Ecology and Evolutionary Biology
2024; 9(1): 9-13
http://www.sciencepublishinggroup.com/j/eeb
doi: 10.11648/j.eeb.20240901.12
ISSN: 2575-3789 (Print); ISSN: 2575-3762 (Online)

Spawning Habitat Selection and Egg Deposition by Reintroduced Lake Sturgeon in a Tributary to Cayuga Lake, NY

Dawn Dittman[1], Marc Chalupnicki[1, *], Phyllis Randall[1], Emily Zollweg-Horan[2]

[1]United States Geological Survey, Tunison Laboratory of Aquatic Science, Cortland, USA
[2]New York State Department of Environmental Conservation – Fisheries, Cortland, USA

Email address:

dditman@usgs.gov (Dawn Dittman), mchalupnicki@usgs.gov (Marc Chalupnicki), prandall@usgs.gov (Phyllis Randall), emily.zollweg-horan@dec.ny.gov (Emily Zollweg-Horan)

[*]Corresponding author

To cite this article:

Dawn Dittman, Marc Chalupnicki, Phyllis Randall, Emily Zollweg-Horan. (2024). Spawning Habitat Selection and Egg Deposition by Reintroduced Lake Sturgeon in a Tributary to Cayuga Lake, NY. *Ecology and Evolutionary Biology*, *9*(1), 9-13. https://doi.org/10.11648/j.eeb.20240901.12

Received: December 12, 2023; **Accepted**: January 5, 2024; **Published**: January 18, 2024

Abstract: In June 2017, we documented the first observed spawning event by a reintroduced population of Lake Sturgeon (*Acipenser fulvescens*) in Fall Creek, a tributary to Cayuga Lake, New York, USA. This is the first observed spawning encounter of adult Lake Sturgeon since the beginning of the multi-agency Lake Sturgeon restoration effort in Cayuga Lake initiated in 1995 by the New York State Department of Environmental Conservation. Lake Sturgeon egg deposition was found specifically on substrate mainly composed of gravel sized rocks with depths and flows that made up a unique microhabitat combination within the creek which is not typical of habitat identified in other Lake Sturgeon spawning habitat studies across the Great Lakes. An estimated 810,052 ± 24,386 eggs were deposited in the sampled area of Fall Creek. The identified, potentially productive spawning microhabitat type in Fall Creek is likely to be widespread in similar tributaries around Cayuga Lake as well as small tributaries to other Finger Lakes and Lake Ontario. Ongoing research is focused on the evaluation of the extent of Finger Lakes habitat similar to that identified in Fall Creek. This microhabitat evaluation of sturgeon spawning and the broad scale landscape knowledge of tributary habitats, should support subsequent management to restore Lake Sturgeon.

Keywords: Lake Sturgeon, Spawning, Habitat Selection, Reintroduction, Egg Deposition

1 Introduction

Lake Sturgeon (*Acipenser fulvescens*) is a native Great Lakes fish species that has virtually disappeared, primarily due to overfishing and habitat destruction–[1, 5, 16]. A commercially important fish, Lake Sturgeon was present in the major Great Lakes drainage waters of New York, including the Finger Lakes [7], but is now listed as a threatened species [17]. In particular, the Lake Sturgeon of Cayuga Lake were considered a rare remnant population and prior to restoration efforts no catches or observations had been reported in decades [7]. Restoration of this native species is a priority goal for the New York Department of Environmental Conservation and other wildlife management agencies [13]. As part of the program to re-establish Lake Sturgeon, a total of 3,782 young-of-year juveniles were released into Cayuga Lake between 1995 and 2003, with 1,000 to 2,500 released each year in 2013-2022. Limited post-stocking assessment has occurred [8, 13].

