Lake sturgeon suitability modeling, and coverage generation in Pools 5A and 8 of the Mississippi River

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Abstract

To increase the understanding of lake sturgeon (*Acipenser fulvensens*) in the upper Mississippi River a radio telemetry study was conducted in Pools 4 through 10. Currently lake sturgeon are listed as a species of concern. GIS analysis of available data was performed to determine the spatial relationships that exist between lake sturgeon and their habitat. Aquatic type, wing dam, revetted dam, and closing dam data were available for Pools 5A and 8. Pool 8 bathymetry data also existed, however interpolation of Pool 5A bathymetric data was necessary to create a bathmetry coverage for that pool.

The Pool 8 bathymetry is considerably older (1989-93) than the collected lake sturgeon data used in this suitability modeling study. However, statistical analysis of coverage and field data demonstrated that Pool 8 coverage data were still useful for the purposes of analyses.

After the spatial coverages were assembled (location to structure, aquatic type, and depth), habitat suitability modeling was performed to determine if these data could be used to model species habitat. After determining percent available and percent used for each coverage, percent used was divided by percent available. Suitability values were then assigned according to a ranking of these values. GIS and statistical analysis were then used to determine habitat suitability for lake sturgeon in portions of Pools 5A and 8. Stepwise linear regressions were performed on coverage data in Pools 5A and 8, and these analyses ranked the habitat factors used in the suitability model in order of importance.

For the determination of spatial relationships between fish and aquatic structures (closing, revetted, and wing dams), UNIX ARC/INFO was used. Various fish species such as bass and walleye exhibit the tendency to be located near aquatic structures, but average distances to these aquatic structures suggests that lake sturgeon do not share that tendency in the Polander Lake area of Pool 5A.

Finally, distances analyses to areas of highly suitable habitat were performed. Many lake sturgeon were located in areas of highly suitability. Those not located within highly suitable areas were in close spatial proximity to these areas.

Introduction

The lake sturgeon are a species which exists in portions of North America including the upper Mississippi River system. Listed as a species of concern, lake sturgeon are not overly abundant, and are generally reclusive. While previous studies regarding lake sturgeon have been performed, it has often been concluded that the analysis of specific populations does not lead to the understanding of other geographically distinct populations. Because distinct populations seemingly exhibit different habitat usage patterns, and lake sturgeon are listed as a species of concern, data in the upper Mississippi River is needed.

Upper Mississippi lake sturgeon were captured with fyke and hoop nets. Once netted, radio and/or sonic transmitters were placed in the abdominal cavity. Fish were located by means of telemetry on a weekly to biweekly basis depending on weather conditions and tracking success. The Upper Mississippi Science Center (UMSC) began tracking in July of 1997. Data used in these analyses include those data collected prior to June 23, 1998. Overall, data collection is expected to be completed in late 1998 or early 1999.

Boats equipped with sonic and radio receivers located the position of the tagged lake sturgeon. Generally, two types of transmitters were used to maximize the benefits of each. This ensured the location of lake sturgeon whether they were far away or located on the bottom of the river. Data gathered at the site of fish locations included dissolved oxygen, current, substrate, distance to shoreline, temperature, barge activity, and depth. GPS receivers and data loggers were used to record the position and other information for each fish sighting.

Data used for spatial analysis included data obtained from the Environmental Management Technical Center (EMTC-USGS) web site. These coverages included wing dams, revetted dams, closing dams, aquatic type, and Pool 8 bathymetry.

