Middle Mississippi River Sturgeon Chub Model

U.S. Army Corps of Engineers, St. Louis District

BACKGROUND

The St. Louis District (District) of the U.S. Army Corps of Engineers (Corps) is charged with obtaining and maintaining a navigation channel on the Middle Mississippi River (MMR). The MMR is defined as that portion of the Mississippi River that lies between its confluence with the Ohio and the Missouri Rivers (Figure 1). This ongoing Project is also commonly referred to as the Regulating Works Project. As authorized by Congress, the Regulating Works Project utilizes bank stabilization, rock removal, and sediment management to maintain bank stability and ensure adequate navigation depth and width. Bank stabilization is achieved by revetment and river training structures, while sediment management is achieved by river training structures. The Regulating Works Project is maintained through dredging and any needed maintenance to already constructed features. The long-term goal of the Project, as authorized by Congress, is to obtain and maintain a navigation channel and reduce federal expenditures by alleviating the amount of annual maintenance dredging through the construction of regulating works. Therefore, pursuant to the Congressionally authorized purpose of the Project, the District continually identifies and monitors areas of the MMR that require frequent and costly dredging to determine if a long-term sustainable solution through regulating works is reasonable. The District also monitors bank stabilization areas to determine if additional work or re-enforcement of existing work is needed to ensure the dependability of the navigation channel.

A Draft Supplemental Environmental Impact Statement (SEIS) for the Mississippi River between the Ohio and Missouri Rivers (Regulating Works) was recently developed to evaluate the impacts of future placement of river training structures. Examples of these structures are provided at Figure 2. Placement of river training structures is expected to reduce shallow to moderate-depth, moderate-to high-velocity habitat along the main channel border (Figure 3) which is important for some MMR fish guilds that have seen declines in abundance since the mid-1900s. To better understand quality of main channel border (MCB) habitat impacted, and evaluate potential effectiveness and ultimately the practicability of different mitigation actions, a habitat model is needed. This need for the development of a habitat model specific to this habitat type also was discussed in the SEIS.

PROBLEM STATEMENT

An acceptable habitat model is not available to assess habitat quality for key MCB habitat of the MMR. More specifically, a habitat model is needed to better understand how river training structures impact shallow to moderate-depth, moderate-to high-velocity habitat. This type of habitat is unique and has been lost over time within the MMR.

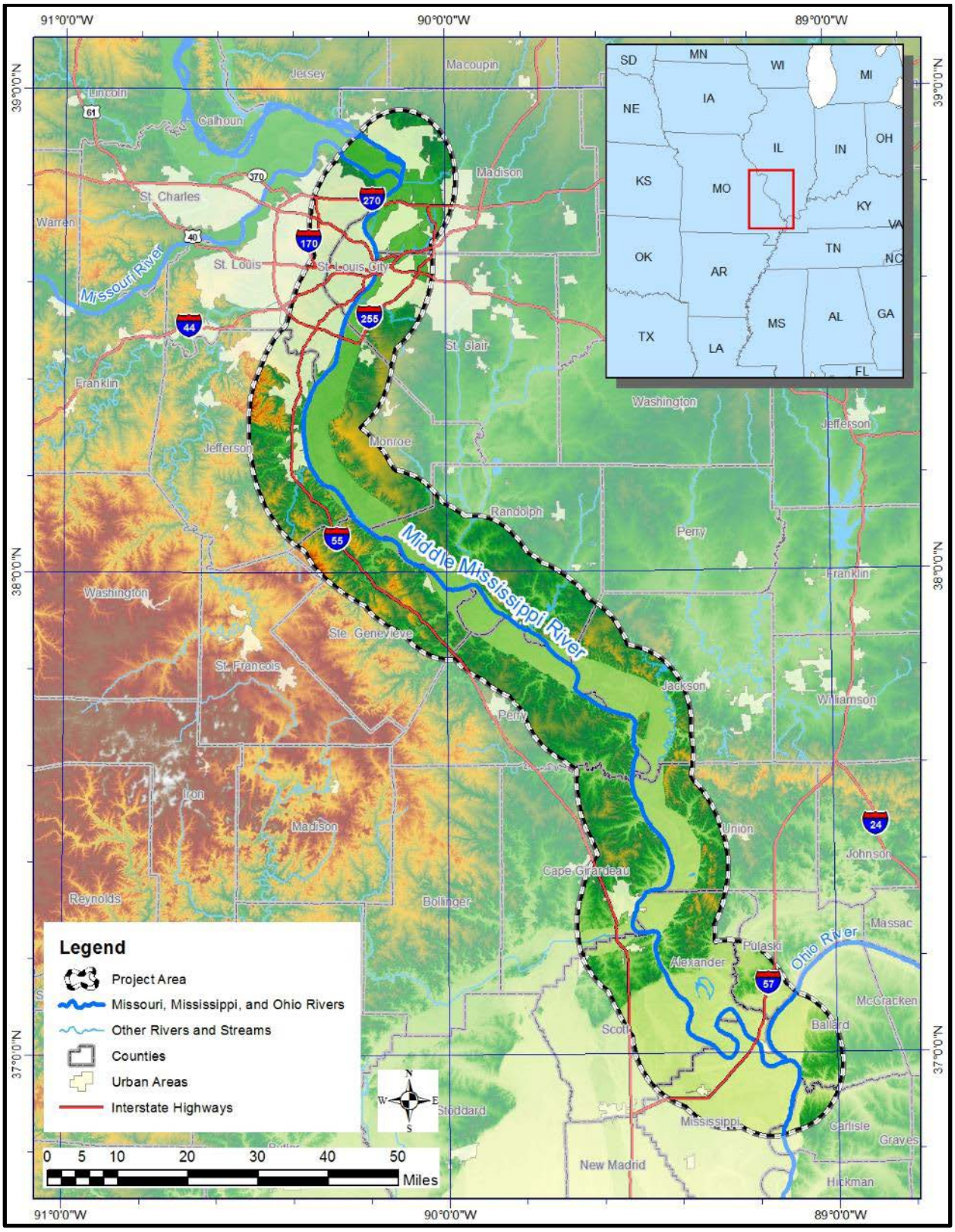

Figure 1. Location and extent of the Middle Mississippi River.

Figure 2. Examples of river training structures on the Middle Mississippi River.