Lake Sturgeon (*Acipenser fulvescens*) are long lived, late maturing fish (females 18-24 years, males 10-13 years) that spawn infrequently [4, 1] and require specific spawning conditions [16, 24]. Typically, the spawning habitat requirements of Lake Sturgeon include: 1) clean cobble and boulder substrate, 2) water velocity >0.5 m/sec, and 3) water temperature in the range of 9-15 ^{o}C. Access to these habitats is often restricted by dams and other barriers [2, 6]. In June of 2017, we expected that a proportion of the > 17-year-old females in the reintroduced Lake Sturgeon population of Cayuga Lake had reached spawning condition.

Lake Sturgeon spawning behavior consists of several males grouped around the female, with characteristic body movements [4, 20]. In June 2017, congregations of Lake Sturgeon were observed for the first time in the Fall Creek tributary to Cayuga Lake, located in Ithaca, New York. The presence of Lake Sturgeon in Fall Creek provided a unique opportunity to document initial spawning, deposition success, and to determine the type of microhabitat that the adult fish were selecting for spawning. The goal of this study was to evaluate Lake Sturgeon spawning habitat use in Fall Creek and determine if the selected habitat was consistent with what is typically observed for Lake Sturgeon across the species range.

2 Materials and Methods

2.1. Study Area

Fall Creek is a small (5-25 m width), shallow (0.5 to 1 m average, 3 m maximum depth at the lake confluence) tributary that drains a 332 km^2 agriculturally rich watershed and flows into southern Cayuga Lake at (42.460182N, -76.510161W). The stream has an overall change in elevation of 383 m with the highest gradient occurring at Ithaca Falls (45 m high), located 1.75 km upstream from the creek mouth. Initial visual surveys for spawning adult Lake Sturgeon were conducted 10-150 m downstream of Ithaca Falls, the first impassable natural barrier (42.452901N, -76.491863W). There is a U.S. Geological Survey (USGS) gauging station (Hydrologic Unit 04140201) located 3.5 km upstream from the mouth of Fall Creek, which records the real time hydrograph of discharge volume [25]. Online access to long term discharge data for Fall Creek is available (1925-2023).

2.2. Habitat Use

Microhabitat variables and egg densities along 15 cross-stream transects spaced 10 m apart were sampled within the study area. These transects bracketed the area of observed adult Lake Sturgeon spawning behavior. Three random sites along each of the 15 transects (115.5 cm^2 total area) were selected for core sampling. This minimum number of samples was taken to allow for quantification of egg deposition without a large disruption of the small spawning area. Eggs were collected from the substrate using a 7 cm core sampler with a 38.5 cm^2 opening. Sampling consisted of a 30 second agitation of the stream bottom at each sample location while pushing the corer into the substrate. Sample contents were emptied into separate jars containing 10% buffered formalin. In the laboratory, eggs were enumerated, checked for development, and developmental stage was identified.

Egg numbers were calculated for each transect using the area of the stream within the 10 m inter-transect area. The average egg density (# +/- se) calculated from the area of the three cores was applied to the transect area to get an overall egg density estimate for each transect. Egg developmental timing was back-calculated based on thermal units, using Kempinger's model [12], to determine likely spawning dates.

2.3. Microhabitat

Both egg microhabitat (3 samples) and available microhabitat (10 samples) were characterized in the study area by measuring depth (m), velocity (m s^{-1}), stream substrate type, and stream width along each of the 15 GPS referenced cross-river transects. Depth was measured with a marked measuring staff. Velocity was measured using a Marsh-McBirney model 201D digital flow meter at 60 % of the depth from the surface [3]. Stream substrate type was assigned using a modified Wentworth particle size scale ranging from detritus (1) clay (2) silt (3) sand (4) gravel (5) cobble (6) boulder (7) to bedrock (8) [19]. Particle diameter size ranges for classification of the microhabitat are: Gravel is 2 - 64 mm, Cobble is 64 - 256 mm, and Boulder is > 256 mm. The length of each cross-stream transect was measured using USGS aerial images (Google Earth). Average transect length for each 10 m inter-transect block was calculated by averaging the two transects bounding each block (e.g., 0-10 m width equals the average of transect one and transect two distances across the creek). Water temperature was measured with an YSI 556 MPS. A HOBO temperature logger (Onset Corp., Bourne, MA) was placed in nearby Cayuga Inlet in April to record temperature patterns throughout the sampling period.

