US ARMY CORPS OF ENGINEERS
NORTHWESTERN DIVISION
MISSOURI RIVER BASIN
WATER MANAGEMENT DIVISION

SUPPLEMENTAL BIOLOGICAL ASSESSMENT FOR THE CURRENT WATER CONTROL PLAN

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INTRODUCTION

The Biological Opinion (BiOp), issued by the U.S. Fish and Wildlife Service (USFWS) in November 2000, set forth a Reasonable and Prudent Alternative (RPA) that, if implemented, would preclude jeopardy to Federally listed species due to the operation of the Missouri River Mainstem Reservoir System (System). In particular, the BiOp RPA included a prescribed flow operation from Gavins Point Dam (element II RPA). The BiOp presented the USFWS's conclusion that the prescribed flows would "restore and maintain sandbars and shallow water areas that serve as nesting and foraging habitat for least terns and piping plovers, as well as nursery habitat for pallid sturgeon and other native fishes; trigger spawning activity in pallid sturgeon and other native fishes; and reconnect potential riverine and floodplain inundating side channels, backwaters, and other off-channel areas needed as spawning and nursery areas for pallid sturgeon and forage fishes, as well as providing additional foraging areas for terns and plovers" (USFWS 2000). The U.S. Army Corps of Engineers (Corps) completed a series of engineering analyses subsequent to receipt of the BiOp. The results of those analyses have led the Corps to conclude that the implementation of the RPA prescribed flows from Gavins Point would not achieve the results expected by the USFWS.

The Corps concludes that, with two low-flow periods annually (summer and winter), the BiOp RPA would likely accelerate erosion of sandbars beyond that of the CWCP. Gains in connectivity in low-lying areas with flow increases as prescribed in the BiOp are relatively minor, with effectively no increase in value downstream of Omaha. Nebraska. The BiOp RPA summer low releases from Gavins Point Dam provide additional shallow water habitat compared to the CWCP; however, the amount falls far short of that identified in the BiOp as being needed to preclude jeopardy to the species. The Corps concludes the best way to achieve this habitat is through modifications to the existing river structures. The magnitude, frequency, and duration of a spawning cue are unknown. A comparison of a hypothetical cue shows that an increase in the frequency of a cue due to the BiOp would occur primarily in the Gavins Point Dam to Omaha reach of the Lower River. The relationship of water temperature and flow to pallid sturgeon spawning is unknown. Without understanding the multiple factors that may be limiting pallid sturgeon spawning and survival, it is not possible to determine if any potential changes to Gavins Point Dam releases are warranted. A robust research, monitoring and evaluation (RM&E) program that examines these multiple factors is needed to remove the uncertainty surrounding pallid sturgeon spawning and survival.

The results of this new information are the basis for the Corps' request for reconsultation on the CWCP. This information supplements the Biological Assessment provided in Dec. 1998. The project description and determination of effect remain unchanged. This supplemental Biological Assessment was prepared to assist in the understanding of the Corps' conclusion that implementation of the BiOp RPA releases from Gavins Point Dam would not achieve the results outlined in the BiOp. The following presents a comparison of the current Water Control Plan (CWCP) and the BiOp RPA with respect to the following processes thought to be needed to preclude jeopardy to the species: 1) Natural physical processes and tern and plover habitat, 2) Connectivity of low-lying lands, 3) Shallow water habitat along the Lower River, and 4) Spawning cue in the Lower River.

NATURAL PHYSICAL PROCESSES AND TERN AND PLOVER HABITAT

Natural Alluvial Geomorphologic Processes on the Missouri River

The Missouri River is an alluvial stream, and by definition, transports sediment whenever water is flowing between the high banks. Channel geometry (width, depth, slope, plan form, etc.) is a function of (1) the predominant hydrology, (2) the amount and characteristic of available sediment, and (3) the local/regional geology. All three of these factors are somewhat interdependent, but hydrology and sediment yield are more closely related. When viewed over a long temporal scale the river attempts to reach a state of "dynamic equilibrium", or "natural stability", where the channel geometry is created/maintained by a dominant discharge, or dominant discharge class. The dominant discharge is defined as the discharge (or discharge class) that transports the majority of bed material sediments through a river reach. Major flood events (25-, 50-, 100-year) can transport an enormous amount of sediment in a short period of time, cause severe bed and bank erosion/build up, and create large channel evulsions. Their infrequent occurrence and relative short duration, however, do not allow them to play a major role in determining the natural stability of a river reach. Rather, the natural stability is determined by normal flows and/or smaller floods with a higher return frequency and longer durations. These flows overtop point bars and medial sandbars at a great enough depth and for a sufficient duration to initiate scour. Natural stability does not imply static conditions. Erosion/deposition processes are ongoing. As high banks erode, point bars advance, and medial sandbars migrate downstream. In a naturally stable river reach over a long time period, the sediment transported into the reach will equal the sediment transported out.

Status of Alluvial Processes in the Present Missouri River

The above discussion represents the alluvial processes of the uncontrolled Missouri River. Presently the hydrology and sediment supply of the Missouri River is largely controlled by six large mainstem dams upstream of Yankton, South Dakota (RM 811), and by channelization downstream of Ponca State Park, Nebraska (RM 753).

Dams impact alluvial processes in two ways. First, dams change the hydrology of the river. Peak flows are reduced to provide flood protection, and base flows are increased for water supply, hydropower, etc. Channel evulsions associated with flood events become very rare and the floodplain ceases to contribute to the sediment supply. Flow regulation causes a shift in the dominant discharge class, usually to a lower discharge. Dams further impact the alluvial processes by preventing sediments from the upper basin to enter the reach below the dam causing a sediment-starved reach below the dam. This leads to degradation of the riverbed and channel widening. The absence of large floods does not allow the river to rebuild high bank land. This process results in lower water surface profiles, flatter slopes, and a general decrease in the dynamic alluvial processes of erosion/deposition. In general, point bars do not advance as rapidly, medial sandbars move slower (some not at all) due to less over topping, and side channels tend to fill and/or drain. The alluvial processes that once took place across the entire floodplain are now confined to the area between the high banks. These slower, less dynamic alluvial processes can lead to vegetation encroachment that can further retard the alluvial processes.

The un-channelized Missouri River was a wide river with multiple channels of varying depths that resulted from erosion, channel evulsions, etc. In contrast, the channelized Missouri River is a single channel characterized by a greater depth-to-width ratio and nearly uniform velocities. Channelization has removed the banks as a source of sediment, leaving only the riverbed and tributary contributions to maintain the alluvial processes. This further exacerbates the degradation process, particularly in the reach above the Platte River. The net result is little or no exposed point bars/sandbars and very little alluvial variability.

Relationship of the Hydrologic and Geomorphic Processes to the Missouri River Ecosystem Form and Function

The Missouri River before man's influence was characterized by a highly variable flow regime both within and between years. This flow regime and the associated sediment it transported drove many of the physical and biological processes thought to be important in maintaining a healthy, functioning ecosystem. The high-flow periods maintained a connection between the river and its floodplain and the constantly moving sediment along with the eroding and filing of the bank line maintained the channel morphology. The resulting channel morphology, in conjunction with the river flow, created the physical habitat template on which endemic Missouri River species are adapted. The distribution and abundance of species associated with a river is highly dependent on this physical habitat structure (Poff and Ward 1990). Naturally variable flows are thought to create and maintain the dynamics of the in-channel and floodplain habitat that are essential to aquatic and riparian species. Important ecological functions are thought to be associated with natural flows (Poff et al 1997). As an example, sediment transport through channels flushes organic matter. Woody debris washed into the channel can help create high quality habitat. Flood flows act to flush organisms and nutrients back to the river.

Poff et al. (1997) thought a river's flow was so important that they concluded it could be considered a "master variable". This conclusion was based on the assumption that stream flow was highly correlated with many critical physical characteristics of a river such as channel geometry and habitat diversity. Richter (1996) further defined the important characteristics of stream flow so that they could be quantified and evaluated. These characteristics include: magnitude, timing, frequency, duration, and rate of change of flow. Each of these characteristics has associated biological relevance. Magnitude refers to mean of the daily water conditions. It is a measure of the habitat availability and suitability and, thereby, defines the volume of habitat on any given day. Timing, or when a flow event occurs, determines whether critical life cycle requirements can be met. Frequency is a measure of how often the flow event occurs and influences reproduction and mortality. Duration refers to how long the flow event occurs and determines whether life cycle phases can be completed. Rate of change is a measure of how rapidly flow changes and can influence an organism's ability to respond.

Effect of the CWCP and the BiOp RPA on the Alluvial Geomorphologic Processes in Relation to Tern and Plover Habitat

As stated above, the geomorphic processes are a product of the hydrology, sediment availability, and geology. Because the BiOp RPA does not include a change in sediment availability and the geologic controls are unchanged, those aspects will not be discussed further. It is important to realize that a change in the present alluvial processes will require a change in the dominant discharge class. The dominant discharge is that discharge (or discharge class) that transports the majority of the bed material sediment load. Determining the dominant discharge class requires flow-duration data and an adequate relationship between river discharge and sediment transport. For the reach below Gavins Point Dam, the Sioux City gage is the nearest gage with an adequate sediment discharge record. Although this gage is not in the reach immediately below Gavins Point Dam, it is appropriate for this analysis as the hydrology of this gage is dominated by releases from Gavins Point Dam. To create a change in the alluvial geomorphology of the reach below Gavins Point Dam, the flow duration curve would need to be rotated clockwise sufficiently to change the dominant discharge class to the 55- to 70-thousand cubic feet per second (kcfs) class. Based on survey data, this is the discharge needed to inundate a significant number of medial sandbars to a depth that would initiate scouring.

The first step in determining the impacts of the BiOp RPA on the alluvial processes required the development of flow duration curves for the CWCP and the BiOp RPA. These curves were developed using the daily flow models and are shown in Figure 1. Examination of the flow-duration curves shows little change between the CWCP and the BiOp RPA. The second step was to determine the percent of the average annual sediment for each flow class. This was accomplished by merging the sediment discharge rating curve data from "Suspended Sediment Data Assessment Study, Missouri River at Sioux City, Iowa, MRR Sediment Series Report No. 39a, January 2001" and the flow duration curves, then dividing the sediment yield for each class by the total yield. The results are shown in Figure 2. Examination of Figure 2 indicates the distribution of sediment yield by discharge class for the BiOp RPA is shifted to the left (lower class) rather then to the right. The slight shift in the 55- to 70-kcfs discharge class is not sufficient to scour and maintain high elevation barren sandbars. In fact, the data suggest that, if any changes were to occur, the most likely scenarios would be for existing barren sandbars to convert to islands and channel border fills, with barren sandbars being maintained at a much lower elevation.