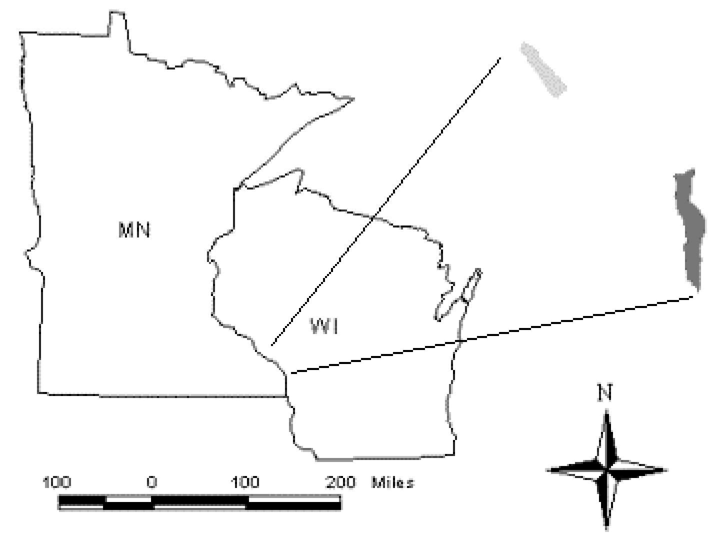
A bathymetry coverage was developed for the Polander Lake portion of Pool 5A. Over 20,000 data points were collected in this small area in the spring of 1998 by the U.S. Army Corps of Engineers. The ARC/INFO Grid module was used to interpolate this coverage. The spline method of interpolation was chosen based on the data distribution and the advantages of this interpolator (McConville, 1995).

Another factor in consideration of this analysis was the availability of spatial data in two separate pools of the Mississippi River. Any comparative analysis done between pools would require similar data sets. Other Pool 8 data exists, including substrate and current velocity. These coverages were not chosen for analysis however. The substrate coverage was generated using less than 100 data points and no substrate coverage existed for Pool 5A. The six current velocity coverages developed for Pool 8 were not used for analysis because of the limited telemetry data set. Forty-eight locations were recorded up to June 23rd 1998 in Pool 8. Modeling of Pool 8 with the inclusion of current velocity coverages would not allow adequate correlations to field collected depth values. This is because each current velocity coverage corresponded to a specific discharge event. Thus, because of the multiple current velocity coverages, the fish sighting data would need to be segmented according to discharge. This would then result in too small a number of fish sightings associated with a particular current velocity coverage. Also, Pool 8 current velocity coverages were not used because Pool 5A current velocity coverages did not exist.

Study Area

The study area is located in the upper Pools of the Mississippi River. Lake sturgeon were captured and released in Pools 4 through 10. Lake sturgeon data were then collected in these Pools and in the Wisconsin and Chippewa Rivers. Pools 5A and 8 (Figure 1) were selected for analysis based on similar data existing for these areas.

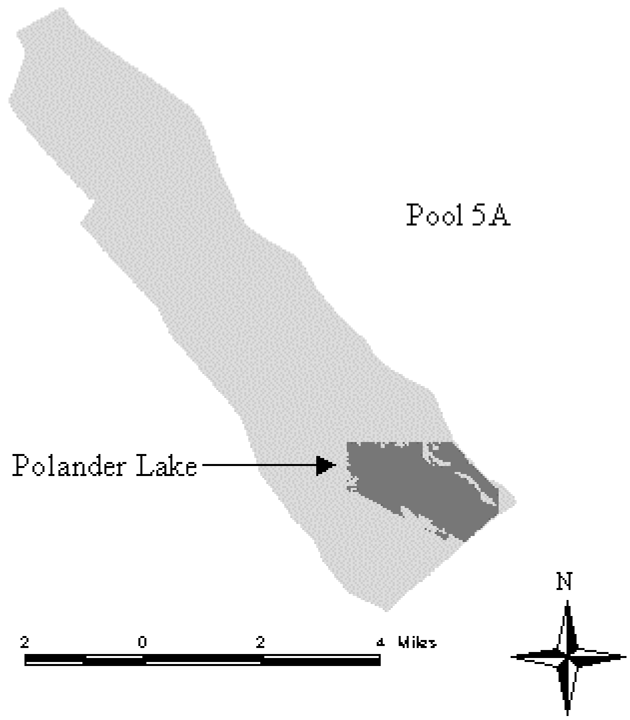
Figure 1. Location of Pools 5A and 8



Pool 8 starts at Lock and Dam 7 near Dresbach Minnesota and extends southerly to Lock and Dam 8 near Genoa, Wisconsin. It encompasses 23.5 river miles. Typical of many pools in the Mississippi River it has three sections. Its tailwaters are constricted and gradually widen into the marshy middle third of the pool, followed by a vast impounded area located in the lower 1/3 of the pool.