2.4. Data Analysis

The data collected in this study are accessible on Science Base a Trusted Digital Repository (TDR) in the U.S. Geological Survey (USGS) [9]. Principal components analysis (PCA) was used to plot the ordination of Lake Sturgeon egg occurrence within the multivariate microhabitat conditions in the study area [23]. Specifically, the PCA was used to determine whether or not egg deposition microhabitat characteristics differed from sampled microhabitats that did not have eggs or the broader available stream habitat. The data were determined to have a non-normal distribution (Shapiro–Wilk test, Statistix 10.0, [22]). Kruskal-Wallis One Way analysis of variance (Statistix 10.0) was used to determine if microhabitat characteristics (depth, velocity, stream substrate type) were significantly different between areas of egg deposition and no egg deposition. Following a significant difference, we used Dunn's Pairwise Comparison on each habitat variable identified as influential to determine which habitat variables differed among preferred and non-preferred egg depositional areas. In all statistical analyses we used a significance level $\alpha = 0.05$.

3. Results

3.1. Spawning

Lake Sturgeon spawning activity was observed for three days starting on 8 June 2017 and ceasing on 10 June 2017 (Figure 1). Spawning fish used an area between 1.5 km upstream of the mouth of Fall Creek and 50 – 100 m downstream from Ithaca Falls (2,832 ±14.1 m^2). Lake Sturgeon eggs and hatching larvae were observed on the substrate within the study on 12 June 2017. For species verification we collected a piece of gravel that had five developing eggs and one hatched sac larva and a hatched egg. Reference Lake Sturgeon eggs from aquaculture were used to properly identify field collected samples of Lake Sturgeon eggs by comparison. During the 13 June 2017 assessment, eggs were not as visible on the surface of the substrate. Quantitatively, 6 of the 15 transects sampled had eggs present with densities ranging from 260 to 1,588 / m^2. Approximately 810,052 ± 24,386 eggs were deposited by adult Lake Sturgeon within the study area. Based on the sampled proportions of live and undeveloped eggs from the core samples, we estimate that 469,126 were likely still developing and 340,926 were likely not developing. There were no significant differences in the microhabitats of cores samples with different proportions of live and undeveloped eggs (the small sample size has low statistical power). The recorded temperatures and stream discharges were used to calculate the probable egg developmental sequence in temperature units (Celsius) and back calculate the probable spawning dates (Figure 1). The back calculation with Kempinger's model, using input of the observed hatching dates, indicated that sampled eggs were most likely deposited on the dates when the adult Sturgeon were observed in Fall Creek (Figure 1). The hydrograph record from the USGS station data showed that spawning occurred just after peak discharge following a rain event that had a maximum discharge flow of 22.5 $m^3 s^{-1}$ (Figure 1). Using Kempinger's Lake Sturgeon developmental model [12] and a Lake Sturgeon developmental index [11], it was determined that on the date of sampling there was a high likelihood that half or more of the viable eggs had already hatched. Thus, the estimate of total egg deposition in Fall Creek is an average of 810,000 and possibly to up to as many as 1.3 million.