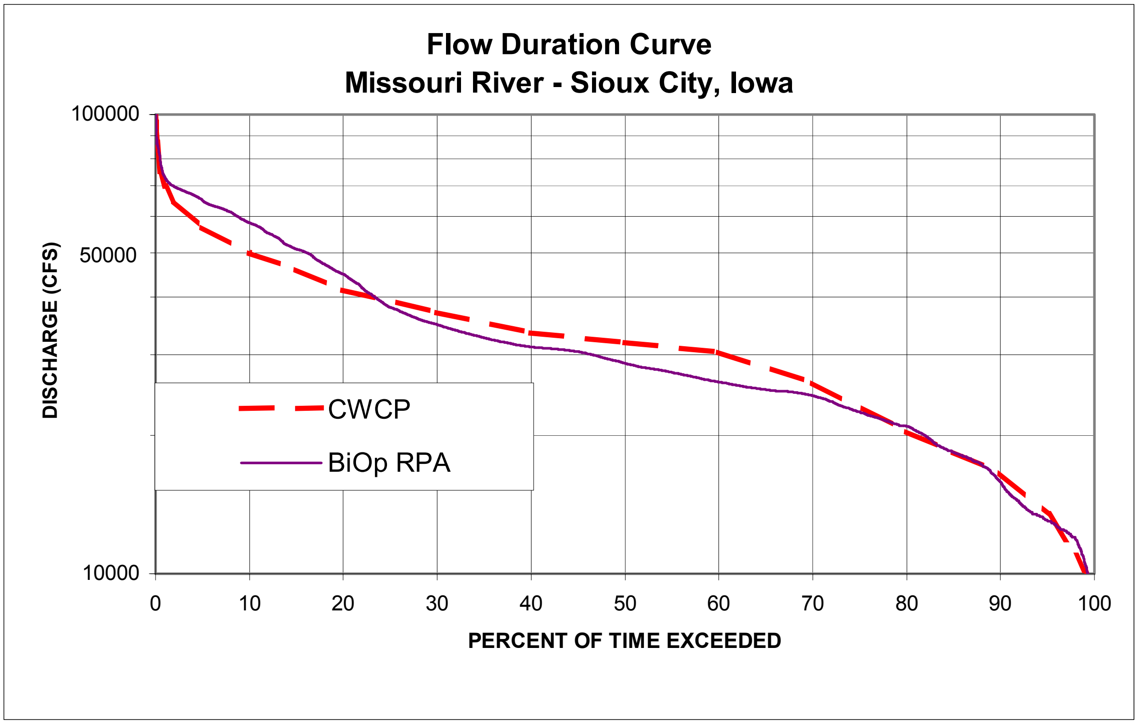

Figure 1. Flow duration curve at Sioux City, Iowa for the CWCP and BiOp RPA.

As the distance from Gavins Point Dam increases, the impacts of any changes in the release pattern decreases even further. This is due to the tributary inflow, both water and sediment, as well as the river's attempt to re-establish a new "natural stability". The stabilization and channelization downstream of Sioux City further restricts the natural alluvial processes. In the reach below Sioux City, the alluvial processes will be nearly identical for both the CWCP and the BiOp RPA.

Additional data were gathered in the fall of 2002 concerning the quantity and quality of sandbar habitat in the reach below Gavins Point Dam. Nine randomly selected sandbars were surveyed in an attempt to determine the total amount of available sandbar habitat at various flows. Sandbar area was broken into three categories: 1) total sandbar, 2) potential habitat, and 3) safe habitat. Potential habitat was defined as having less than 25 percent vegetation cover with a beach slope of less than 1:10. Safe habitat was defined as potential habitat that is more than 18 inches above the water surface. The survey data were integrated with rating curves for each site to develop a habitat-discharge relationship for each site. The area from the nine sites was prorated based on 2000 data (last year for which data exist) to estimate the total habitat for the reach below Gavins Point Dam. The results of this investigation are shown in Figure 3. It is important to note that, in Figure 3, the Total Emergent Sandbar line approximates the conditions of the reach in 1998 (following 1997 high flows). Lack of a true scouring/sandbar building event has allowed erosion and the vegetation encroachment to reduce the amount of habitat.

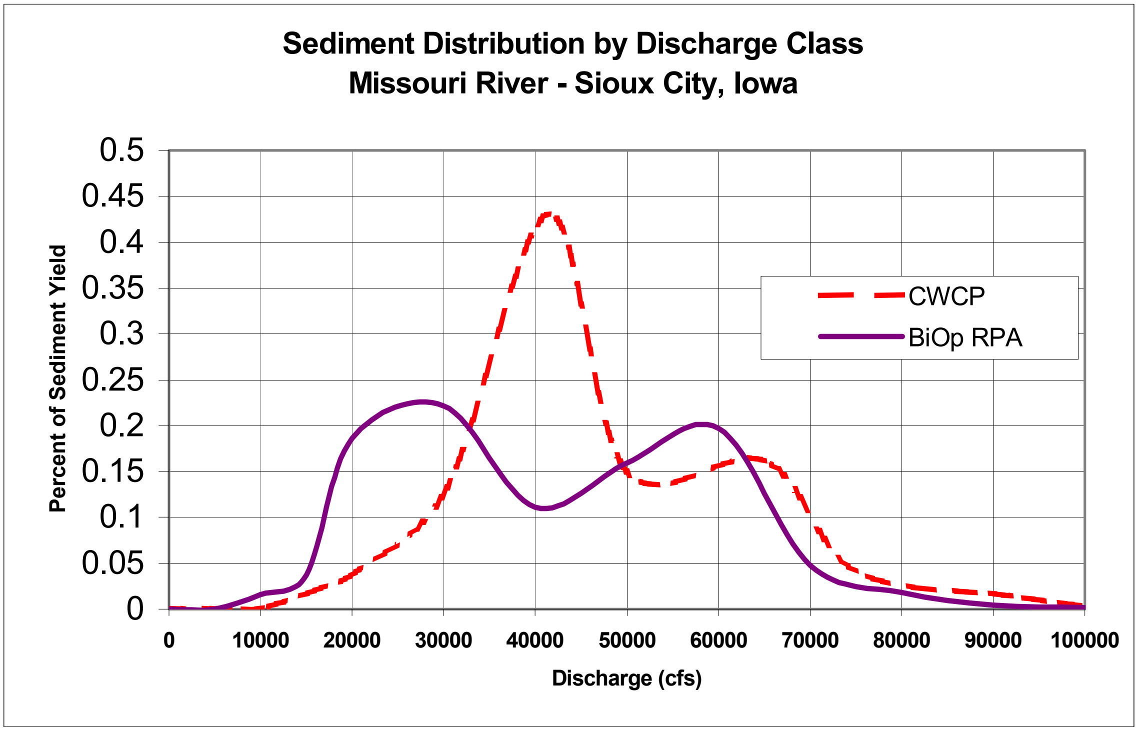

Figure 2. Sediment distribution by discharge class for the Missouri River at Sioux City for the CWCP and BiOp RPA.

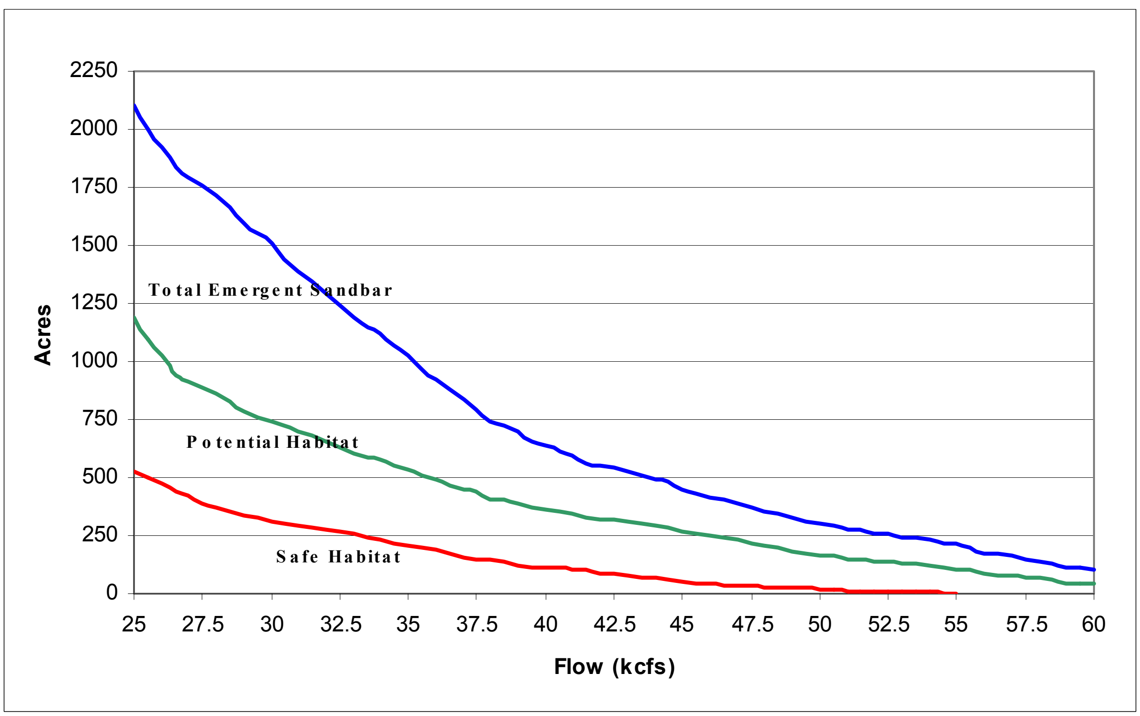

Figure 3. Relationship between flows (25 to 60 kcfs) and acres of emergent sandbar, potential habitat, and safe habitat on the Missouri River between Gavins Point Dam and Ponca, NE, Fall 2002.

During the sandbar survey, Gavins Point Dam releases dropped from approximately 26.5 kcfs to about 13.0 kcfs. Erosion of the perimeter of the sandbars was observed at a number of locations. A tenth sandbar was staked, but was eliminated from the analysis because the survey stakes had eroded into the river. This erosion is a natural process that would take place whenever stages drop to the point that flowing water concentrates in the main channel(s) of the river. This process, however, is likely more pronounced in an incised/degradational reach like the one below Gavins Point Dam. In a natural river setting, this erosion loss would be offset by the presence of a scouring/sandbar building event. The BiOp RPA, with its two low flow periods (summer and winter), would likely accelerate this erosion process beyond that of the CWCP, but it does not provide for a complimentary scouring/sandbar building event. The long-term net result would be less available habitat.

CONNECTIVITY TO LOW-LYING LANDS

As stated in the BiOp, "Floodplain connectivity refers to the seasonal flooding of areas adjacent to the river. The spring flood pulse often provides connectivity between the floodplain to the river. For native river fish like the pallid sturgeon, this floodplain connectivity, especially during May/June, provided spawning areas for forage species, increased phytoplankton production, and redistributed carbon to the river". This carbon, in the form of detritus scoured off of the floodplain, settled out in the shallow water areas along the river where the microscopic biota grew. As the pallid sturgeon hatched, the larval fish would float down the river until they were able to float into the shallow water areas, where they would reside during their fragile first months of life.