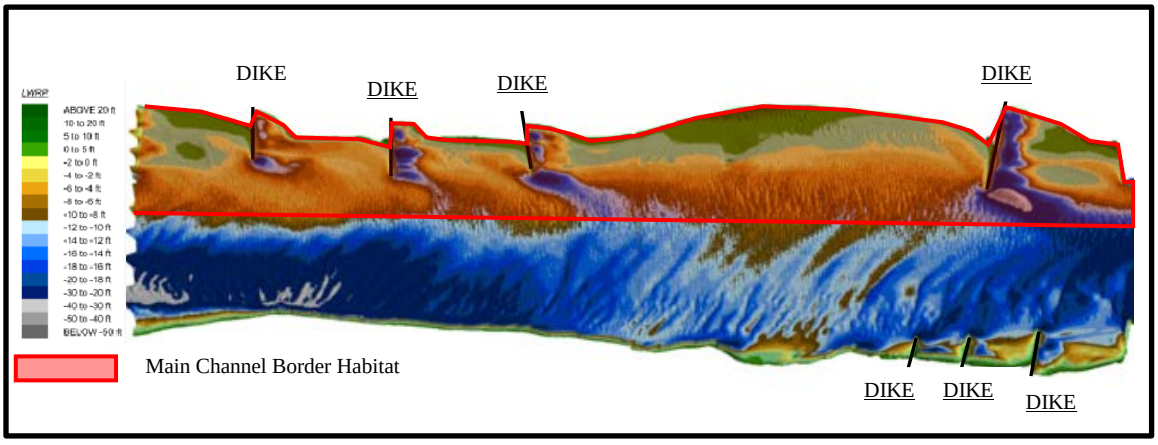

Figure 3. General location of main channel border habitat.

The District did consider using traditional U.S. Fish and Wildlife Service Habitat Suitability Index (HSI) Models (i.e., "Blue Book" models) to assess habitat changes in MCB habitat. However, after review of

existing models for all MMR fish species it was determined that these models did not utilize variables affected by river training structures in main channel border habitat, or that they would not adequately capture the adverse effects to physical habitat brought about by implementation of river training structures.

MODEL PURPOSE

Due to the lack of existing models, the District made the decision to develop a new model that would adequately represent the key MMR habitat variables adversely affected by river training structure construction. The Middle Mississippi River (MMR) Sturgeon Chub Model is intended to help quantify the effects of river training structure construction or modification on the quality of Sturgeon Chub (*Macrhybopsis gelida*) habitat. Similarly, it would be used to evaluate the effectiveness of potential mitigation actions to improve or restore this specific type of MMR MCB habitat. The model also could be used to evaluate other project actions that impact key variables in main channel border habitat of the MMR.

MODEL SUMMARY

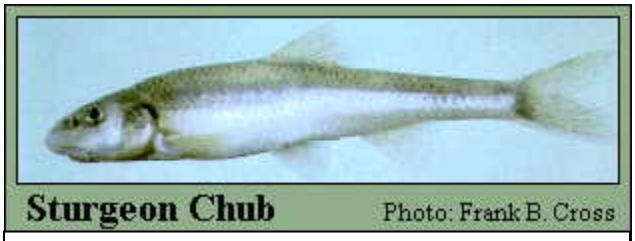

Photo from USFWS on-line source

The Sturgeon Chub Model consists of HSI curves for the habitat variables depth, velocity, substrate, and structured/unstructured habitat. These represent key variables in determining sturgeon chub habitat that also are most directly influenced by the construction or modification of river training structures. HSI curves are based on available literature and MMR, Lower Missouri River, and Lower Mississippi River Sturgeon Chub capture data presently available. Other datasets from the Missouri River Basin were used for comparison and confirmation of HSI curves. HSI curve equations are used in conjunction with corresponding data to compute a total HSI score that ranges between 0.0 (poor quality or complete lack of habitat) to 1.0 (high quality or "perfect" habitat). The model can be used to better understand habitat quality under existing conditions, future without project conditions, and future with project conditions. Habitat quality generated from the model would be multiplied by an assumed aerial measurement (e.g., acres) to compute a "habitat unit" for comparison. Microsoft Excel, IWR Planning Suite, or other methods would be used to calculate Average Annual Habitat Units.

This report is intended to provide documentation of the model's technical details, use, and relevant information for USACE model certification (EC 1105-2-412, PB 2013-02). Because of its basic nature, this report includes necessary information to also serve as the user's guide for the model.

CONCEPTUAL MODEL DEVELOPMENT

Model development followed the process of conceptualization, variable identification, curve development, development of a summation equation, and initial model testing. Model development included collaboration with State and Federal natural resource agency stakeholders and represents a solid foundation for quantifying the effects of river training structures, as well as potential mitigation measures, on the types of MCB habitat identified above. Although the model has gone through preliminary testing, reevaluation of the model may be appropriate following initial use evaluating early projects.

Conceptual ecological models are required for all USACE ecosystem restoration projects due to their utility to increase understanding, identify potential alternatives, and facilitate team dialog (Fischenich 2008, USACE 2011). Conceptual models also inform the development of quantitative ecological models (Grant and Swannack 2008, Swannack et al. 2012). As such, a conceptual model was first developed to serve as the foundation of understanding for the key habitat variables that make up the habitat type of concern for MCB habitat, and to serve as the foundation for overall model development.

Model development began with an interagency workshop in April 2016. This included participation from representatives of the U.S. Fish and Wildlife Service (USFWS), the Missouri Department of Conservation (MDC), and the Illinois Department of Natural Resources (IDNR), as well as the U.S Army Corps of Engineers. Areas of expertise included fisheries biology, river ecology, river hydraulics, and maintenance activities for the river navigation channel. The agency workshop included facilitation and guidance by experts in model development, including representatives from the USACE Engineering Research and Development Center (ERDC) and the Ecosystem Restoration Planning Center of Expertise (EcoPCX).

The agency workshop was conducted over three days with the focus of first building a conceptual model to describe key habitat factors for MCB riverine habitat affected by regulating works activities. Once key habitat variables were collaboratively identified, discussion was held on what fish species are most responsive to the variables of concern. After lengthy discussion the group selected chub species (e.g., sturgeon chub and sicklefin chub (Macrhybopsis meeki)) as possible representative species for the aspects of MCB habitat most directly affected by river training structures.

A draft of the conceptual model was developed at the conclusion of the agency workshop (Figure 4). This was refined over the next couple months and included additional resource agency review and input. The final conceptual model is included at Figure 5. This conceptual model forms the basis for a basic, mathematical model to calculate habitat quality for a given area.

During completion of the conceptual model, focus for development of specific habitat curves included both sturgeon chub and sicklefin chub. However, data review of the sicklefin chub suggested that habitat variables for this species did not align as well with the habitat conditions of concern identified during conceptual model development. For that reason, quantitative model development shifted focus to the sturgeon chub to represent key habitat conditions.

