benefit from a holistic approach to flow management that balances recreational, economic and ecological goals. The case of the smallmouth bass provides a starting point for managing dams to achieve multiple goals. **Successful dam management to support improving the smallmouth bass fishery and healthy populations of many other native fish would:**

1. Prevent any change in flow that exceeds 150% within a 12-hour period between April 15th and June 30th each year. Ideal target is <100% change in flow within a 12-hour period.
2. Ensure flows remain above 80% of baseflow (defined as 50% of August average daily exceedance flow from the last 10 years) at all times during the frost free season.
3. Release incoming water gradually in a way that approximates a more natural rise and fall of flow.
4. For impoundments with summer/winter lake levels, stretch the raising and lowering of lake levels out over a longer period of time and adjust based on the availability of water such that spikes in flow are minimized and flow below the dam does not drop below the 70% exceedance flow (based on April 15-June 30 flows for the last 10 years).

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[9] Rapid River Coalition, Main Department of Inland Fisheries and Wildlife, 2008. Smallmouth Bass/Brook Trout habitat manipulation studies in Rapid River TWP C and Upton, Oxford County Maine, 2007 Progress Report.

[10] Lukas, J.A., D.J. Orth, 1995. Factors affecting nesting success of smallmouth bass in a regulated Virginia stream. Transactions of the American Fisheries Society. 124, 726-735.

Challenges and Opportunities

In order to allow dam operators to manage dams using the best practices outlined in this document several barriers must be overcome. There are a unique set of challenges and opportunities associated with each dam. FERC and DEQ regulations have to be adhered to. Lakefront residents have expectations for water level management. The mechanism used to manage flow at a dam constrain to what degree flow can be controlled. Some reservoirs have limited storage capacity. At the same time, there is great opportunity. The Huron River is increasingly becoming a destination for recreation. The smallmouth bass fishery is prized by fly fishermen. Liveries are putting more paddlers than ever on the Huron after the 2015 designation as a National Water Trail. This means a growing local economy, the foundation of which is a healthy clean river that supports a quality native fishery. Additionally, there is a strong network of dam owners and operators in the watershed and a wealth of flow data that provide the enabling conditions under which multi-use flow management can be achieved.

In conclusion

Multi-use flow management will improve the health of the Huron River, its ability to support a thriving native community of species and the capacity to adapt to a changing climate while continuing to utilize dams for designated purposes.