To better understand how much floodplain connectivity may be occurring along the Lower River from Sioux City to the mouth, the Corps estimated the acreage and elevation of the low-lying lands (areas adjacent to oxbow lakes and chutes) that could be inundated by high river flows. The elevations were then converted to river stages for the output nodes of the Daily Routing Model (DRM) hydrologic model used for the Master Manual Study to determine when the spring rises were inundating these areas. The months of May and June, the period when the spring rise was modeled in the DRM simulation runs, were checked to see how many acres were flooded for a varying number of days for the CWCP and BiOp RPA.

The graphical results of the analyses of connectivity are duration plots of acres inundated versus percent of the time. Duration plots were developed for inundation for at least 2 days up to over 10 days. As the number of days is increased, the amount of acres inundated diminishes, and the curves shift towards the lower left on the plots. The duration plot of the 2-day analysis is shown as Figure 4. This figure shows that the CWCP and the BiOp RPA provide similar duration plots of connectivity with the number of acres of connectivity for 2 days sometime during May or June increasing with the addition of a spring rise at Gavins Point Dam. This figure also includes the duration plot for a run-of-river (ROR) scenario to provide a perspective for how often these low-lying lands would have been inundated for 2 days with no flow control. This flow scenario has considerably higher values across the entire range of the plot from near zero percent to near 100 percent.

Table 1 presents the total values for the 25th percentile (lower quartile) from Figure 4 with a breakdown among the reaches making up the total reach from Sioux City to the mouth. The 25th percentile was selected for presentation because the BiOp RPA was designed to have spring rises about one-third of the time, and the 25th percentile falls within the range when spring rises may be affecting the amount of connectivity.

The CWCP provides a total of 3,282 acres of connectivity. The BiOp RPA has only a slightly higher total value (+164 acres) because only two reaches have substantially higher values—the Sioux City and Omaha reaches.

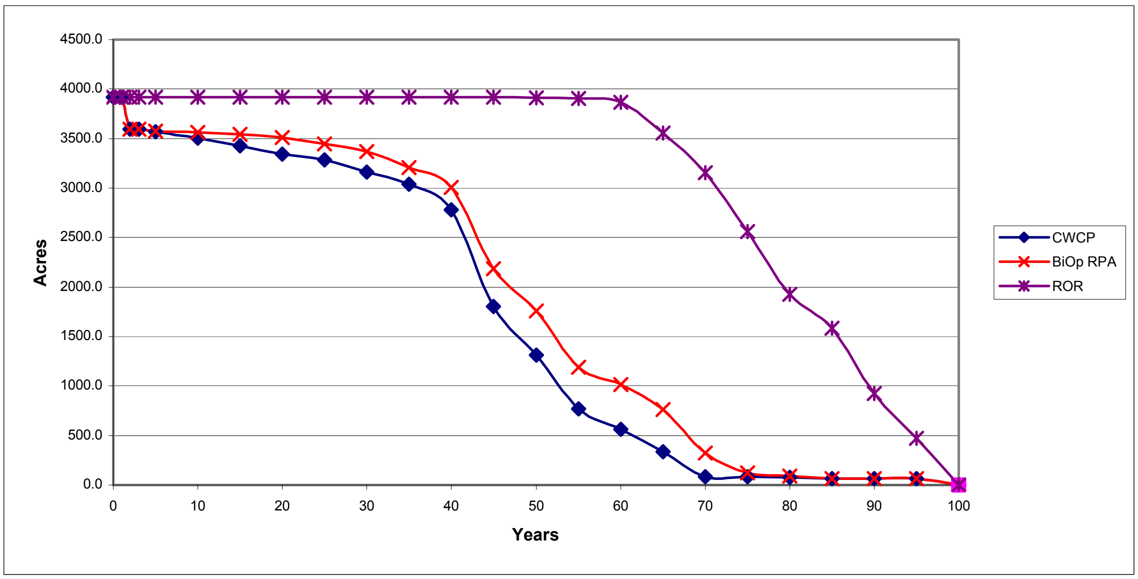

Figure 4. Acres of connectivity for 2 days in May and June for the CWCP, BiOp RPA, and ROR scenario.

Table 1. Connectivity to low-lying lands for 2 days in May and June (acres for the 25th percentile).

River Mile	Reach	CWCP	BiOp RPA
734-648	Sioux City	249	332
648-597	Omaha	270	344
597-497	Nebraska City	136	137
497-374	St Joseph	287	287
374-250	Kansas City	265	272
250-130	Boonville	768	768
130-0	Hermann	1,307	1,307
Total		**3,282**	**3,446**

In conclusion, the gains in connectivity in the low-lying areas with flow increases via spring rises are relatively minor. In fact, there is effectively no increase in value downstream of the Omaha reach. By adding a spring rise of 20 kcfs, the gain in connectivity is only 164 acres. These data indicate that the spring rise should not be added based on the gains in connectivity that could occur with the increased flows. Another way of looking at the end result of connectivity, or the flushing of detritus into the river, is to think about how this type of material gets into the river. The BiOp RPA, according to the data presented above, would inundate approximately 3,500 acres of low-lying lands for 2 days during the May through June timeframe. This is approximately 5.5 square miles. A small tributary to the Missouri River is likely to be several times larger than 5.5 square miles, and a rainfall event on the drainage area for each tributary flushes detritus into the tributary, which ultimately gets carried into the Missouri River. There are many thousands of acres that drain into the Missouri River, and many of the tributaries carry heavy sediment loads into the river during major rainfall events. These tributaries are, and will continue to be, the main source of detritus to the Missouri River no matter how the Missouri River Mainstem Reservoir System is operated.

SHALLOW WATER HABITAT ALONG THE LOWER RIVER

In its BiOp, the USFWS states that shallow water habitat has value to all life stages of native big river fish and other river organisms. As stated in the introductory remarks of the connectivity analysis discussion, shallow water habitat is especially important during the first few months of the life of the larval pallid sturgeon, an endangered species. The Corps and USFWS agreed during the formal consultation for, and the review of, the BiOp, that 20 to 30 acres of shallow water habitat per mile may provide the habitat necessary for initial recovery of pallid sturgeon. This section focuses on the amount of shallow water habitat occurring in the Lower River for the CWCP and BiOp RPA.

The analysis of existing shallow water habitat under the various alternatives was conducted using data obtained for the physical habitat model developed by the Corps as one way of assessing impacts of alternatives. As part of the development of that model, cross sections were taken at a representative sub-reach of seven reaches of the Lower River and hydraulically modeled. These data provided a basis for determining the amount of habitat fitting into a variety of depth and velocity classes for each of the seven reaches (habitat per mile times reach length). Shallow water habitat for the purpose of this analysis is habitat that is up to 5 feet deep with a velocity no greater than 2.5 feet per second. The amount of habitat in each depth and velocity class could be determined based on the amount of flow in each river reach. Using these relationships, the Corps developed a model that would provide duration plots of the acres of habitat per mile in each reach for any timeframe of interest. Generally, the Corps looked at individual months; however, the lowest flows for one of the alternatives occur from mid-July to mid-August. Data were computed for this period for the seven Lower River reaches and are presented in Figure 5. Integration of the area under the duration curve leads to the average daily value per mile for shallow water habitat for each reach. Table 2 presents these data for all seven sub-reaches modeled. This table also presents historic data (prior to the construction of the navigation channel) to provide some insight into habitat losses due to the construction that has taken place on the river. Figure 6 shows the acres per mile for the six reaches from Sioux City to the Osage River for the CWCP and BiOp

RPA. Data are not presented for the reach downstream from Gavins Point Dam because there is already adequate habitat (63.8 acres per mile for the CWCP) in this reach. Using the acres per mile from Figure 6 and Table 2, the total acreage available in each reach of the Lower River from Gavins Point Dam to the Osage River (River Mile 130) can be computed. The data for five reaches are presented in Table 3 on a reach and total basis (data combined using data from two locations for the Sioux City to Omaha reach) for the CWCP, BiOp RPA, and the ROR scenario (no control of system inflows by the Mainstem Reservoir System).

Table 2. Expected daily shallow water habitat for representative sub reaches from mid-July to mid-August (acres/mile).

Reach	CWCP	BiOp RPA	ROR	Historic
Gavins Point	63.8	71.6	64.9	106.6
Sioux City	2.2	5.8	3.6	107.0
Omaha	1.9	5.1	3.3	107.0
Nebraska City	4.5	6.0	5.1	103.4
St. Joseph	4.8	7.9	6.2	100.3
Kansas City	1.4	1.7	1.2	-
Boonville	18.3	18.7	17.4	-

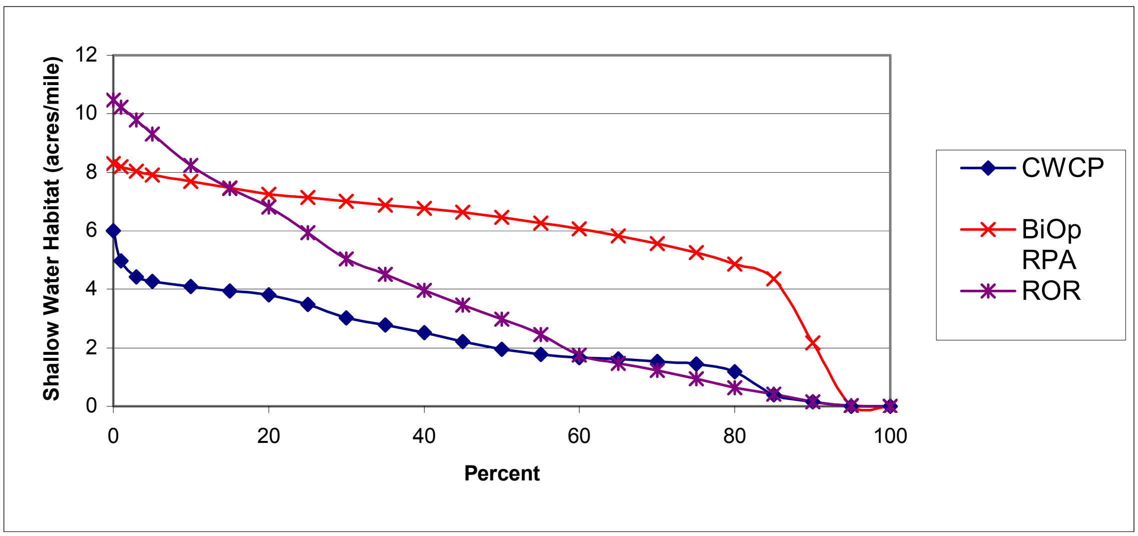

Figure 5. Duration Plot of Shallow Water Habitat during the mid-July to mid-August Period - Sioux City Reach.