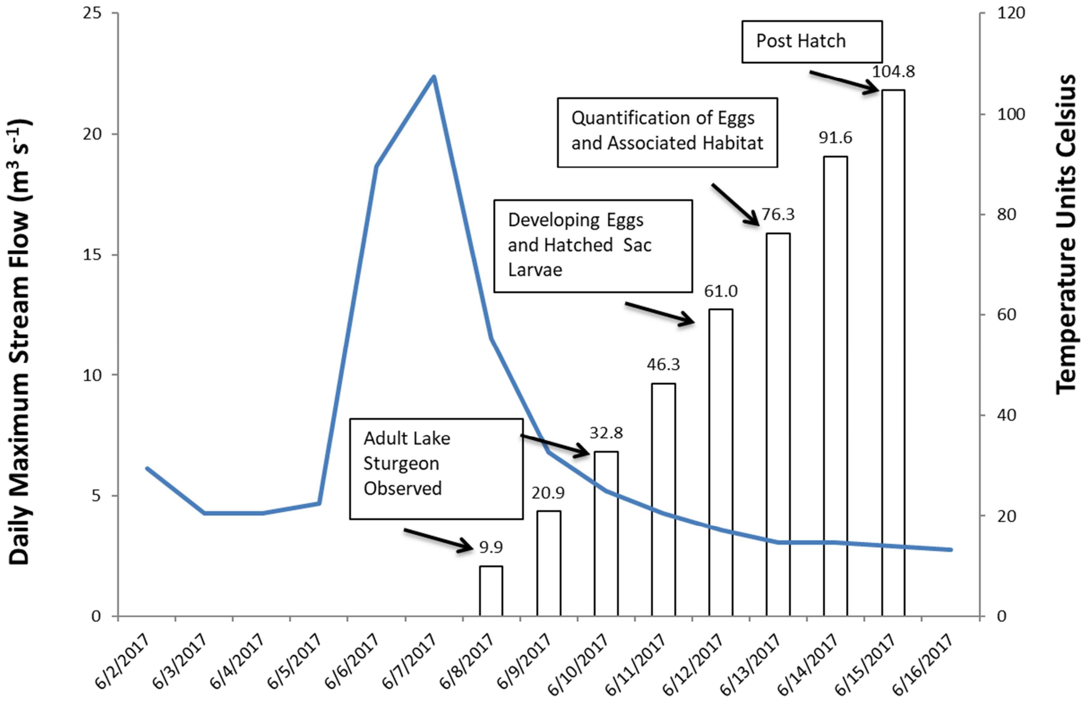

Figure 1. *Lake Sturgeon spawning and egg development timing in Fall Creek relative to the time series of stream discharge (blue line, daily maximum discharge, m^3s^{-1}) and cumulative thermal units (degrees Celsius).*

3.2. Microhabitat Selection

Egg presence was not distributed evenly throughout the study area. The highest densities occurred just upstream of and in a small rapids area approximately 70 m downstream from Ithaca Falls. The habitat consisted of a rocky substrate (gravel to cobble) with flow above 0.4 m/s and depths from 0.2 to 0.7 m. The first PCA axis explained 95.5 % of the variation in the Lake Sturgeon spawning microhabitat. The habitat variable primarily associated with the first principal component was substrate size (i.e., hardness index, Figure 2). PCA axis two explained 4.5 % of the habitat variation, with water depth and velocity as the primary habitat variables. The ordination indicated that eggs were found in microhabitats that had smaller substrate and greater velocity than microhabitats in which no eggs were present; depths were similar (Figure 2). Eggs were found in smaller, shallower substrate than was generally available in the stream (Figure 2).

Kruskal-Wallis One Way analysis verified that eggs were deposited on finer substrate than was generally available ($p=0.005$, Table 1). However, neither depth ($p=0.09$) nor velocity ($p=0.43$) differed significantly between egg deposition habitat and other microhabitats (Table 1).

Spawning adults appear to have selected areas for egg deposition that had a greater proportion of gravel substrate than was generally available within the study area.