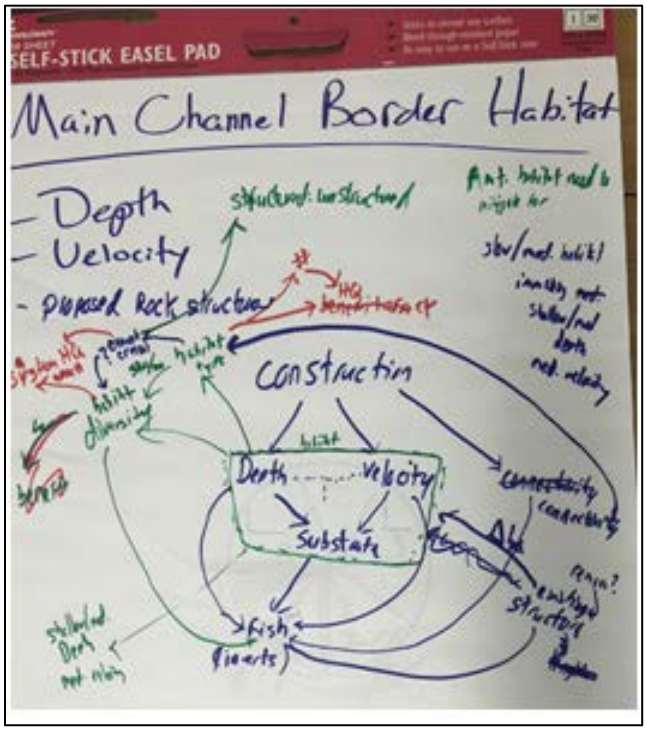

Figure 4. Preliminary conceptual model developed during agency workshop. April, 2016.

STURGEON CHUB HABITAT MODEL

Sturgeon chub are a small-bodied minnow (family Cyprinidae) often associated with large rivers such as the Mississippi or Missouri rivers. They appear to favor moderate to higher flow velocities, course substrates and shallow to moderate depths (Herzog 2004; Rahel and Thel 2004). They are relatively rare, and at one time were under consideration for listing under the federal Endangered Species Act. Their habitat requirements align with potential habitat effects from construction of structures associated with the Regulating Works Project.

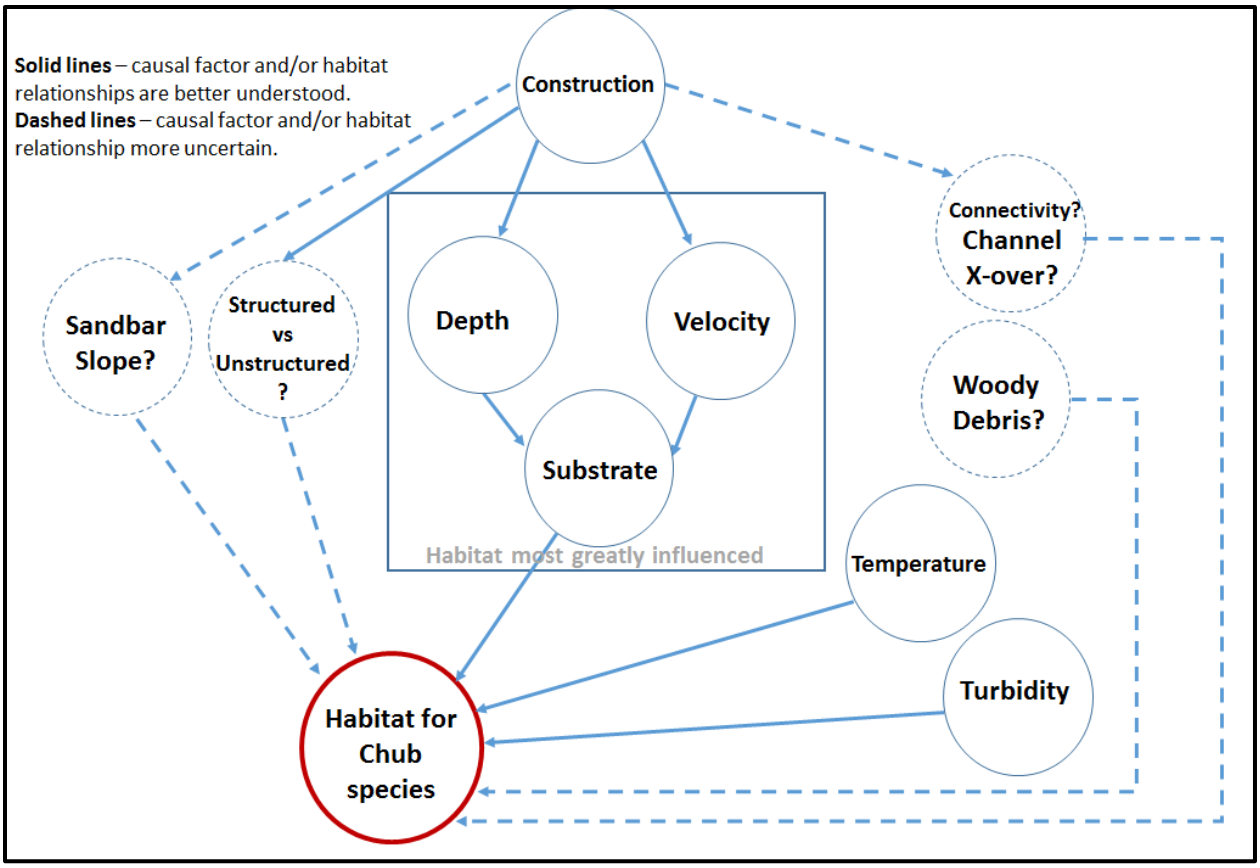

Figure 5. Conceptual model for key habitat considerations in main channel border habitat impacted by channel regulating structures.

Primary literature and available field data were reviewed to verify key habitat requirements of sturgeon chub. Although limited, detailed habitat characteristics of sturgeon chub were available to facilitate development of a quantitative model. Key references for model development include the following that are specific to sturgeon chub habitat in the MMR:

- Herzog, D. 2004. Capture efficiency and habitat use of sturgeon chub (*Macrhybopsis gelida*) and sicklefin chub (*Macrhybopsis meeki*) in the Mississippi River. Thesis. Department of Biology, School of Graduate Studies and Research, Southeast Missouri State University. Cape Girardeau, MO. March 2004.

- Missouri Department of Conservation routine trawl sampling data for the Middle Mississippi River.

The Herzog dataset is from trawling conducted on the Middle Mississippi River and just outside the Middle Mississippi River on the Lower Missouri River and the Lower Mississippi River from 2000 to 2001. The Missouri Department of Conservation dataset is from trawling conducted on the Middle Mississippi River from 2002 to 2014. Sampling was conducted with modified two-seam slingshot balloon trawls (i.e. Missouri trawls) in main channel, main channel border, side channel, and tributary habitats. Depth,

velocity, substrate, and macrohabitat stratum information was collected at each sample location. Sturgeon chub collected were recorded, with select habitat conditions noted for the area trawled. One of the limitations with this approach is that it collects fish over a protracted area (e.g., 100 yards or more per trawl run). The habitat notes that accompany the trawling observations are generalized over the duration of the trawl. It's impossible to know when or where a fish was collected within a trawling run and, thus, impossible to know the precise habitat conditions where the fish was collected within the trawl. However, the datasets represent the best available data to link sturgeon chub observations to habitat conditions, particularly on the MMR. As such, it represents the best source of information to describe habitat preferences of sturgeon chub on the MMR and, thus, prescribe a habitat model for the area. Moreover, where possible, trawling observations from Herzog (2004) and MDC were compared to other data sources to confirm reasonableness of the data.