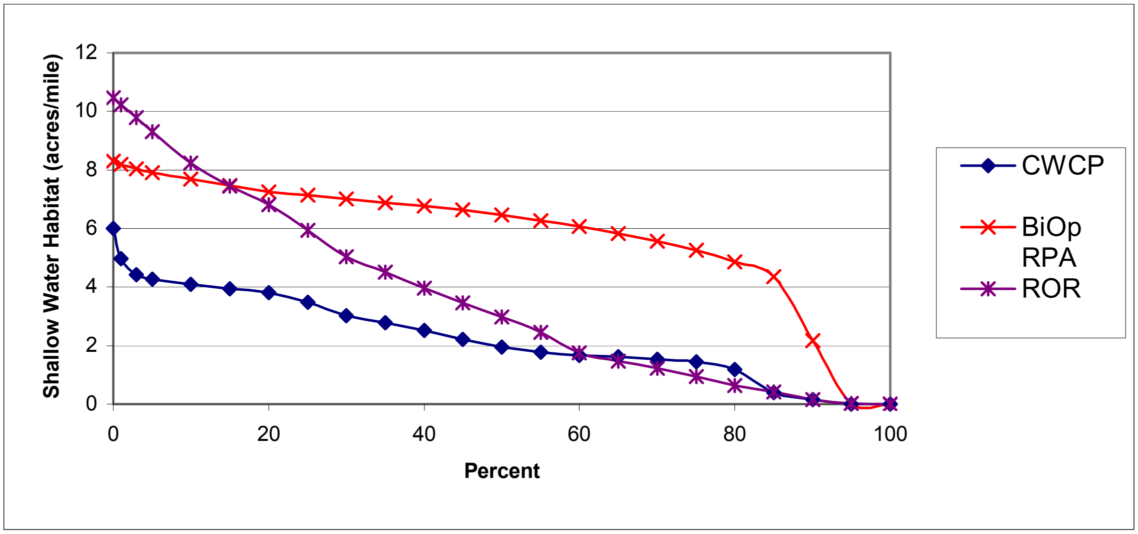

Figure 6. Expected Daily Shallow Water Habitat for River Fish.

Table 3. Expected daily shallow water habitat available from mid-July to mid-August (acres).

Reach	CWCP	BiOp RPA	ROR	20 Ac/mile
Sioux City to Omaha	288	757	479	2,740
Omaha to Nebraska City	144	191	165	640
Nebraska City to Kansas City	929	1,513	1,187	3,840
Kansas City to Grand River	164	200	144	2,320
Grand River to Osage River	2,193	2,245	2,086	2,400
Total	**3,717**	**4,906**	**4,061**	**11,940**

The CWCP provides 3,717 acres of shallow water habitat for the five reaches. The greater share of this habitat is provided between the Grand and Osage Rivers in the central part of the State of Missouri: 2,193 acres, or 59.0 percent of the total. Operation with the lower summer split season release of 25/21 kcfs under the BiOp RPA provides an increase of 1,189 acres more than the CWCP. If the flows were to be completely uncontrolled, as they would be under the ROR, the amount of total shallow water habitat would be less than it is for the BiOp RPA but 344 acres more than for the CWCP.

The shallow water habitat model was modified to create an output file of the average daily habitat values for each year. This data set allowed the creation of Figure 7. This figure compares the annual values for the CWCP and the BiOp RPA. Reducing the summer Gavins Point Dam release to 21 kcfs during this mid-summer period, as operations under the BiOp RPA would, results in more shallow water habitat in most years. Both the CWCP and BiOp RPA provide a wide range of habitat from year to year. This results from the year-to-year variability in flows, which indicates that flow should not be relied upon to provide the required amount of shallow water habitat.

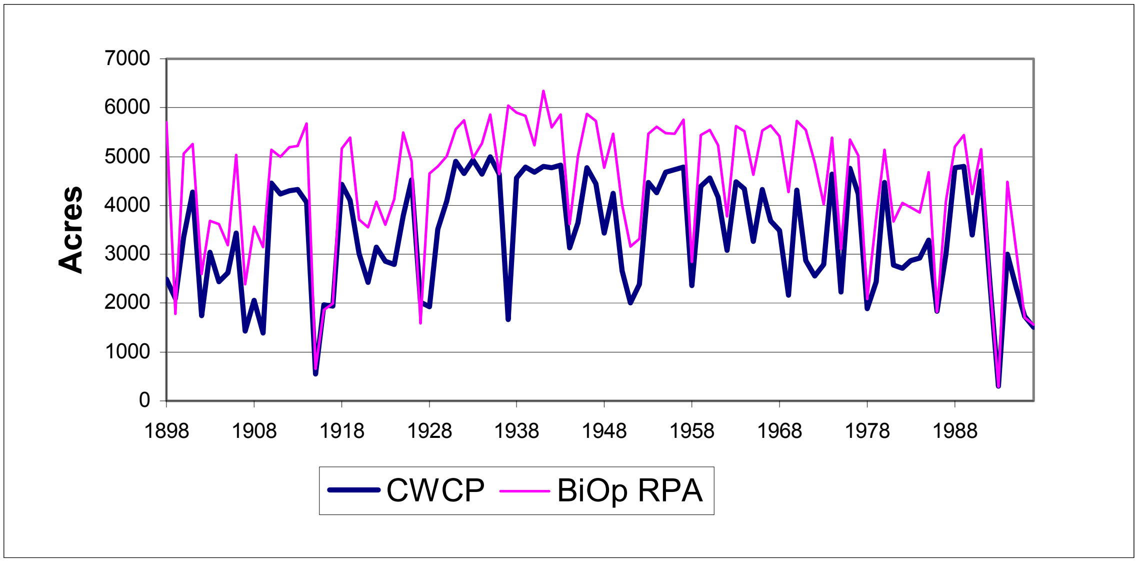

Figure 7. Annual Average Daily Acres of Shallow Habitat from Sioux City to the Osage River from mid-July to mid-August.

Additional discussion is needed regarding the amount of habitat that exists per mile in the reaches from Sioux City to the Osage River. With the exception of the Grand River to Osage River reach, habitat acreage is well below the minimum of 20 acres per mile that the Corps and USFWS agreed was a necessary attribute for the continued survival of the pallid sturgeon. Even though there are some increases in shallow water habitat (as discussed above and shown in Figure 6), the gains provided by release changes alone are also not enough to provide, on average, the minimum 20 acres per mile. Because of this, the USFWS included in its BiOp RPA the recommendation for the Corps to construct additional shallow water habitat. The changes in flow primarily have an impact on the amount of additional habitat that needs to be provided through channel alternation methods. For example, the BiOp RPA may reduce the amount of required acres to be constructed, on average, by 1,189 acres. This amounts to only 10 percent of the total of 11,940 acres required to meet the 20 acres per mile requirement.

As flows in the Lower River decrease, shallow water habitat associated with the Corps' mitigation and Section 1135 habitat enhancement projects is affected. Figures 8 through 10 identify the changes in habitat with flow for the CWCP and BiOp RPA. For the sites in the Sioux City to the Platte River reach, the BiOp RPA reduces the habitat by about 150 acres at the median value with its 21-kcfs release from Gavins Point Dam in the mid-July to mid-August timeframe. Similarly, habitat is lost in the Platte River to Rulo river reach, with the loss for the BiOp RPA being about 50 acres at the median value. Finally, the loss at sites further downstream is anticipated to be minimal, as evidenced by the relatively minor loss at the Jameson Island site (Figure 10). The total of about 200 acres of lost habitat would reduce the increase in shallow water habitat provided by the flow changes of the BiOp RPA.

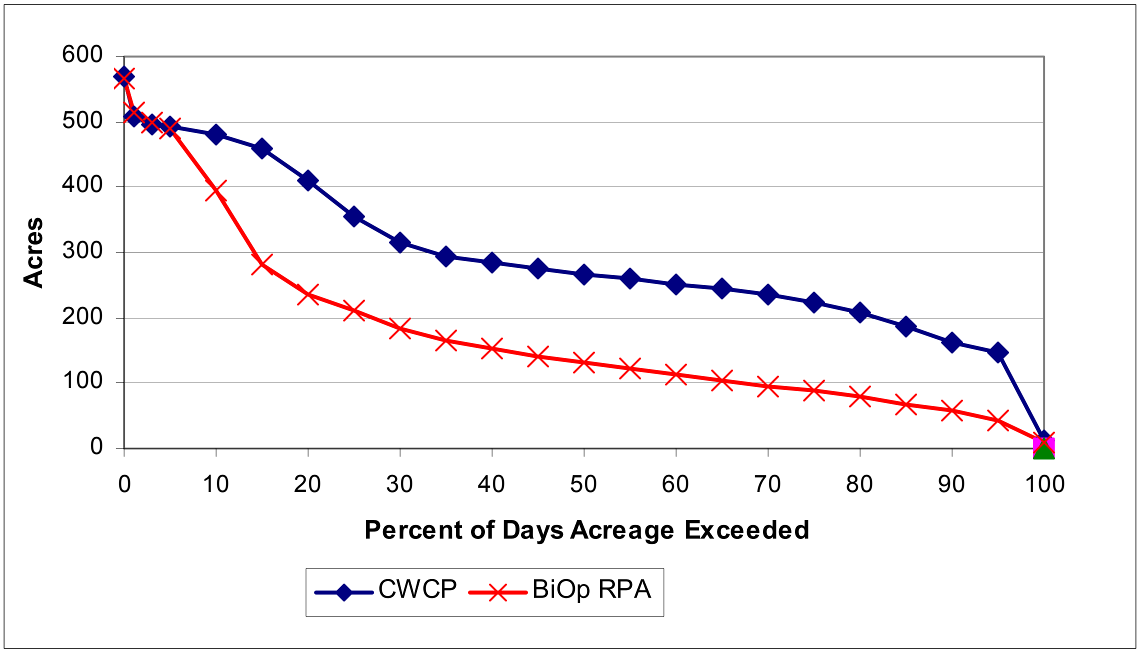

Figure 8. Impacts on existing mitigation and Section 1135 projects - Missouri River, Sioux City to the Platte River.