Table 1. *Habitat values (mean +/- se) for core samples within Fall Creek associated with egg deposition (Eggs) and without (No Eggs) and the systematic transect samples of available habitat (Available). A Kruskal-Wallis One Way Analysis of Variance and Dunn's All-Pairwise comparison were used to test between habitats (α = 0.05).*

Habitat	Depth (m)	Velocity (m/s)	Hardness
Eggs	0.42+/-0.06	0.60+/-0.07	4.83+/-0.13A
No Eggs	0.40+/-0.08	0.52+/-0.06	5.22+/-0.09B
Available	0.49+/-0.04	0.60+/-0.03	5.36+/-0.04B
N	140	140	140
AOV df, f stat, p	2, 2.34, 0.09	2, 0.85, 0.43	2, 5.49, 0.005

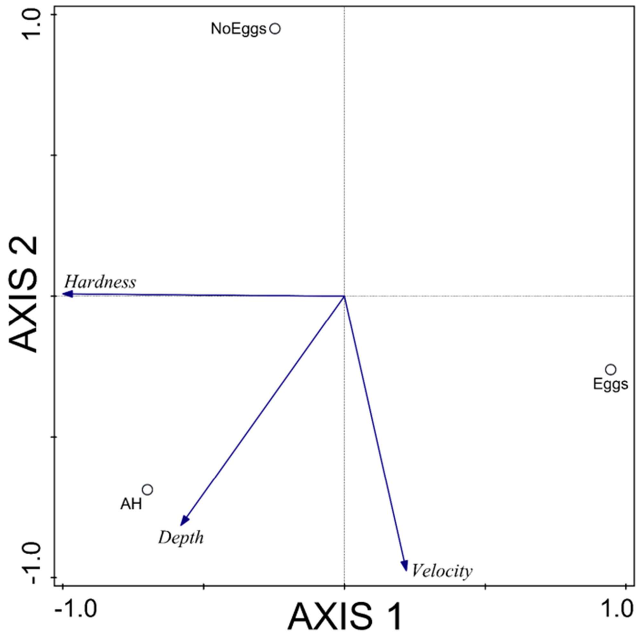

Figure 2. *Principal Components Analysis ordination of habitat conditions associated with the presence of Lake Sturgeon eggs (Eggs), no eggs present (No Eggs), and the available habitat (AH). Axis 1 explained 95.5% and axis 2 explained 4.5 % of the habitat variation. Habitat vectors point in the direction of increasing value and their length indicates relative influence. The circles indicate the habitat condition associated with the presence (or absence) of Lake Sturgeon eggs or the average available habitat.*

4. Discussion

Spawning timing for the Lake Sturgeon population in Cayuga Lake matches the spawning pattern of the St. Lawrence River source population for these stocked fish [15, 13] and in other sturgeon populations [21, 24]. Water temperatures and flow regimes are the key cues for Lake Sturgeon spawning [4, 20] and were appropriate in Fall Creek in June 2017 (Figure 1). Both live eggs and larvae were collected from the sample site and spawning adults selected areas for egg deposition that had a greater proportion of gravel substrate than was generally available within the study area.

Our observations on the timing of egg development and hatching match the current developmental models for Lake Sturgeon [12, 20, 24], where incubation occurs within five to seven days of deposition, depending on water temperature. Female Lake Sturgeon are estimated to produce just over 11,000 eggs / kg of body weight [5]. Fish in New York lakes tend to grow fast [14]. An adult female Lake Sturgeon is likely to be over 20 kg [5, 18], potentially producing more than 220,000 eggs during a spawning event. Our estimate of an average of 810,052 eggs present in the study area on June 13 is indicative of four or five females that spawned in the study area. Quantitative egg sampling was accomplished after the probable midpoint of egg hatching. If this first observed spawning Lake Sturgeon deposited closer to 1.3 million eggs in Fall Creek there may have been six or more females.