Pool 5A begins at Lock and Dam 5 located ten river miles northeast of Winona, Minnesota and extends to Lock & Dam 5A. Pool 5A encompasses 10 river miles. This pool does not share the same characteristics as Pool 8 and other pools; it is smaller, and does not share the typical sections characteristic of other pools. The hydrological dynamics of this pool combined with the location of wing dams has lead to a unique impounded area. A sharp bend in main channel above Polander Lake has resulted in an increase in current velocity in the impounded area. With increased water flow, deep holes have developed which are not typical of impounded areas. Also, based on increased water flow, sedimentation and water chemistry are different than other impounded areas. This impounded area shown in Figure 2 is commonly known as Polander Lake.

Figure 2. Location of Polander Lake in Pool 5A of the Mississippi River.



Unlike Pool 8, the Pool 5A bathymetric layer exists only for Polander Lake. Bathymetric readings were taken in the spring of 1998 and interpolation of the data resulted in a continuous bathymetric coverage for Polander Lake. Thus, for Pool 5A, all analyses performed were restricted to this region.

Methods

A GIS was a critical instrument in the spatial coverage generation and analyses. Lake sturgeon data collected over the period of one year was used. Analyses included the determination of spatial relationships to aquatic structures, the statistical analyses of interpolated surfaces, and the spatial relationship between lake sturgeon and areas of high suitability.

Distance and direction to structures

Man-made aquatic structures including closing, revetted and wing dams exist throughout both Pools 5A and 8. Many analyses can be done to examine relationships between lake sturgeon and these aquatic structures including relationships to each type of structure, orientation to aquatic structures, and seasonal relationships. A preliminary examination was needed to determine their applicability for further investigations.

To gain a broad understanding of any relationships that may exist between lake sturgeon and aquatic structures, analyses were done in the ARC/INFO module GRID. The aquatic structures line coverages were converted to grids. Lake sturgeon locations were buffered 10 meters, then converted to a grid. Distances and direction to lake sturgeon locations were then calculated with the eucdistance command.

Prior to converting the line coverages to grids, the extents of these coverages were examined. Use of the eucdistance command, like all grid functions, is performed in the extent of the grid. Therefore, consideration needed to be made for lake sturgeon locations outside of the extent of the created grid. When necessary, ArcEdit was used to add arcs beyond the extent of the grid. The added arcs were placed at distances great enough to ensure that values associated with lake sturgeon locations would be appropriately associated to the nearest real aquatic structure because distance and direction values are based on the closest aquatic structure. A 5 meter cell size was chosen for all grids created using the eucdistance command as a compromise between processing speed, file size, and output distances. Large cell sizes increase processing speed and reduce file size. But, final output is based on measurements from the center of cells. For these reasons a 5 meter cell size was chosen.

Distance and directions grids were created for both Pool 5A and 8 for all aquatic structure types. Distance and direction grids were clipped with the con statement to reduce the data to the buffered sturgeon locations. These coverages were exported and brought into ArcView. Once in ArcView, they were spatially joined to lake sturgeon data to perform distance analyses.

An average orientation near 180 degrees between lake sturgeon and aquatic structures could imply a spatial relationship to wing dams. This orientation would suggest that the fish position themselves downstream of these aquatic structures. Direction averages other than 180 degrees would imply that the lake sturgeon do not position themselves downstream of wing dams and thus do not exhibit this relationship.

Revetted and closing dams are located along shore. Directions of 90 and 270 degrees to these structures may imply a relationship. For all aquatic structures, the directional data were not deemed important.

Directional data were not considered important because average distances to aquatic structures was great. Average distances to aquatic structures varied considerably among structure types suggesting that the lake sturgeon had no spatial tendency towards close proximity to any of the structure types (Table. 1).

Table 1. Distances and directions from lake sturgeon locations to aquatic structures in Pools 5A and 8. All distances are mean values measured in meters. Direction values are mean values described in degrees.