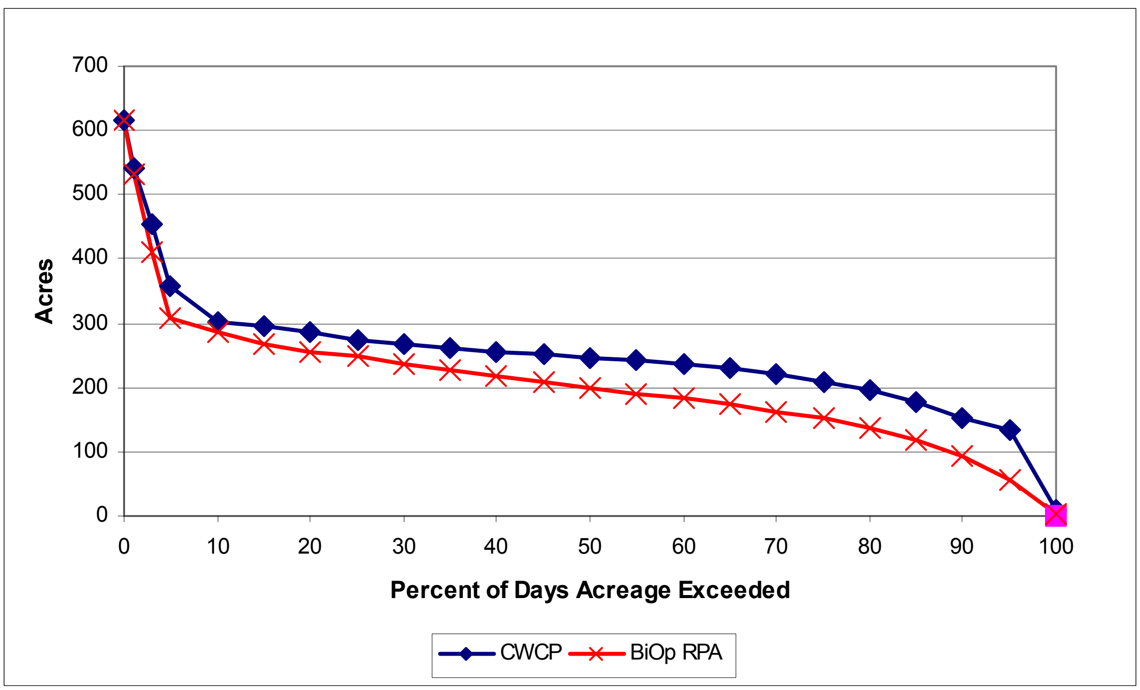

Figure 9. Impacts on existing mitigation and Section 1135 projects - Missouri River, Platte River to Rulo.

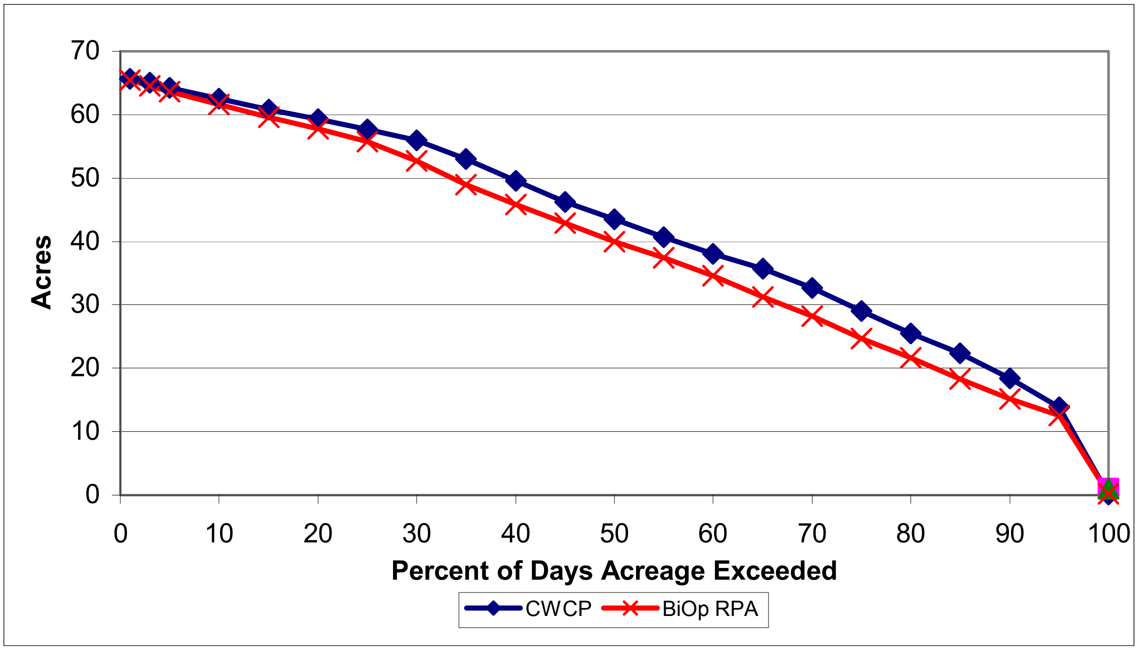

Figure 10. Impacts on existing mitigation site – Jameson Island.

SPAWNING CUE IN THE LOWER RIVER

The BiOp RPA recommends a spring rise release from Gavins Point Dam to provide, among other biologically important functions, a spawning cue for native river fish, especially the endangered pallid sturgeon. The BiOp RPA specifies a modified annual release pattern that has a spring rise above the full navigation service releases of 15 to 20 kcfs. This release is to have a duration of 2 weeks at its peak and a total of 4 weeks including the period over which the releases are gradually increased and decreased. Discussions between the Service and Corps staff determined that the spawning cue requirements of the pallid sturgeon are basically unknown at this time.

In an e-mail sent to the Corps on January 22, 2001, the Service requested the Corps to conduct a set of hydrologic analyses. This set of analyses included a spring rise analysis. The Service requested, "For gage sites downstream of Gavins Point, document spring rise spawning cues. Rises should be defined as increases of discharge of at least 20 percent above the mean discharge prevailing for the preceding 15 days, during the period May to July. The rise should take place over three days or less". The Service provided no information on what duration of rise to analyze. This lack of information supported the general understanding between the Corps and Service staffs that the required spawning cue is basically unknown at this point in time. Corps staff understood that the aforementioned criteria were hypothetical, and they did not have supporting data, analysis, and documentation of associated spawning success. A discussion of the analysis conducted for evaluating a spawning cue follows.

A model was developed that would access the daily flow data for each DRM node location from Gavins Point Dam to the mouth. A running average of the daily flows for the previous 15 days was conducted using the data starting on May 1 and ending on June 30 of each year. (The likelihood of spawning cues after June 30 is low, so it was not checked.) The flows for May 1, 2, and 3 were checked to determine if the flows over this 3-day period exceeded the prior 15-day average by at least 20 percent. If the flows on one of the days met the 20 percent increase, the model would continue to check the daily average flow until it dropped to less than 20 percent of the flows for the 15 days prior to May 1. The model continued the day by day check of the prior 15 days, computed an average, and counted the number of days the flows continued to be at least 20 percent above that prior 15-day average. This continued up to June 30.

In various years there were some short periods and some longer periods. The model recorded the longest period in terms of days. The longest period was recorded for each year, and then the 100 years of data were analyzed. The 100 annual values were sorted from highest to lowest with the highest value assigned a 1 (for equaled or exceeded 1 percent of the time) and the lowest value was assigned a 100 (for equaled or exceeded 100 percent of the time). A plot of these data is called a duration plot, and Figure 11 is an example of such a plot for the CWCP. This figure shows the duration plots for the CWCP at all of the gage locations in the DRM simulation output files for the Lower River from Sioux City downstream. A similar plot was completed for the BiOp RPA. Another set of curves was developed for the ROR scenario (no control of inflows to the mainstem of the Missouri River). Sets of curves were compiled for each gage location using this first set of curves, as shown on Figure 12. The second set of curves, one for each gage location in the DRM, provides the spawning cues for a full range of days. For example, to determine how often a 20 percent increase in flow occurred for a total of 21 consecutive days, one would go to the point where the 21-day line crosses the duration curves. Next one would slide down and read off the percent of time from the bottom axis of the graph for each curve. In the case of the CWCP curve on the figure, this point is located at 7 percent of the time. Similarly, it is 36 percent of the time for the BiOp RPA.

Because the Service did not specify a length for the spawning cue, a 21-day length was selected for analysis based on the spring rise recommended in the BiOp RPA. The total rise occurs over a 28-day period. If it takes 3 days to go up 20 percent, there will also be 3 days at the end of the spring rise where the releases will drop below the 20 percent value. This means that the spawning cue lasted 22 days (28 minus 6). Based on this basic consideration, a 3-week, or 21-day, length was evaluated for the spawning cue. Figure 13 shows a bar plot of the resulting data for all of the gage locations included in the DRM. The bars shown on this plot shift upward for shorter lengths of spawning cues, and vice versa.

Figure 13 shows that the CWCP and BiOp RPA have spawning cues that occur for differing percents of time. The values are presented in Table 4. For example, the Sioux City line on the plot shows that the percent of time increases for the CWCP in a downstream direction, with a 21-day spawning cue occurring 7 percent of the years at Sioux City and a maximum of 38 percent of the years at Hermann. The BiOp RPA increases the percent of years values for most of the reaches to 33 percent or greater. The exception is for the St. Joseph reach. Generally, for the reaches from Kansas City upstream, the values are higher moving across the figure because of the spring rise included in the BiOp RPA. Downstream from Kansas City, however, the value for the percent of the time the spawning cue occurs remains relatively constant with the values ranging from 38 to 39 percent. The ROR scenario has more spawning cues because the uncontrolled flows were historically much higher than the modeled spring rises, with the percent values ranging from high on the reaches closest to Sioux City (78 or 79 percent) to the lowest value occurring at Hermann (54 percent).

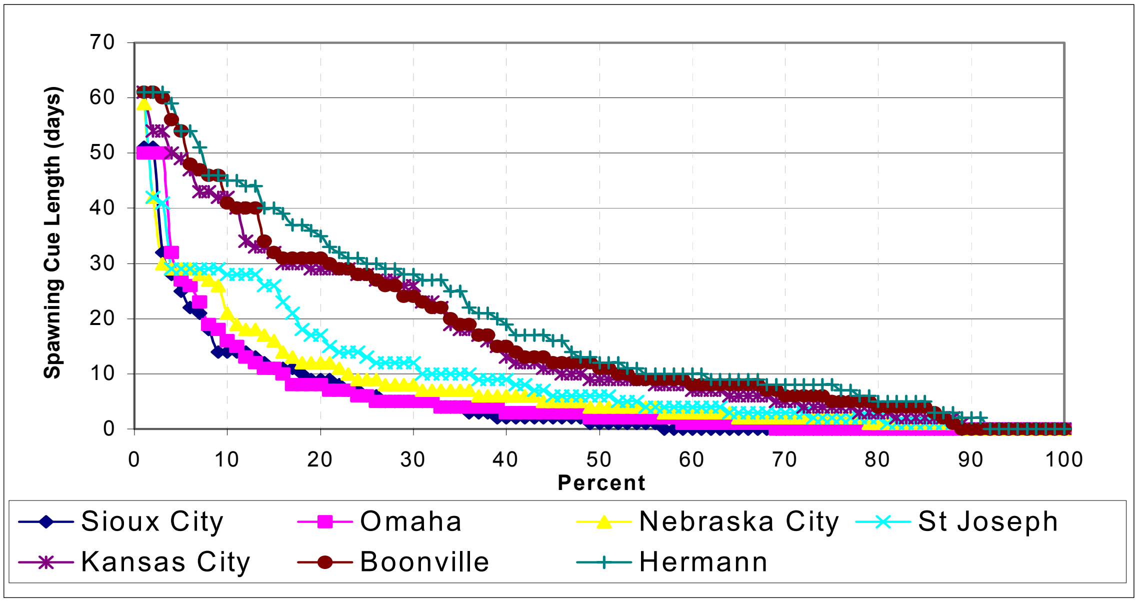

Figure 11. Duration plot of spawning cue length during May and June for the CWCP.