This is the first documentation of Lake Sturgeon spawning in New York's Finger Lakes with the associated microhabitat used. In general, Lake Sturgeon spawning habitat in rivers is found in fast flowing areas of relatively shallow, well oxygenated water below rapids or impassible barriers, often at the base of falls or dams; spawning usually lasts for 2-4 days [16, 6, 24]. Spawning habitat suitability is considered critical for reintroduction success and spawning adults in Fall Creek selected for smaller substrate than is generally expected for Lake Sturgeon [11]. In Fall Creek, egg deposition was on gravel size substrate with depths and flows that were a unique microhabitat combination, not typical of habitat use values found in other Lake Sturgeon spawning studies. While larger rocks were present (cobble, boulder), the eggs were primarily found on the gravel. In areas with eggs, it appeared that the larger substrate had been pushed aside by the bed cleaning behavior of the spawning sturgeon, [4, 15].

The identified microhabitat type in Fall Creek is likely to be widespread in similar tributaries around Cayuga Lake and the nearby Lake Ontario. This broad scale landscape knowledge will support management and subsequent efforts to restore Lake Sturgeon in New York waters [13]. However, more assessments of Lake Sturgeon spawning and habitat selection are still needed within Cayuga Lake to better understand this relationship.

5. Conclusion

To our knowledge, this is the first documented observation of adult Lake Sturgeon from Cayuga Lake spawning in Fall Creek. There was an identified microhabitat within the creek comprised of gravel sized rocks where eggs were deposited. Deposited eggs sampled from the creek were positively identified to be Lake Sturgeon eggs with egg deposition number estimated to be 810,052 ± 24,386. Documentation of a reintroduced Lake Sturgeon population that has reached reproductive maturity is a critical restoration milestone. This information is essential to help managers and protect Lake Sturgeon populations within New York and across the Great Lakes.

Acknowledgments

Special thanks to R. Abbott, J. Johnson, and J. McKenna for assistance with field sampling, laboratory sample processing, and advice. Thanks to E. Won, who provided for the initial alert of Lake Sturgeon in Fall Creek. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Anderson, W. G., Schreier, A., & Crossman, J. A. (2022). Conservation aquaculture—A sturgeon story. In *Fish Physiology* (Vol. 39, pp. 39-109). Academic Press.

[2] Auer, N. A. (1996). Response of spawning lake sturgeon to change in hydroelectric facility operation. *Transactions of the American Fisheries Society*, 125, 66–77.

[3] Buchanan, T. J., & Somers, W. P. (1969) Discharge measurements at gauging stations. Techniques of water resources investigations, book 3. *U. S. Geological Survey*, Washington, D. C.

[4] Bruch, R. M. & Binkowski, F. P. (2002) Spawning behavior of Lake Sturgeon (*Acipenser fulvescens*). *Journal of Applied Ichthyology*, 18, 570-579.

[5] Bruch, R. M., Haxton, T. J., Koenigs, R., Welsh, A., & Kerr, S. J. (2016) Status of Lake Sturgeon (*Acipenser fulvescens* Rafinesque 1817) in North America. *Journal of Applied Ichthyology*, 32, 162-190.

[6] Buszkiewicz, J. T., Phelps, Q. E., Tripp, S. J., Herzog, D. P. & Scheibe, J. S. (2016) Documentation of lake sturgeon (*Acipenser fulvescens* Rafinesque, 1817) recovery and spawning success from a restored population in the Mississippi River, Missouri, USA. *Journal of Applied Ichthyology*, 32, 1016-1025.

[7] Carlson, D. M. 1995. Lake Sturgeon Waters and Fisheries in New York State. *Journal of Great Lakes Research*, 21, 35–41.

[8] Chalupnicki, M. A., Dittman, D. E. and Carlson, D. M. (2011). Distribution of Lake Sturgeon in New York: 11 years of restoration management. *The American Midland Naturalist*, 165, 364-371.

[9] Chalupnicki, M. A. & Dittman, D.E. 2024, Lake Sturgeon Spawning in Fall Creek, Cayuga Lake, NY: U.S. Geological Survey, https://doi.org/10.5066/P9U3LC5T

[10] Eckes, O. T., Aloisi, D. B. & Sandheinrich, M. B. (2015) Egg and larval development index for lake sturgeon. *North American Journal of Aquaculture*, 77, 211-216.