Distance (m)	Pool 5A	Pool 8
Closing dam	7348	2326
Revetted dam	679	746
Wing dam	636	362

Direction in Degrees	Pool 5A	Pool 8
Closing dam	313	238
Revetted dam	117	218
Wing dam	177	190

Interpolation of bathymetry

During the spring of 1998, the United States Army Corps of Engineers (USACOE) collected over 20,000 data points in the portion of Pool 5A known as Polander Lake. These data were collected in the Minnesota State Plane South coordinate system. Z values were in Datum 1911. It was necessary to investigate the USACOE internet homepage for Pool elevation values. After determining an average Pool elevation, the z values could be associated to create depth. Daily depth data collections occurred numerous times each day for the head, middle and tailwaters of the Pool. Use of the average Pool elevation for the time period of lake sturgeon data collection was used as recommended by staff at the Upper Mississippi Science Center.

For effective GIS modeling, interpolation was necessary to create a continuous surface. Many interpolators were used, and the data generated was analyzed to determine how closely it resembled field data. Locations in the created grids next to lake sturgeon locations were randomly examined to determine the differences between the interpolated and field values. Testing in this manner lead to selecting the spline method of interpolation. The spline method was chosen because it "performs a two-dimensional minimum curvature spline interpolation on a point data set resulting in a smooth surface that passes exactly through the input points." (ESRI, 1997)

An exact interpolator is quite advantageous assuming that the accuracy of the collected depth data is high. Advantages include a smooth surface where peaks and angles are rounded (Heine, 1986), and the surfaces created with spline are quickly interpolated (Burrough, 1986).

Options for this interpolator include "regularized" and "tension." The regularized option was not chosen because it "tends to yield a smoother surface with less agreement between estimated values and measured values" (McConville, 1995). The tension option was chosen because of the densely sampled data, and because a high degree of correlation between the estimated and measured values was desired. A 5 meter cell size was used considering the eventual reclassification of data, and processing speed.

Use of the spline method of interpolation with the tension option created a surface with great detail. Again, the con statement was used to clip areas of the interpolated bathymetry grid. This clip was exported and imported into ArcView. Spatial join was used to add interpolated depth values to the existing sturgeon data. Correlations were performed to determine the correlation coefficients between interpolated and measured values.

The format of Pool 8 bathymetry was previously categorized in 1 meter increments by EMTC-USGS. This coverage was created in 1993. Pool 5A correlations were performed on both truncated and rounded data to establish whether Pool 8 bathymetry data were useful, and whether the method of categorization could lead to model inaccuracies.

Great detail was, however, not necessary for the suitability model. After converting the output interpolation values to integers, values were reclassed to 1 m increments in GRID. This reclassed Polander Lake coverage was then used in suitability modeling.

Creation of suitability values

Values used to create a suitability model were generated after considering the methods of Friedman (Friedman, 1937). This method for analyzing resource selection assumes that data are "categorical rather than continuous variables" (Alldredge and Ratti, 1991). Using the Friedman method, a ranking is established by determining the "differences in use and availability" (Alldredge and Ratti, 1991) between a species and habitat. Friedman's method was not used to examine structures because they are linear, and have no specific area availability.

All available coverages were used in the suitability model to determine spatial relationships to lake sturgeon locations. Final completion of the Friedman Method tests the null hypothesis that “all habitats are used with equal intensity” (Alldredge and Ratti, 1991). If the null hypothesis is not rejected (i.e., no statistical claim to selection of habitat), potential coverages for suitability modeling would not be used. Because only two coverages existed, this was not performed. Rather, it was desirable to examine if relationships exist between lake sturgeon, aquatic type, and bathymetry.

Instead of testing the null hypothesis, the percent available and percent used values were calculated for Pools 5A and 8 depth and aquatic type coverages. In order to rank these results for suitability modeling, the percent use was divided by the percent available to create a suitability value. The percent of available habitat and depth were calculated using the Spatial Analyst extension in ArcView. Hectares of habitat and depth were summed, so that percent available could be calculated. Based on the numbers calculated from dividing the percent use by the percent available, a ranking was assigned to each bathymetry category and aquatic type. The ranked numbers assigned to aquatic types and depths were determined based on comparisons of suitability values calculated in each particular coverage. Pools 5A and 8 data were combined in determination of percent use and percent available.