In addition to the above, the following also served as a point of information and reference for sturgeon chub habitat:

- Rahel, F.J. and L.A. Thel. (2004, August 31). Sturgeon Chub (*Macrhybopsis gelida*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/sturgeonchub.pdf [accessed February 2016].

- U.S. Fish and Wildlife Service. 2001. Updated Status Review of Sicklefin and Sturgeon Chub in the United States. U.S. Dept. of Interior. USFWS, Region 6. Denver Colorado. March 2001.

- Young, B.A., T.L. Welker, M.L. Wildhaber, C.R. Berry and D. Scarnecchia, editors. 1997. Population structure and habitat use of benthic fishes along the Missouri and Lower Yellowstone Rivers. 1997 Annual Report of Missouri River Benthic Fish Study PD-95-5832 to the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation.

Quantitative model variables were developed from the conceptual model. In order to better evaluate the effects of construction activities, selection of model variables focused on habitat parameters affected by construction. The following variables were selected for the quantitative model. Each variable had a corresponding Habitat Suitability Index-type curve developed to describe general habitat quality across the range of conditions for that variable.

Water depth: This is a measure of the preferred depth where sturgeon chub are found within MCB habitat. The Water Depth HSI curve (Figure 7) is generally based on Herzog 2004 and MDC 2002-2014 trawl data since they are based on MMR, LMR, and Lower MO River capture data and therefore should be based on habitat that is most similar to habitat the Regulating Works Project would affect. Other datasets were used for comparison or confirmation purposes particularly when the Herzog 2004 and MDC 2002-2014 datasets were not in agreement (see below).

The Herzog 2004 and MDC 2002-2014 datasets generally follow a trend of higher Catch Per Unit Effort (CPUE) of sturgeon chub at shallow to moderate depths and lower CPUEs at greater depths. However, there is considerable variability, particularly in the 2002-2014 dataset. In Herzog 2004, CPUEs of sturgeon chubs were highest in water 0 to 2 m deep, though some fish were caught at all depths less than 7 m. In the MDC 2002-2014 dataset CPUEs were generally highest in water 0 to 4 m deep but were variable in water 4 to 7 m deep. Based on these two datasets, depths between 0.1 and 4 meters were assigned an HSI of 1.

Based on good agreement between Herzog 2004 and Young et al. 1997, depths greater than 4 m were assigned decreasing HSIs down to 7 m. Herzog 2004 and MDC 2002-2014 datasets show no catch deeper than 7 m; however, Young et al. 1997 show limited catch at depths to 10 m so an HSI of 0 is assigned at 10 m.

The shallowest suitable depth is unknown so a depth of 0 m was assigned an HSI of 0 and a depth of 0.1 m was assigned an HSI of 1.

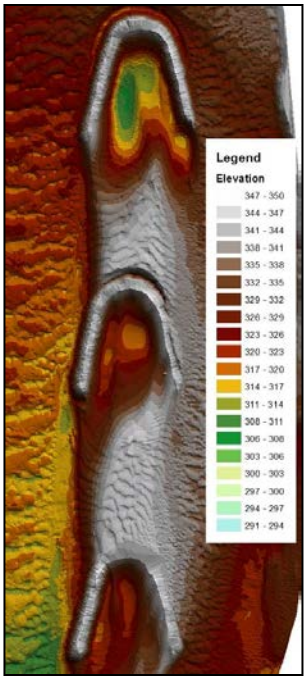

Figure 6. Example of bathymetry around a chevron dike on the MMR.

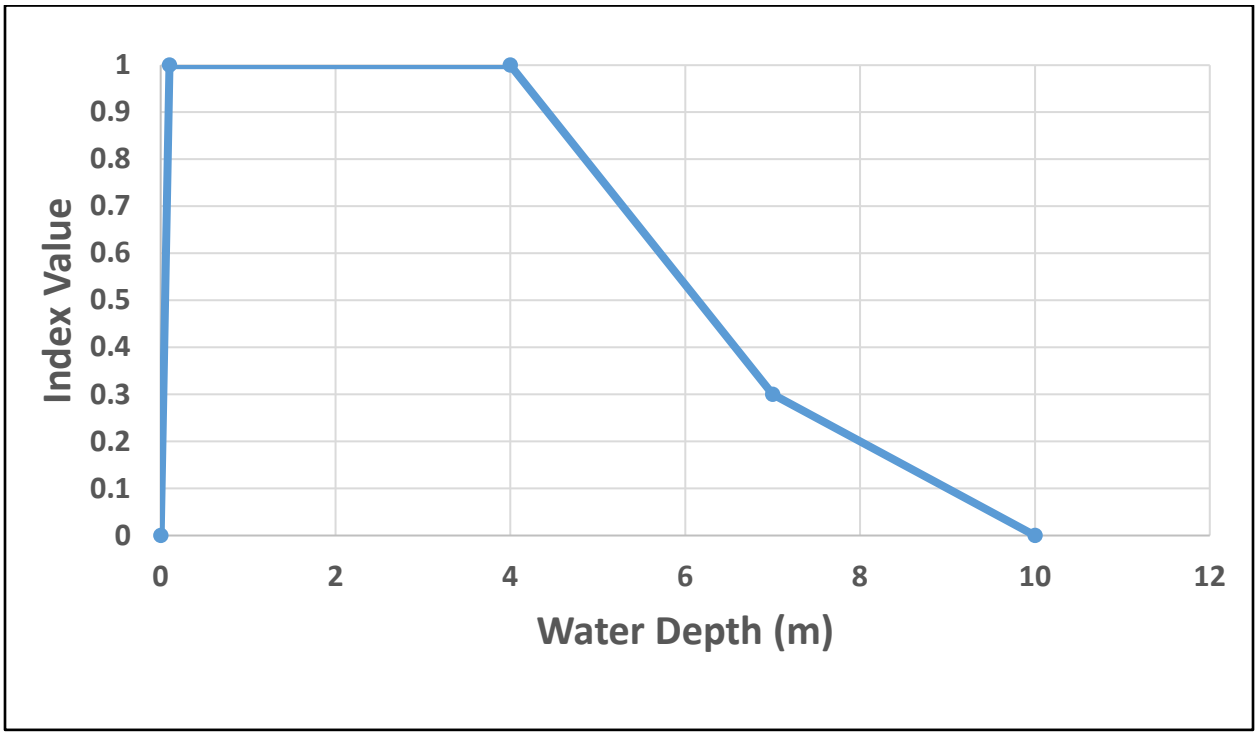

Figure 7. HSI curve for water depth for sturgeon chub on the MMR.