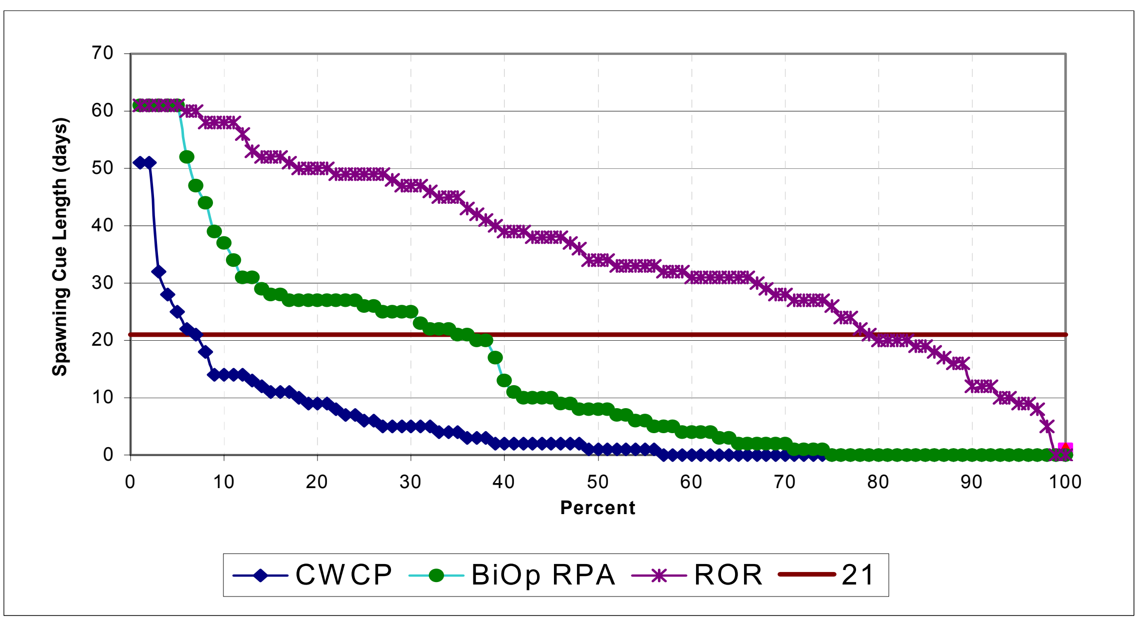

Figure 12. Duration plot of spawning cue length during May and June at Sioux City.

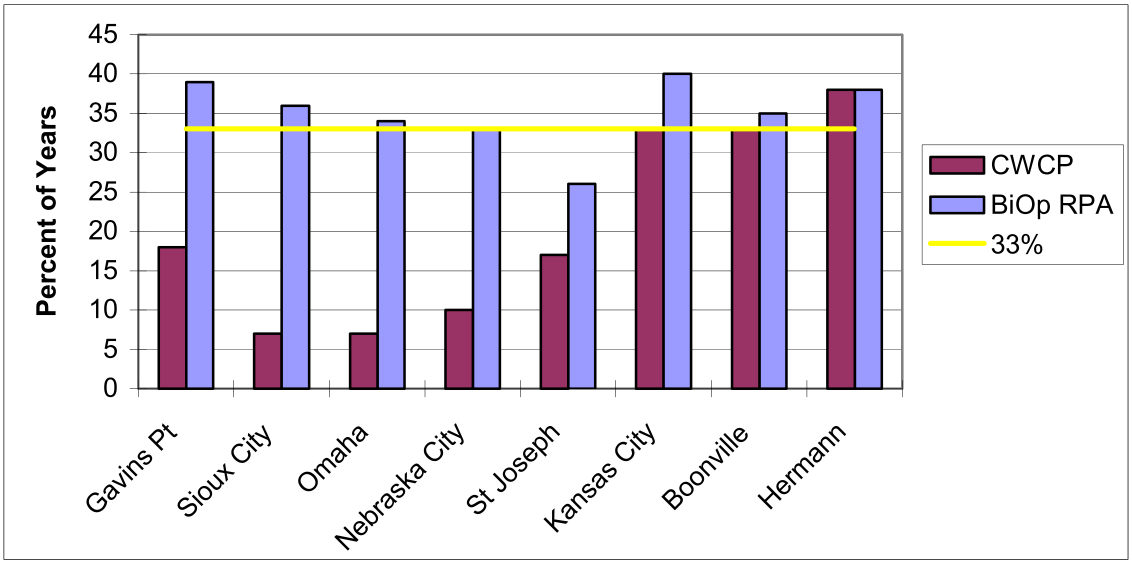

Figure 13. Percent of years with a 21-day spawning cue at various locations.

Table 4. Percent of years with a 21-day spawning cue at Lower River gaging stations.

Reach	CWCP	BiOp RPA	ROR
Gavins Point Dam	18	39	78
Sioux City	7	36	79
Omaha	7	34	79
Nebraska City	10	33	68
St Joseph	17	26	63
Kansas City	33	40	62
Boonville	33	35	62
Hermann	38	38	54

To demonstrate what happens when shorter length spawning cues are used in the analysis, a 14-day and 7-day spawning cue lengths were analyzed. As stated earlier, the shorter the spawning cue, the more often it occurs (duration plots shift upward). Figure 14 shows that this is indeed the case. All of the bars in the graph have shifted upward. For the 7-day spawning cue length (Figure 15) and the CWCP, the minimum percent of years is over 20 percent, and all of the reaches from Nebraska City to Boonville have this spawning cue length in over 33 percent of the years. The BiOp RPA has a 7-day spawning cue in 50 percent or more of the years for all of the reaches.

This brief analysis demonstrates how important it is to have a definitive length for a spawning cue. The CWCP comes very close to meeting the one-third requirement for a relatively short spawning cue, and it has a 34.5-kcfs flat release from Gavins Point Dam in many years. This release value is equivalent to a spring rise of about 5 to 6 kcfs in the May timeframe. The Corps' understanding of the primary purpose of the spring rise is to cue the pallid sturgeon to spawn; however, the absolute length and magnitude of the required flow to provide an adequate spawning cue are not known at this time.

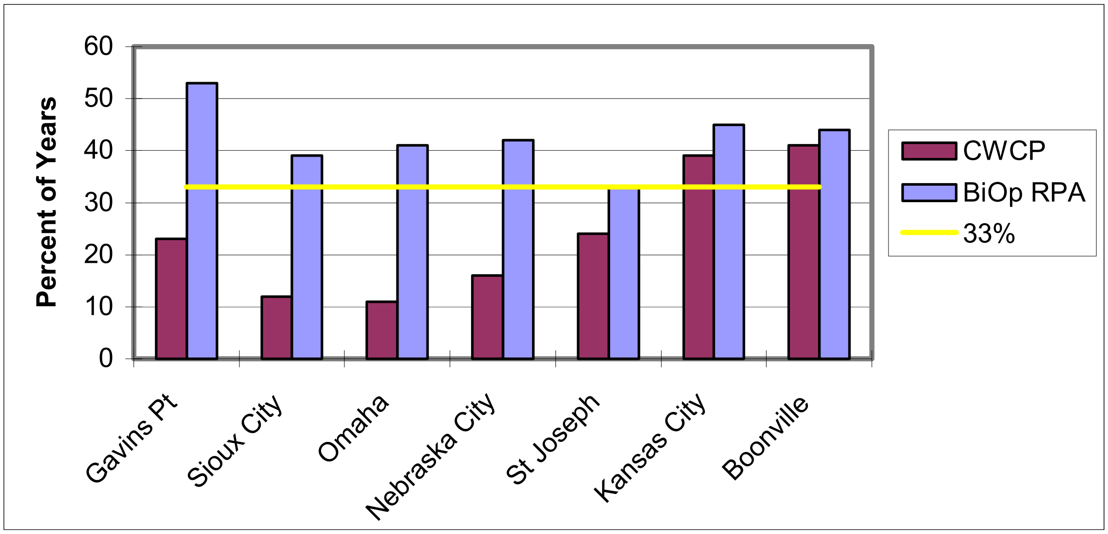

Figure 14. Percent of years with a 14-day spawning cue.

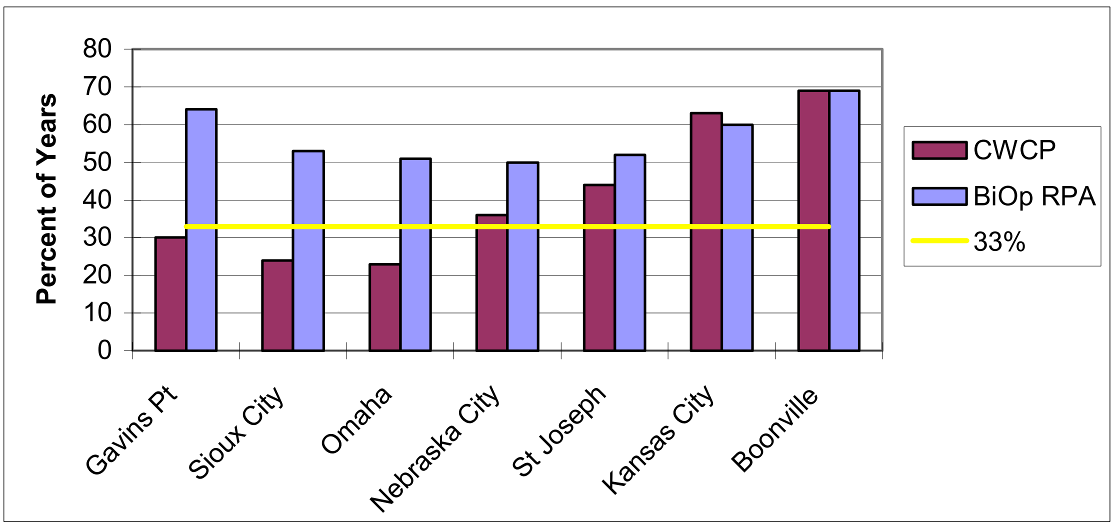

Figure 15. Percent of years with a 7-day spawning cue.

The criticality of the spawning cue length is also demonstrated using another analysis that provides more insight into the relationship between spawning cues and shallow water habitat. For the pallid sturgeon to receive the greatest potential for future growth in numbers, the larval fish need to have adequate shallow water habitat following the spawn. Figure 16 shows BiOp RPA plots of both spawning cue length and shallow water habitat over the period of analysis from 1898 to 1997 for the Sioux City reach. The spawning cue lengths range from zero days up to 61 days, and the shallow water habitat areas range from zero up to 8.0 acres per mile. The spawning cue length is affected by the spring flows, with the higher flows generally resulting in longer cue lengths. Conversely, the shallow water habitat size is affected by the summer flows, with the lower flows resulting in greater amounts of habitat. Because they are driven by different factors, they may not always coincide, as shown in the figure. The Sioux City data were selected for display because of the wider variation between the cue and habitat values.