Higher ranking values were assigned to bathymetry categories and aquatic types that had higher suitability values. Lower ranking values were assigned to those that had lower suitability values. A slight modification was instituted for the assignment of bathymetry suitability values based on the author’s belief that high model values could result from a low number of sturgeon locations in an area of extremely low availability. Instances occurred where extremely low percent availability values < 0.03 led to high suitability values when divided by percent use. The suitability values were then lowered taking into account potential error due to GPS units and the dynamic changes that can occur in the bathymetry of large rivers. The calculations and determinations of generating suitability model values are illustrated in Table 2. The percent use in those instances where the author modified the suitability values were always less than seven lake sturgeon locations.

Suitability Modeling

Prior to modeling in GRID, the additem command was used so that the suitability values could be added to the bathymetry and aquatic coverages of Pools 5A and 8. Model values were added based on attribute information.

The creation of a suitability model was done in the Grid module of UNIX ARC/INFO. The coverages were converted to grids after suitability values were added to these coverages. The value preserved when converting to grid was the assigned model value. The previous eucdistance analysis suggested that lake sturgeon exhibited no preference towards aquatic structures. Taking the observed avoidance into account, the suitability model value for inside the buffer was 0 and outside the buffered area was 1. Aquatic structures were buffered by 100 meters.

To model the suitability of all coverages, a grid containing suitability values was created by the addition of all grids. Once created, this grid was converted to a polygon coverage and exported to ArcView. Once in ArcView, the coverage was spatially joined to the lake sturgeon data.

Table 2. Calculations performed to create suitability model values. Percent available values < .03 evaluated differently when assigning suitability model values. Column titled 'Suitability Value' is the suitability value assigned to each depth.

Depth	Hectares	% avail	# fish	% fish	% of fish / % avail	Suitability Value
1	3395	0.39	16	0.07	0.18	0
2	2850	0.33	75	0.35	1.06	1
3	941	0.11	41	0.19	1.73	2
4	507	0.06	21	0.1	1.67	2
5	383	0.04	20	0.09	2.5	2
6	259	0.03	22	0.1	3.33	2
7	148	0.02	7	0.03	1.5	0
8	111	0.01	5	0.02	2	0
9	36	0.004	3	0.01	2.5	0
10	22	0.003	1	0.005	1.67	0
11	20	0.003	6	0.03	10	0
	8672		217			

Many analyses were performed once a suitability model was created. First, the models were analyzed in Spatial Analyst to ensure that the average value in the model was less than optimum. If high suitability model values encompassed most of the coverages then the model would be of little use. Any spatial pattern present could not be associated to the model if the majority of the model area was highly suitable.

After determining the potential usefulness of the suitability model, an analysis of suitability model values within the 100 meter aquatic structure buffer was performed. The ArcView extension X-Tools was used to clip the suitability model coverage to the extent of the buffer. Spatial Analyst was then used to calculate hectares within this buffer to determine if lake sturgeon perceived avoidance to aquatic structures was influenced by low suitability values or not.

With suitability model values joined to lake sturgeon data, lake sturgeon found to have low suitability values were analyzed in ArcView tables to determine if any consistency existed based on bathymetry, aquatic habitat, or aquatic structure.

Extending the functionality of ArcView by incorporating a nearest feature Avenue script (Fox, 1998) allowed for examination of spatial proximity. Using this script, distances were measured from lake sturgeon found in areas of low model suitability to areas of high model suitability. Data generated from this script was then linked to the lake sturgeon data.

Results

Distance and direction to structures

Distance and direction grids created in ARC/INFO GRID helped define the spatial relationship between lake sturgeon and aquatic structures. Unlike many fish species, the data generated by this analysis suggest that lake sturgeon do not exhibit a spatial preference towards aquatic structures in Polander Lake. However, there appears to be some preference to the aquatic structures in Pool 8 when the suitability model is examined. Overall, distances to aquatic structures were great. Lake sturgeon in Pools 5A and 8 within 100 meters of revetted dams accounted for only 6% and 13% of the total respectively, with an average distance of 59 meters for these fish. No lake sturgeon in Pools 5A or 8 were found to be within 100 meters of closing dams. And finally, lake sturgeon in Pools 5A and 8 within 100 meters of wing dams only accounted for 9% and 29% of the total respectively, with an average distance of 53 meters for these fish.