Velocity: This is a measure of the preferred water velocity by sturgeon chub. Preferred habitat conditions and the water velocity HSI curve is generally based on Herzog 2004 and MDC 2002-2014 trawl data since they are based on MMR, Lower Mississippi River, and Lower Missouri River capture data and therefore should be based on habitat that is most similar to habitat the Regulating Works Project would affect. Surface water velocities were provided in the datasets due to this being the standard sampling protocol associated with the trawl capture data. Surface water velocities are used in the velocity variable in this model for consistency.

There is generally good agreement between Herzog 2004, the MDC 2002-2014 dataset, and other datasets (Rahel and Thel 2004, Young et al. 1997) with respect to surface water velocities of habitat used by sturgeon chubs. The maximum CPUE of sturgeon chub observed in Herzog 2004 was at 0.4-0.59 m/s. Similarly, maximum CPUE in the MDC 2002-2014 trawl data was at 0.6-0.79 m/s. Therefore, velocities from 0.4 to 0.8 m/s were assigned HSIs of 1.0.

Sturgeon chub CPUEs below 0.2 m/s were zero in Herzog 2004. The MDC 2002-2014 dataset observed low CPUEs at low flows, so a low HSI of 0.2 was assigned. CPUEs between 0.2 and 0.4 m/s were very low in Herzog 2004 and were moderate in the MDC 2002-2014 dataset so a moderate HSI of 0.4 was assigned. HSIs of 0.4 and 0.2 were also assigned to velocities of 1.0 m/s and 1.2 m/s due to CPUEs being similar to those at low velocities in both the Herzog 2004 and MDC 2002-2014 datasets.

There is no catch data in Herzog 2004 above 1.2 m/s and none above 1.25 m/s in the MDC 2002-2014 dataset; however, Young et al. 1997 show some limited catch at velocities above 1.2 m/s up to 2.2 m/s so the HSI curve declines steadily from 0.2 to 0 in this range. The range of velocity conditions and associated HSI scores for velocity are presented in Figure 8.

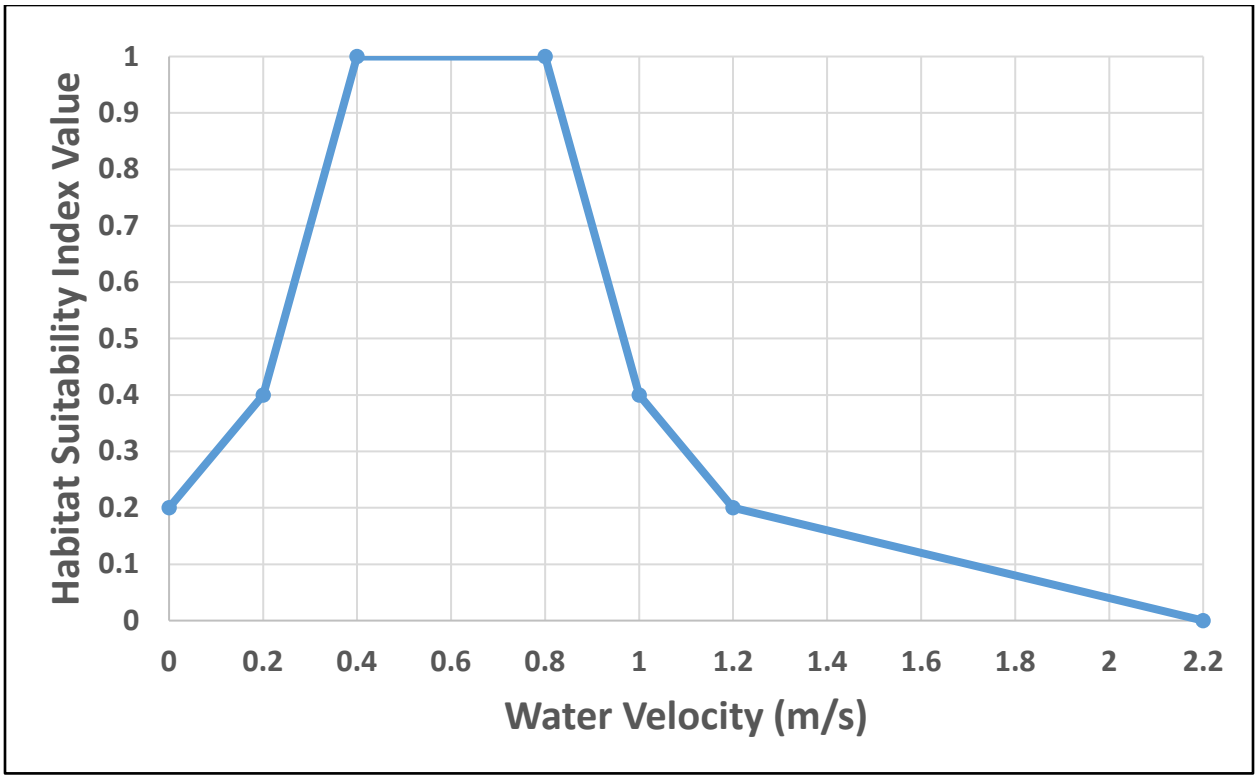

Figure 8. HSI curve for surface water velocity for sturgeon chub on the MMR.

Substrate: Available literature suggests that sturgeon chub favor coarse substrate for preferred habitat (USFWS 2001; Rahel and Thel 2004). Agency coordination during development of the conceptual and quantitative model also suggested a preference by sturgeon chub for gravel and coarse sand vs. silt substrate.

Available trawl data from MDC was reviewed to relate trawl catch data to substrate conditions for sturgeon chub. Definitions of substrate categories used for trawl data are as follows:

Gravel/Cobble/Hard Clay – Hard substrate consisting of dehydrated (firm) clay, gravel, rock, bedrock or concrete
Sand/Mostly Sand – Firm to very firm fine to coarse sediments with sand dominant or entirely sand
Silt/Clay/Little Sand – Fine and soft sediments dominated by silt but usually containing little fine sand with perhaps dehydrated firm clay pellets or moderately hydrated clay with little fine sand
Silt – Very fine and very soft sediments that may contain highly hydrated (very soft) clay; sand lacking

Although the catch of sturgeon chub was very limited (108 individuals that also had observations for substrate at catch), the CPUE did favor coarser substrate with fewer individuals collected over finer substrate. MDC observed a CPUE (fish/minute trawling) of 0.024 for sturgeon chub over gravel/cobble/hard clay; 0.012 for sturgeon chub over sand/mostly sand; 0.009 over silt/clay/little sand; and no observations of sturgeon chub over silt.