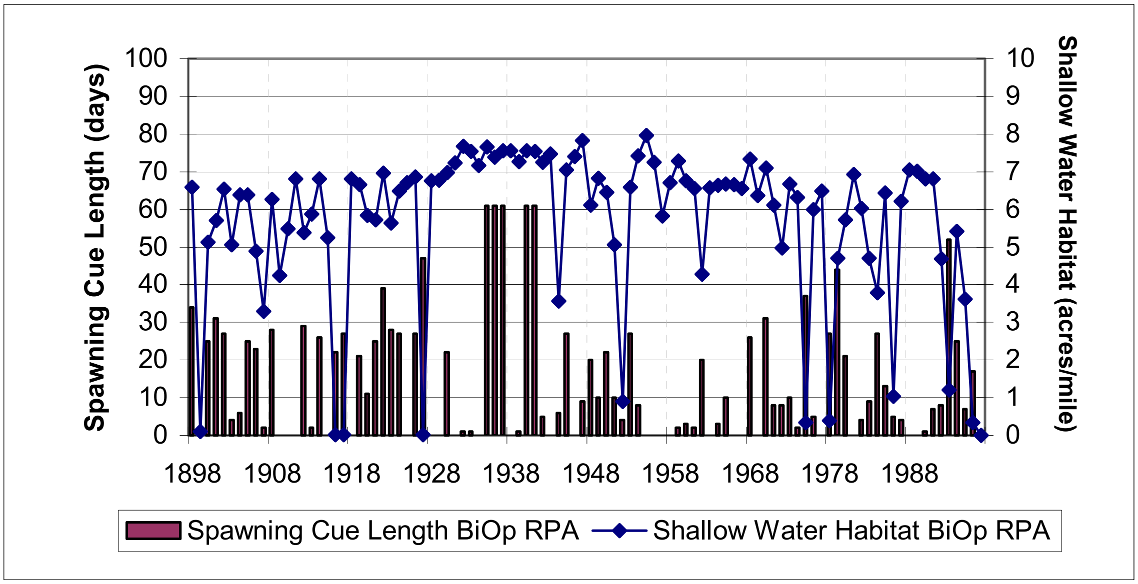

Figure 16. Annual values for spawning cue length and shallow water habitat at Sioux City for the BiOp RPA.

To assist with the identification of years in which these two values are coincident, an Excel spreadsheet model was developed to identify whether the two are coincident in each year, with the shallow water habitat held constant and the cue length allowed to be variable. Four different cue lengths were run to develop the output for the Sioux City reach. The output file was plotted and is shown on Figure 17. This figure shows that the percent of the years the shallow water habitat availability and spawning cue coincide increases as the spawning cue length decreases. A considerable percentage increase across the range of spawning cue lengths occurs between the CWCP and the BiOp RPA. One can also determine the spawning cue length required to have both factors coincide in 33 percent of the years (note 33 percent line on the plot). To have at least 2 acres per mile of shallow water habitat available for the BiOp RPA, a spawning cue length of at least 14 days has a coincident rate of 33 percent. In conclusion, shorter spawning cues of 14 days have to result in successful spawning to have a spawning cue with at least 2 acres per mile of shallow water habitat in 33 percent of the years. This analysis was based on the spawning cue occurring in May or June and the shallow water habitat being measured in the period from mid-July to mid-August..

Similar analyses were done for the Nebraska City and Boonville reaches. The results are shown on Figure 18 for at least 3 acres per mile of shallow water habitat in the Nebraska City reach and on Figure 19 for at least 15 acres per mile in the Boonville reach. For the Nebraska City reach, the BiOp RPA meets the 33 percent level as long as spawning cues can be as short as 16 days to count as a spawning cue. For the Boonville reach, the spawning cue requirement needs to be no longer than 12 days for the BiOp RPA if there are to be coincidental spawning cues and at least 15 acres of shallow water habitat in the same year for 33 percent of the years. If longer spawning cues are required, smaller habitat requirements are needed. Conversely, if more habitat requirements are needed, an “adequate” spawning cue needs to be shorter.

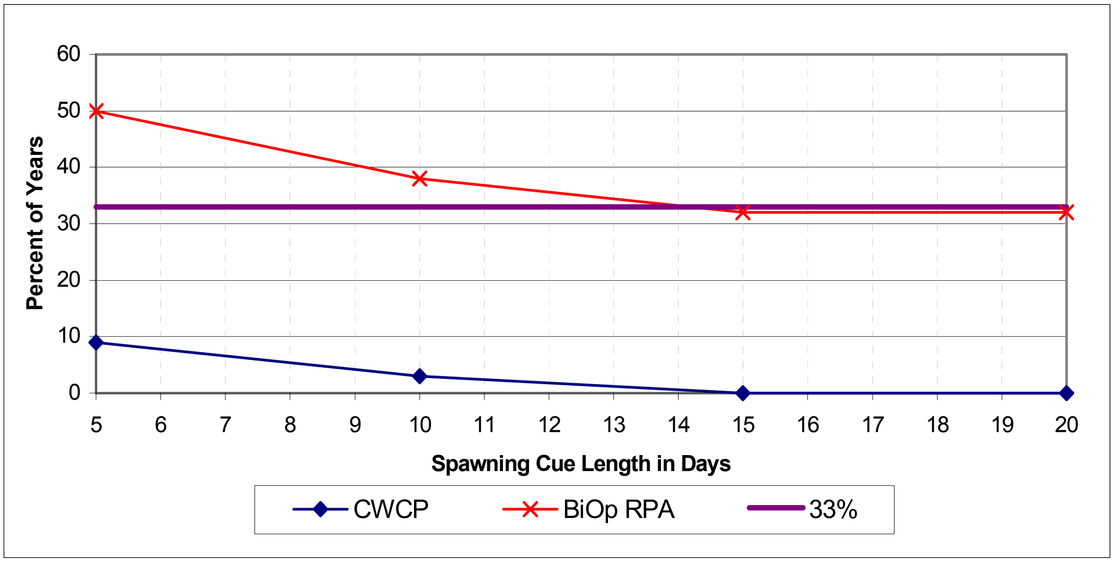

Figure 17. Percent of years when spawning cue length and shallow water habitat (2 ac/mi) coincide at Sioux City

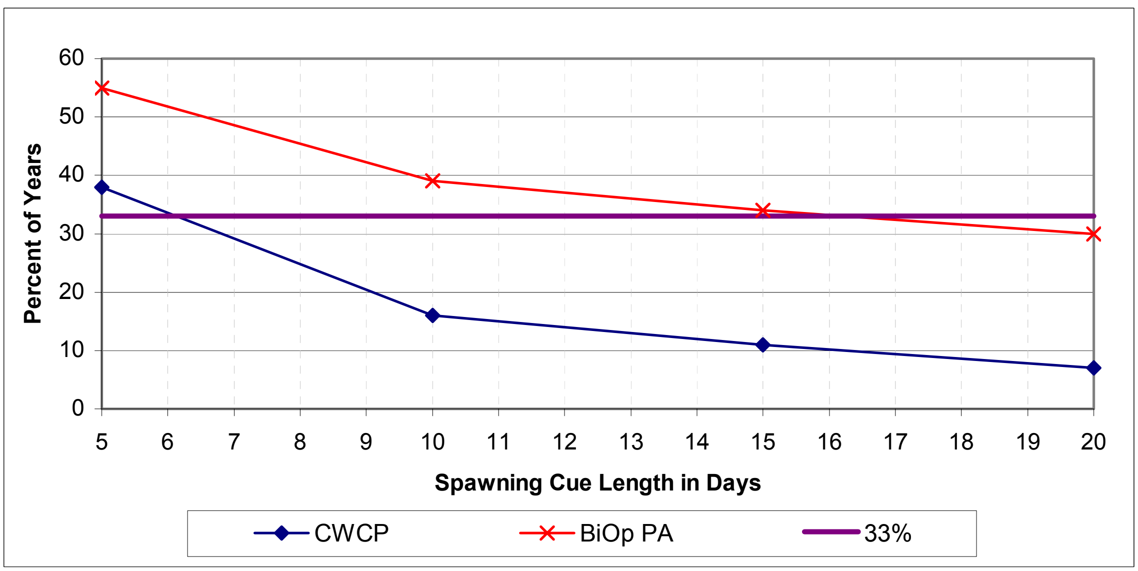

Figure 18. Percent of years when spawning cue length and shallow water habitat (3 ac/mi) coincide at Nebraska City.

Spawning cues of greater magnitude were also evaluated to determine their frequency at the Lower River gaging stations for the two alternatives. The results are shown in Figure 20, which shows that the differences between the CWCP and BiOp RPA diminish in a downstream direction. Also, the percent of years that the specified percent increase in spring flow occurs diminishes as the percent increase gets larger. Finally, this figure shows that the higher spring rises cannot meet the third-of-the-time requirement for even the BiOp RPA at all sites for magnitudes of rises that are 30-percent or greater. This demonstrates that the necessary magnitude may not be able to meet the desired frequency with any of the alternatives if the spawning cue requirement of the pallid sturgeon is greater than a 30-percent increase in flow.

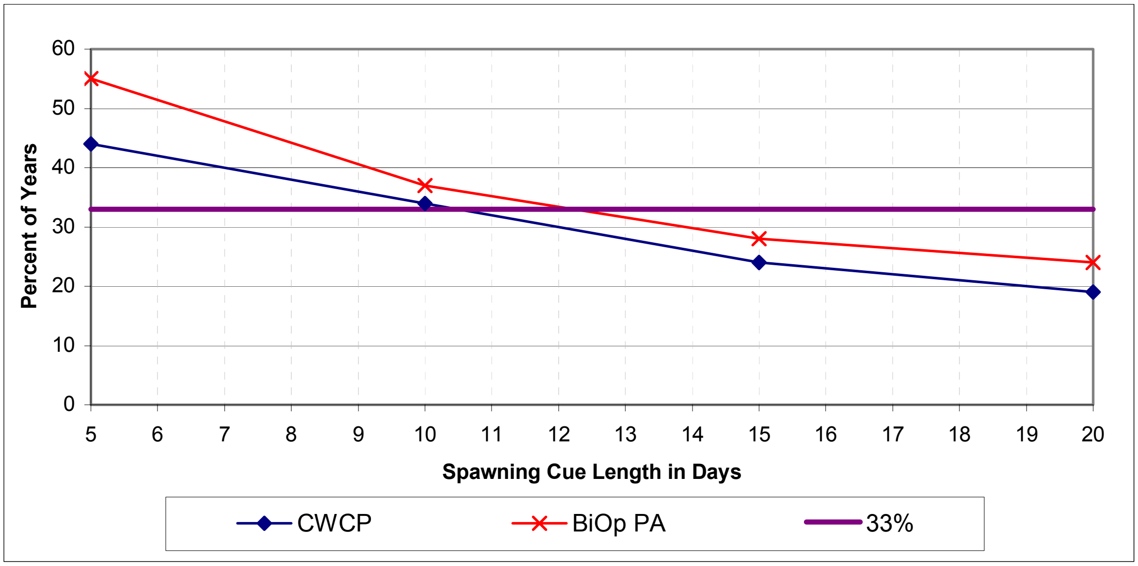

Figure 19. Percent of years when spawning cue length and shallow water habitat (15 ac/mi) coincide at Boonville.