Interpolation of bathymetry

The USACOE Pool 5A web page containing every measured Pool elevation during the study period was summarized. The average elevation during this time period for Pool 5A was 650.7 feet (Datum 1911). Using this value, the spline method of interpolation lead to a bathymetric surface that closely resembled actual field data. Bivariate correlation results for this data set are shown in Table 3.

Table 3. Polander Lake bivariate correlations between spline interpolated depth and field depth. Correlations are significant to the 0.001 level. Spline depth 1 is the correlation using all points. Spline depth 2 is the correlation minus 8 data points collected in suspected areas of error.

Correlations

	Field Depth
Spline depth 1	0.775
Spline depth 2	0.875

A correlation of 0.775 was found between the field data and the spline interpolated data. However, the accuracy of this coverage is potentially even greater. Error could be attributed to lake sturgeon located near deeper water. These areas are presumed to have a greater slope than other areas of the Pool. GPS error in areas of little slope should not significantly affect the correlation coefficient. But, GPS error in an area of higher slope could lead to a lowered correlation. Performing bivariate correlations after excluding these potential errors resulted in a higher correlation of 0.875.

Use of Pool 8 bathymetry

The Pool 8 bathymetric coverage used in these analyses was created in 1989-93. The bathymetry of this Pool is subject to varying degrees of change due to the dynamic nature of the Mississippi River. Thus, to validate the use of this coverage in creating a Pool 8 suitability model, a correlation was performed between field and bathymetry coverage data. The Pool 8 bathymetry coverage had been previously reclassed to 1 meter increments. To somewhat validate the use of this data, correlations were performed on Pool 5A bathymetry that was rounded and truncated to 1 meter increments. As shown in Table 4, correlations were high regardless of the method the data were reclassed i.e. either truncated or rounded.

Table 4. Pool 5A depth, truncated depth, and rounded depth correlations. Correlation between Pool 8 field collected depths and bathymetry coverage depths.

Correlations

	Pool 5A	Pool 8
5A spline depth	0.775	
5A truncated depth	0.786	
5A rounded depth	0.778	
Pool 8 depth		0.904

Suitability Model

Completion of the suitability model was performed in ARC/INFO GRID. Both Pools 5A and 8 had values ranging highest to lowest from 5 to 1. Assigned depth suitability values are shown in Table 2. Aquatic type was assigned suitability values as shown in Table 5. In Pool 5A, Polander Lake consists largely of the contiguous impounded aquatic type. The suitability value the author assigned to the contiguous impounded areas differed. Lake sturgeon in Polander Lake are often found in contiguous impounded areas unlike lake sturgeon in Pool 8. Because of the unique nature of contiguous impounded areas in Polander Lake, and the high use of this area by lake sturgeon, the suitability value for contiguous impounded areas in Polander Lake was raised.

Finally, after buffering the aquatic structures by 100 meters, areas within the buffer were assigned suitability values of zero while areas outside the buffer were assigned suitability values of 1. Results generated by the suitability model were spatially joined to the lake sturgeon data in Pools 5A and 8.

Table 5. Pools 5A and 8 assignment of suitability model values. Because Polander Lake is composed mainly of contiguous impounded areas, the suitability model value was 2 for Pool 5A and zero for Pool 8.

Aquatic type	Suitability Value
Contiguous floodplain lake	0
Contiguous floodplain shallow aquatic areas	1
Contiguous impounded area	2
Isolated floodplain shallow aquatic areas	0
Main channel - channel border	2
Main channel - navigation channel	2
Non-aquatic area	0
Other	0
Secondary Channel	0
Tertiary Channel	0
Tributary Channel	0

Polander Lake in Pool 5A was composed mainly of areas deemed to be moderately suitable. Little area of high suitability was found. Similarly, Pool 8 was found to have very little areas of high suitability, but was mainly composed of moderate to low suitability areas.

In Polander Lake, high suitability (5) made up 7% of the total. This area was used by 33% of the lake sturgeon.