The CPUE observations were compared relatively amongst the four substrate categories. This resulted in relative observations where 53.3% of sturgeon chub CPUE occurred over gravel/cobble; 26.8% occurred over sand; 19.9% occurred over sand/silt/clay; and 0% over silt substrate.

The relative contribution of what substrate sturgeon chub were collected over most frequently was proportionately related to an HSI scale between 0 and 1.0. This produced four substrate categories with the following HSI scores: gravel/cobble - 1.0; sand - 0.5; silt/sand - 0.35; silt - 0.01. A score of 0.01 was selected for silt to provide a diminutive substrate habitat score. The range of substrate conditions and associated HSI scores for substrate are presented in Figure 9.

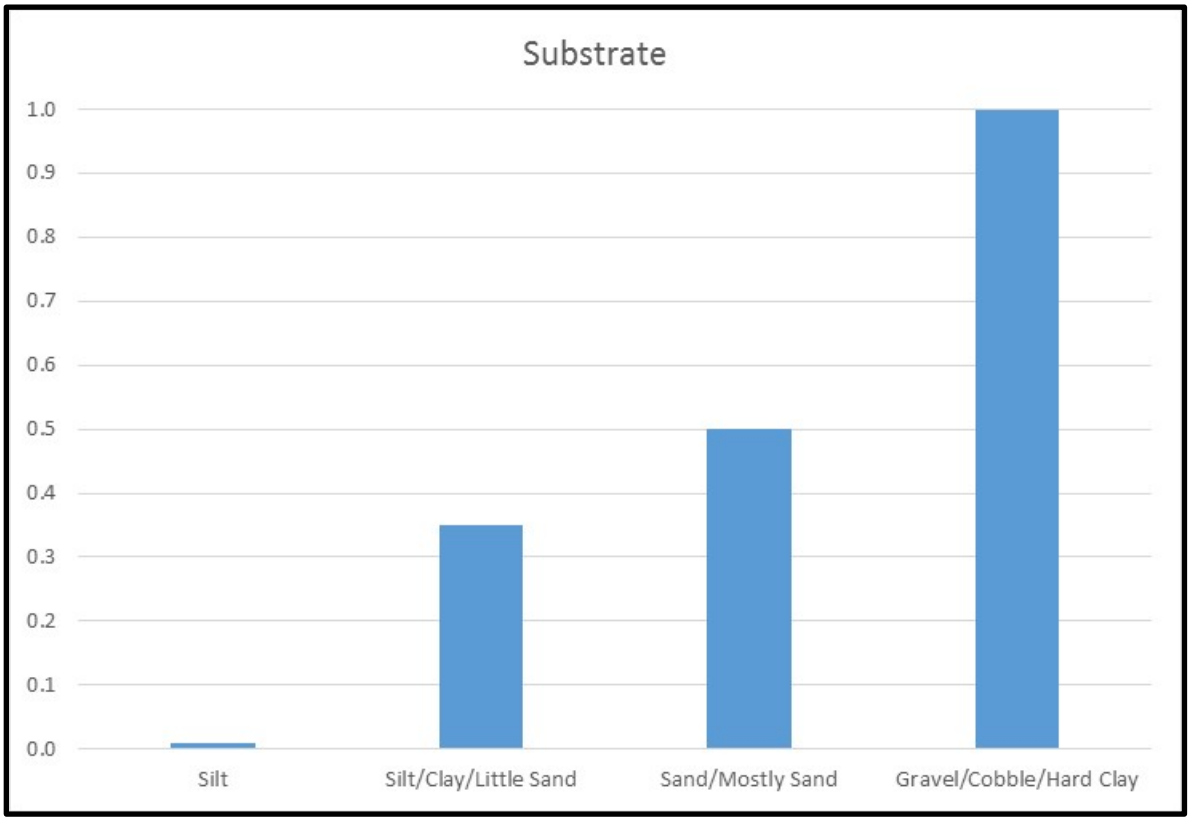

Figure 9. HSI values for assigned substrate conditions for sturgeon chub on the MMR.

<u>Presence/Absence of river training structures</u>: This variable is intended to gauge the degree to which an area provides habitat that is not influenced by river training structures, provides longitudinal connectivity for fish movement, and provides large patches of contiguous habitat of the same type.

The need for longitudinal connectivity and large patches of habitat is largely based on best professional judgment. Agency partners believe the implementation and presence of river training structures negatively affects aspects of MCB habitat and presence of some species, including sturgeon chub. It is believed that river training structures, when not overtopped, block main channel border movement corridors that facilitate fish movement between adjacent habitats. Presence of river training structures may force fish to use higher-velocity main channel habitat for longitudinal movement instead of lower

velocity main channel border habitat. Likewise, it is assumed that large patches of unbroken habitat more closely resemble the historic condition of the MMR to which this species is adapted and are more ecologically suitable than disconnected smaller patches of habitat.

Although discussion of this hypothesis is limited or absent from available literature, there is good support in MDC's trawl capture data for sturgeon chubs being caught much more frequently in unstructured habitat. Trawl data suggest that approximately 70% of sturgeon chub were collected from MCB areas outside of the influence of river training structures. Approximately 30% were collected in areas influenced by river training structures.

The monitoring protocol used for fish data collection (Gutreuter et al. 1995)[1] defines a structured area as "... a localized portion of main navigation channel border area in which a wing dam is the predominant physical feature." The exact interpretation of this is left up to the field crew collecting the data. Professional judgement was used to develop the following generic definition for model application. Main channel border areas influenced by river training structures are defined as the area within the main channel border in which the presence of a river training structure impacts the hydraulics and sediment transport or changes the contiguity of similar habitats. As with field application of the monitoring protocol definition, best professional judgment will have to be used in each situation where the model is applied to determine the most appropriate definition of structured versus unstructured to use. For areas of main channel or main channel border habitat influenced by either an unmodified existing river training structure or a newly constructed river training structure, an HSI value of 0.3 is assigned. If the area is main channel border habitat that is influenced by a river training structure that has been notched or otherwise modified to provide improved longitudinal connectivity or patch size, it is assigned an HSI value of 0.7. An HSI value of 0.7 is also assigned to main channel or main channel border habitat that is unstructured. If the area is contiguous main channel border habitat created by complete removal of existing structures or if the area is a large contiguous main channel border habitat area that is devoid of river training structures, it is allocated an HSI value of 1.0. The potential presence of river training structures and associated HSI scores are presented in Figure 10.