Water temperature is also an important factor in initiating spawning in sturgeon. The BiOp stated the shovelnose sturgeon is believed to provide a good indication of the spawning requirements of the pallid sturgeon. Shovelnose sturgeon in the un-channelized Missouri River downstream of Gavins Point Dam were thought to spawn in swift water in or near the main channel (Moos 1978). Moos (1978) studied the spawning timing and duration during 1968 and 1969. He observed that spawning initiation and duration was related to water temperature. In 1968, water temperatures increased steadily during the later part of May and early June to 18 to 19 degrees C. then rose rapidly in July to near the summer maximum. In 1969, water temperatures were more variable over the same time period. The differences he observed between the two years with regard to initiation and duration of spawning correlated with a faster increase in water temperature, subsequent fluctuations in temperature, and higher flow rates in the second year. Spawning in the second year was thought to be less successful because of the variability in these factors. The summer hydrographs for 1968 and 1969 are shown in Figure 21.

Hurley and Nickum (1984) studied shovelnose sturgeon spawning and early life history on the Mississippi River in the tail waters of Lock and Dam 12 to Pool 13 during 1983. They concluded sturgeon probably spawned between May 21 and June 28 when water temperatures were between 16 and 24 degrees C. Peak spawning was thought to be in mid-June when water temperatures were 21 to 24 degrees C. Peak catches of males running milt occurred during periods of stable flows and rising water temperatures. Pallid sturgeon spawning is also directly related to water temperature (USFWS 2000). When water temperature increases to 16.7 to 18.3 degrees C, pallid sturgeon initiate spawning. Optimum spawning temperatures for pallid sturgeon spawning in hatcheries was determined to be 15.5 to 18.5 degrees C.

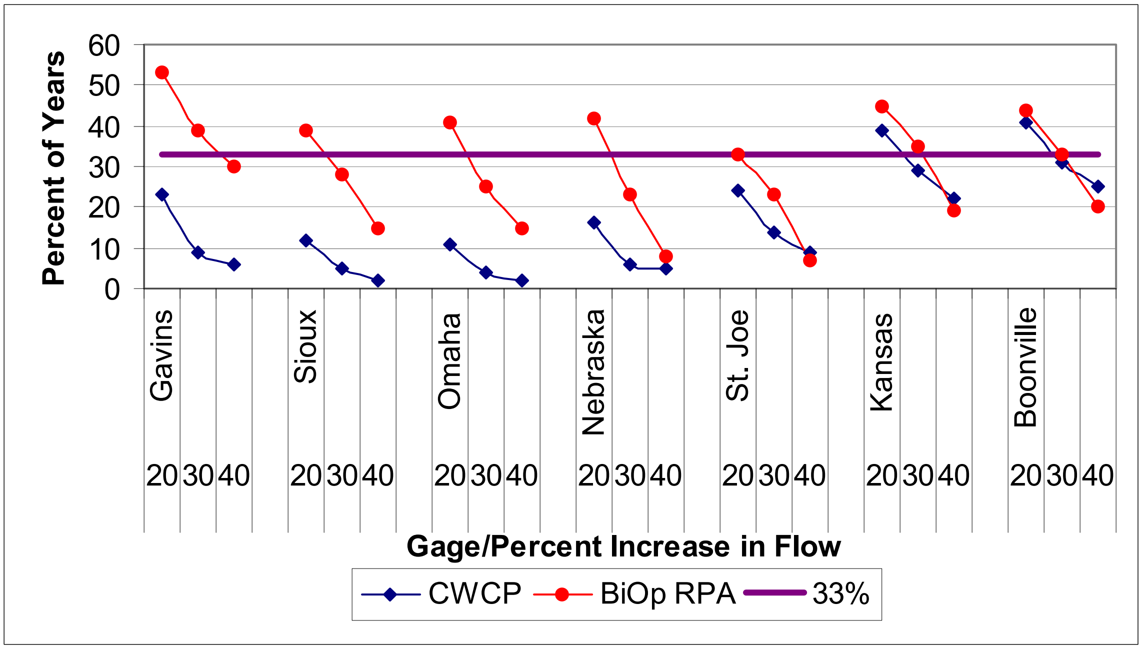

Figure 20. Percent of years that a 14-day spawning cue is provided for three different magnitudes of spawning cues (20-, 30-, and 40-percent increase in flow).

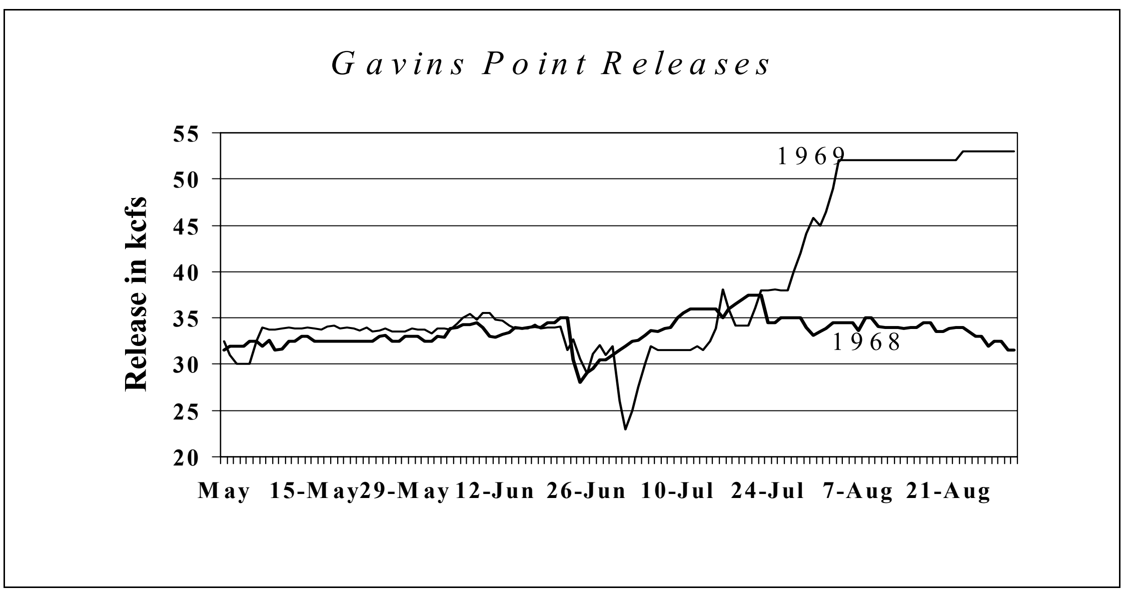

Figure 21. Hydrograph during shovelnose sturgeon spawning for 1968 and 1969 below Gavins Point Dam (Corps of Engineers unpublished data).

In conclusion, greater knowledge of what constitutes an adequate spawning cue is required. If the primary reason for having a spring rise is to provide an adequate spawning cue for the pallid sturgeon so this species can recover, better definition of an adequate spawning cue is essential. The relationship of water temperature and flow to pallid sturgeon spawning is unknown. Without this understanding, it is impossible to determine if any potential Corps Preferred Alternative or the BiOp RPA can adequately meet the spawning needs of the pallid sturgeon. A robust RM&E program that examines the multiple factors that may be limiting pallid sturgeon spawning and recruitment will fulfill this need.

SUMMARY OF CONCLUSIONS ON POST-BIOP ANALYSES

This biological assessment supplement provided substantial, relevant information on the various requirements that the Gavins Point flow element of the BiOp RPA was designed to meet. The following paragraphs provide a summary of the key points discussed in this supplement.

The BiOp RPA, with its two low-flow periods (summer and winter), would likely accelerate erosion of sandbars beyond that of the CWCP, and it does not provide for a complimentary scouring/sandbar building event. The long-term net result would be less available habitat.

The gains in connectivity in the low-lying areas with flow increases via spring rises are relatively minor, with effectively no increase in value downstream of the Omaha reach. Tributaries to the Missouri River are, and will continue to be, the main source of detritus to the Missouri River no matter how the System is operated.

The BiOp RPA summer low releases from Gavins Point Dam provide additional habitat compared to the CWCP; however, the amount of habitat falls short of that identified as being necessary (initially 20 acres per mile). Furthermore, the year-to-year variability in flows (whether as releases from Gavins Point Dam or from downstream tributaries) provides a wide range in habitat from year to year. This indicates that flow should not be relied upon to provide the required amount of shallow water habitat.

The increased habitat provided by the lower summer releases from Gavins Point Dam under the BiOp RPA likely only reduces the amount of habitat that will have to be provided by non-flow means. This reduction is estimated to be, on average, about 1,200 acres. The resulting lower flows will reduce some of the shallow water habitat created at some of the mitigation and Section 1135 habitat enhancement projects by an estimated 200 acres, which diminishes the net gain to only 1,000 acres of the additional approximately 20,000 acres estimated to be required.

With the primary reason for having a spring rise is to provide an adequate spawning cue for the pallid sturgeon so this species can recover, better definition of an adequate spawning cue is essential. Also, the relationship of water temperature and flow to pallid sturgeon spawning is unknown. Without this understanding, it is impossible to determine if any potential Corps preferred alternative or the BiOp RPA could adequately meet the spawning needs of the pallid sturgeon.

A robust RM&E program that examines the multiple facts that may be limiting pallid sturgeon spawning and recruitment will fulfill the need for more scientific information.

A similar program for the terns and plovers could provide additional scientific information on the needs of these species.

Given the results of the analyses presented in this BA, and the results of impact analyses to System project purposes conducted for the Master Manual Review and Update Environmental Impact Statement, the Corps believes that some of the recommendation in the BiOp RPA should be reconsidered and should not be implemented at this time. The Corps believes that there is too much scientific uncertainty at present to justify prescriptive implementation of the "spring rise" and "low summer flow" recommendations of the BiOp RPA. The Corps' current view is that implementation of those particular recommendations of the BiOp RPA (i.e., the spring rise and low summer releases) would unnecessarily interfere with some of the other intended and authorized purposes of the multipurpose System and related improvements. Consequently, during formal consultation our agencies may want to further examine the full range of opportunities for System operation to ensure the continued existence and recovery of the listed species. This examination should be undertaken in light of the Corps' proposal to pursue other elements of the BiOp RPA and associated incidental take statement, including the following: develop a strategy to restore 2,000 acres of shallow, slow moving water by 2005; restoration/creation/acquisition of shallow/slow-water habitat; restoration of emergent sandbar habitat; and implementation of mutually agreed upon adaptive management program, including monitoring.

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