[11] Friday, M. J. (2014). Estimating the critical reproductive periods of lake sturgeon (*Acipenser fulvescens*) using daily water temperature units. *Ontario Ministry of Natural Resources*, *Northwest Biodiversity and Monitoring Section*, BAMS Technical Report TN-48, 1-7.

[12] Holst, L. K., & Zollweg-Horan E. C. (2018). New York State Lake Sturgeon Recovery Plan 2018-2024. NYSDEC, Albany NY. https://www.dec.ny.gov/outdoor/111557.html

[13] Jackson, J. R., Van DeValk, A. J., Brooking, T. E., vanKeeken, O. A., & Rudstam, L. G. (2002) Growth and feeding dynamics of lake sturgeon, *Acipenser fulvescens*, in Oneida Lake, New York: Results from the first 5 years of a restoration program. *Journal of Applied Ichthyology,* 18, 439-443.

[14] Jackson, J. R., Van DeValk, A. J., Brooking, T. E., van Keeken, O. A., & Rudstam, L. G. (2002) Growth and feeding dynamics of lake sturgeon, *Acipenser fulvescens*, in Oneida Lake, New York: Results from the first 5 years of a restoration program. *Journal of Applied Ichthyology,* 18, 439-443.

[15] Johnson, J. H., LaPan, S. R., Klindt, R. M., & Schiavone, A. (2006) Lake sturgeon spawning on artificial habitat in the St. Lawrence River. *Journal of Applied Ichthyology*, 22, 465–470.

[16] Kerr, S. J., Davison, M. J., & Funnell, E. (2010) A review of Lake Sturgeon habitat requirements and strategies to protect and enhance sturgeon habitat. *Ontario Ministry of Natural Resource*s, Peterborough, ON, Canada, 58 pp. + app. DOI: https://www.fws.gov/midwest/sturgeon/documents/kerr-etal-2010-habitat-req.pdf

[17] Lapan, S. R., Schiavone, A., Klindt, R. M., Schlueter S. L., & Colesante. R. T. (1998) 1997 Lake Sturgeon Restoration Activities. *NYDEC Lake Ontario Annual Report 1998*.

[18] New York State Department of Environmental Conservation (NYSDEC) Statewide Fisheries Database (release 57, collections from 1987–2017).

[19] Orth, D. J. (1983) Aquatic habitat measurements. In Nielsen, L.A. & Johnson D. L. (eds), Fisheries Techniques. *American Fisheries Society*, Bethesda, 61–84.

[20] Roseman, E. F., Adams, E., DeBruyne, R. L., Gostiaux, J., Harrington, H., Kapuscinski, K., Moerke, A., & Olds, C. 2020. Lake sturgeon (*Acipenser fulvescens*) spawn in the St. Marys River Rapids, Michigan. *Journal of Great Lakes Research,* 46, 1479–1484.

[21] Seesholtz, A. M., Manuel, M. J. & Van Eennaam, J. M. 2015. First documented spawning and associated habitat conditions for green sturgeon in the Feather River, California. *Environmental Biology of Fish*, 98, 905–912.

[22] Statistix 10.0 (2013) Analytical Software. Tallahassee, Florida

[23] Ter Braak, C. J. F. & Smilauer, P. (2002) CANOCO Reference Manual and Cano Draw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5).

[24] Tucker, S. R., Houghton, C. J., Harris, B. S., Elliott, R. F., Donofrio, M. C., & Forsythe, P. S. 2021. Reproductive status of a remnant Lake sturgeon (*Acipenser fulvescens*) population: Spawning and larval drift in the lower Fox River, Wisconsin. *River Research Applications*, 37, 1265–1278.

[25] U.S. Geological Survey, 2017, USGS water data for the Nation: U.S. Geological Survey National Water Information System database, accessed at https://waterdata.usgs.gov/nwis/uv?site_no=04234000.