[1] Gutreuter, S., R. Burkhardt, and K. Lubinski. 1995. Long Term Resource Monitoring Program Procedures: Fish Monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, July 1995. LTRMP 95-P002-1. 42 pp. + Appendixes A-J

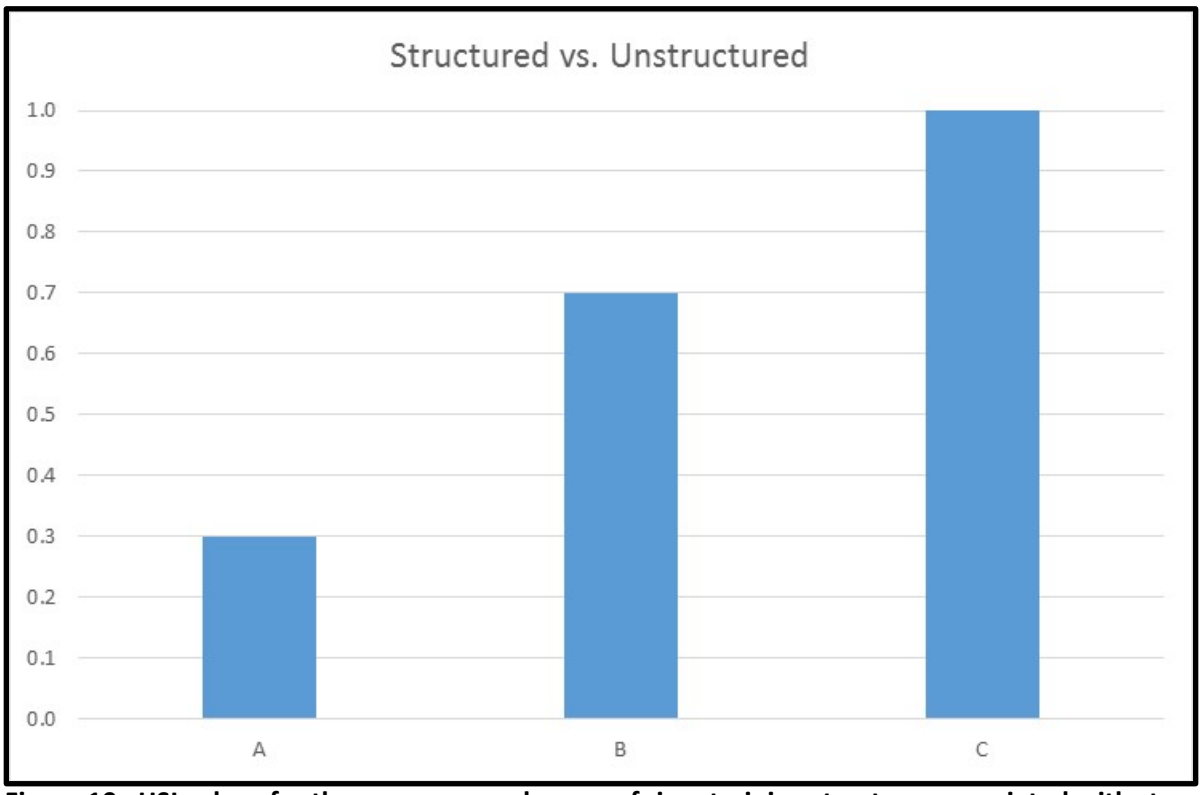

Figure 10. HSI values for the presence or absence of river training structures associated with sturgeon chub on the MMR. (A) Area is main channel or main channel border habitat that is influenced by either an unmodified existing river training structure or newly constructed river training structure; (B) Area is main channel border habitat that is influenced by an existing river training structure that has been notched or otherwise modified to provide improved longitudinal connectivity or patch size; or the habitat is unstructured main channel or main channel border habitat; (C) Area is contiguous main channel border habitat created by complete removal of existing structures; or the habitat is a large contiguous main channel border habitat that is devoid of river training structures.

<u>Summation of Habitat Conditions</u>: Overall habitat conditions are then calculated from the series of HSI curves with the following equation:

($DEPTH_{HSI}$ + $VELOCITY_{HSI}$ + $SUBSTRATE_{HSI}$ + $STRUCTURE_{HSI}$)/ 4 = TOTAL HSI Score

This simplistic approach applies equal weight to all variables. Discussion was held with agency partners on whether or not any variable should be weighted more heavily. However, no clear data or evidence suggests any variable more important than another under normal circumstances. However, in situations where the velocity is over 2.2 m/s, the overall HSI defaults to 0.0. This is done to account for the fact that high-velocity habitat is unusable, regardless of the values of the other variables.

Conceptual Model Variables Not Carried Forward

The conceptual model (Figure 5) identified additional habitat variables that were not carried forward for the quantitative model. These include the following:

- **Temperature:** thermal preference clearly is a component of all aquatic biota. However, thermal preference does not appear to be a key limiting factor for MCB habitat or its typical associated species, including sturgeon chub. Moreover, activities within the Regulating Works Project would do little to affect temperature. Therefore, this variable was not carried forward for inclusion within the model.

- **Turbidity:** water clarity is often an important component of aquatic habitat for most biota. Sediment transport has been heavily altered within the MMR, and may have altered water clarity relative to historic conditions. However, beyond temporary construction effects, activities within the Regulating Works Project would do little to affect turbidity. Therefore, this variable was not carried forward for inclusion within the model.

- **Woody structure:** woody debris recruitment was identified during the model workshop as a concern for MCB habitat. However, it was not clear how strongly woody debris served as a key habitat component of sturgeon chub. Moreover, it appears unlikely that the Regulating Works Project would substantially alter recruitment of woody debris in MCB habitat. Therefore, this variable was not carried forward for inclusion within the model.

- **Sandbar slope:** agency personnel identified this variable as an important component of MCB habitat. The belief is that elongated, gently sloping sandbars have been lost on the MMR. They have been replaced by shallow sandbars that abruptly drop into the fast flowing main channel at the edge of dike fields. While this may be an important habitat feature, it is extremely difficult to define and quantify. Moreover, there was no evidence within available literature or data that would allow development of such a model variable. Therefore, this variable was not carried forward for inclusion within the model. Sandbar slope is indirectly incorporated into the scoring for the structured/unstructured variable. In reaches where a structure is completely removed from a dike field a more natural sloped sandbar should form.

- **Channel crossover habitat:** agency personnel identified this variable as an important component of MMR habitat. The belief is that the main channel has lost shallower sandbars within areas between channel meanders where the river thalweg crosses from one side of the channel to the other. Such areas may serve as important features to allow fish an easier ability to move across the main channel and have improved ability to move both laterally and longitudinally within the river. While this may be an important habitat feature, it is extremely difficult to define and quantify. Moreover, there was no evidence within available literature or data that would allow development of such a model variable. Therefore, this variable was not carried forward. Channel crossover habitat is indirectly incorporated into the scoring for the structured/unstructured variable. In reaches where structure is removed (notching, complete

removal, reduction in top elevation) depths in the navigation channel could be reduced, thus restoring some channel crossover habitat.