Moderately high suitability (4) accounted for 28% of the total area and was used by 52% of the lake sturgeon. Of the remaining lake sturgeon located in Polander Lake, average distance to a suitability value of 4 or more was less than 28 meters.

In Pool 8, high suitability (5) made up 3% of the total. This area was used by 23% of the lake sturgeon. Moderately high suitability (4) accounted for 5% of the total area and was used by 19% of lake sturgeon. However, for the remaining lake sturgeon located in Pool 8, the average distance to a suitability value of at least 4 was approximately 258 meters. Fifty percent of the lake sturgeon in areas of low suitability were within 100 meters of areas of suitability of at least 4. Forty-three percent of the lake sturgeon not within 100 meters of high suitability areas were located in the area where the Black River joins Pool 8.

To better understand relationships that may exist between lake sturgeon and aquatic structures, the suitability model values for Pools 5A and 8 were examined. Distance analyses performed earlier resulted in areas within 100 meter of aquatic structures having suitability values of zero. Values of 1 were added to the suitability model in areas outside this buffer. Areas of the suitability model within the 100 meter buffer of aquatic structures thus contained suitability model values ranging from 0-4, and values of 5 were theoretically impossible.

Areas in the above buffer having the highest suitability value (3-4) amount to 46% (33 hectares) of the total 71 hectares in the Polander Lake buffer. This area contained 14% of the lake sturgeon locations. In all of Polander Lake, areas of high suitability account for 11% (148 hectares) of the total 706 hectares. These areas contained 85% of the lake sturgeon suggesting that in Polander Lake, areas of higher suitability beyond the aquatic structure buffer were preferred to areas of high suitability within the buffer.

Areas having a high suitability value (3-4) amount to 523 hectares (47%) of the total 1117 hectares in the buffered area in Pool 8. These areas accounted for 54% of the lake sturgeon locations. In all of Pool 8, areas of high suitability account for 966 hectares (8%) of the total 11476 hectares. These areas contained only 42% of the lake sturgeon. A smaller area of high suitability exists in the buffer than the rest of the pool while more lake sturgeon are located in the buffered areas. This suggests that areas of high suitability are preferred more when they are near aquatic structures in Pool 8.

A stepwise multiple regression was performed on the Pool 5A and 8 data sets. The dependent variable was the model values where the lake sturgeon were located. Independent variables included depth, aquatic type, and aquatic structure buffer. For the lake sturgeon located in Polander Lake, the highest relation to the modeled values occurred with depth and aquatic structure buffer. The Coefficient of Determination was highly significant, 0.463 with a significance $P < .0005$. For the lake sturgeon located in Pool 8, the highest relation to the modeled values occurred with depth and aquatic type. Here, the Coefficient of Determination was significant 0.303 with a significance of $0.05 > P > 0.025$.

Conclusions

The use of the Pool 8 bathmetry coverage was not perceived to be a significant source of error in creating the suitability model. Correlations were surprisingly high between field data and spatial data almost ten years old. Similarly, the creation and use of bathymetry in Polander Lake was considered statistically accurate. The main channel-channel border is adjacent to the Northeast portion of Polander Lake. This area contained all of the depth values which lowered the correlation. Because this area has deeper water and steeper slopes, GPS error, and change in river depth could potentially reduce the correlation. Based on the belief that small changes and/or GPS error could lower the correlation, these data points were removed and the correlation was significantly higher.

The use of bathymetry, aquatic type, and aquatic structures in suitability modeling suggests many things about lake sturgeon. Lake sturgeon select depths and aquatic types which can be classified. Based on the values given to these classifications, the locations of lake sturgeon are found to be near selected classifications of depth and aquatic type. This implies that these habitat classifications are indicative of lake sturgeon's preferred locations. Also, because preferred locations can be identified, the preference or avoidance toward aquatic structures can be identified.

Other data would most likely increase the understanding that a model could summarize. Pool 8 lake sturgeon in areas of low suitability were mainly located near the entrance of the Black River suggesting that other spatial data may explain this phenomenon. Even without additional data sets, the use of the available coverages clearly shows a spatial relationship. Depth and aquatic type appear to be good indicators of areas heavily used by lake sturgeon. The addition of aquatic structures appeared to add little to the overall understanding of the species

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