- **Juvenile Sturgeon Chub habitat:** Intrinsic to the consideration of the environmental variables that contribute to good Sturgeon Chub habitat is a consideration of varying habitat requirements by life stage. For the purposes of this habitat model, it was assumed that Sturgeon Chub nursery habitat is abundant on the MMR, as it is provided by low-velocity areas behind river training structures, and modifying MMR main channel border habitat for adult Sturgeon Chubs is not anticipated to functionally reduce population viability.

MODELING APPLICATION

Geographic Extent: The model is largely developed from field observations and literature focused on the MMR and areas just outside the MMR on the Lower Missouri River and Lower Mississippi River. Use of the model beyond this range should only be done with careful consideration.

Geographic Scale: This model is best applied to assessing MCB habitat conditions at a scale of one or multiple regulating structures, extending up to approximately a dike field (e.g., up to a couple miles of MCB habitat). The model user will need to identify the appropriate unit size within which to summarize and compute habitat conditions (e.g., acre, square meter). Similarly, the user will need to account for variability of any individual variable within the unit size. The unit size is not specified and is up to the user to identify the appropriate unit scale for their evaluation. It's likely that multiple unit or block areas may be selected to evaluate habitat within any given area. Additional discussion follows in the next section.

Model Inputs: Much like traditional HSI models, input data for each variable could come from a variety of sources. However, the most likely sources include the following:

Depth: bathymetry data collected on-site; reference/surrogate site; hydraulic modeling (physical or numerical); best professional judgment
Velocity: hydraulic modeling (physical or numerical); field data collection; reference/surrogate site; best professional judgment
Substrate: field data collection; best professional judgment
Presence/Absence of structures: GIS database for existing/potential river structures, aerial photography, field assessments.

The model is set to run as a basic mathematical model in Microsoft Excel. Input data will be summarized for the area under evaluation and entered for each variable. It's possible, though not required, that data could be calculated for each variable on a smaller scale within ArcMap (e.g., calculate variable HSI scores for 1-meter grid cells). In this case, the data could be calculated for individual cells, with an average variable HSI taken for the broader area. These could then be entered into the overall equation to calculate the HSI for the target area.

The model would not require any special software or computer programs for analysis. Input data may be generated from hydraulic models, data summarized within ArcView GIS, and other computer based tools. However, this is not required.

Important Considerations: A critical consideration for use of this model is the river discharge at which the model is run for a given area. For example, within any given area of MCB habitat, river depth and velocity can change greatly based on river discharge. Those two variables constitute half of the model and dramatically affect the output. Areas that may provide high quality MCB habitat at high discharge may be completely dry and function as terrestrial habitat at low discharge. Model users will need to consider how to address differences in river stage and how to account for drastically different conditions. For example, model users may desire to run the model multiple times to understand how habitat quality changes for an area over a range of discharges. Alternatively, the model user may select a single flow level to model, using the output as a representation of habitat under certain conditions or assumptions. It will be up to the model user to identify the best approach to the situation, and understand and explain the assumptions and limitations.

Another consideration is that substrate is temporal and can vary depending on the hydrograph and the flow for which samples are taken. Field data has shown that different substrates can be collected at different times from the same site. It is up to the model user to justify substrate selected and understand the assumptions and limitations.

Model Limitations: As identified above, the model is based off limited data for a relatively rare fish of the MMR. Much of the habitat relationships is based off trawling observations that have certain limitations in linking observations with known habitat conditions. However, the trawling data represents the best available information for describing sturgeon chub habitat, especially as it relates to the physical habitat variables of concern. Moreover, trawling observations were also compared to other available data to help improve reliability. In general, trawling observations were in-line with other observations from available literature.

Output of the model shouldn't be interpreted as an absolute quantification of habitat quality for any given area. Rather, it provides insight into general MCB physical habitat quality for key indicator species. It provides a relative index of habitat quality and conditions, particularly with how specific physical habitat quality may change as a result of installing, modifying or removing river training structures. This model is only intended as a planning tool to assess habitat conditions and is not a predictor of population response for sturgeon chub.

Preliminary Model Testing

Initial testing of the model with river training structure construction/removal scenarios has been performed to verify effectiveness and limitations. The model generally performs as expected. With a limited number of variables and equal weighting, the model is responsive to predicted changes associated with placement or removal of river training structures.

As is often the case, model results can sometimes be initially surprising, but it relates directly back to the input variables. For example, initial testing suggested that implementing new structures sometimes resulted in little change to habitat scoring or even an increase in habitat quality. This was due to the fact that new river training structures resulted in physical changes that caused conditions to fall within the preferred HSI range. This typically occurred with velocity and depth where areas that were largely main channel or deep, fast flowing MCB habitat were converted to shallower, slower (or more moderate) velocity MCB habitat. In such cases it is likely that the model would accurately represent that habitat may become more favorable for sturgeon chub with structure construction in some areas. Likewise, the model would accurately represent that habitat may become less favorable in some areas when structures are removed.

Field testing of the model has not been completed. However, the model can be verified over time as additional field data becomes available. It should be noted that USACE does not have any plans to perform field fisheries surveys as a part of model verification. Sturgeon chub are a rare species and targeting them for intense study would prove extremely time consuming and expensive. However, as observations of sturgeon chub are made in the future, whether as a part of the MDC sampling activities, or actions by other agencies, these observations can be compared back to model variables to further verify model effectiveness. An adaptive management approach will be employed to refine the model should future field observations or research associated with Sturgeon Chub or with application of the model indicate that modification is warranted. Any potential model modifications will undergo required review and approval.

Model Technical Quality: The model represents the best, most practical approach to estimating quality of MCB habitat for sturgeon chub and similar species. It was assembled collaboratively with input from State and Federal natural resource agencies, with assistance in facilitation from experts in model development and the EcoPCX. The model was constructed based on the best available scientific literature and, more importantly, from direct field observations within the geographic extent the model would be applied to. It should be reiterated that this model addresses fairly specific, unique habitat conditions, and sturgeon chub are a unique and rare species. While available information is limited at best, this model represents the most reasonable approach to quantifying habitat quality for the unique MCB habitat in question.

Model System Quality and Usability: This quantitative model is a simplistic mathematical equation that can be carried out in Microsoft Excel. An electronic file from Excel will be provided as a part of this report for review and approval.

Intended Model Usage: The model is intended for use by the District as a part of their planning for the Regulating Works Project. This includes evaluating related impacts of future projects, as well as potential future mitigation actions or habitat restoration activities within the geographic extent of the model.