Addendum: ISAP Comments on Draft Biological Opinion

This addendum accompanies the ISAP's 22 March 2018 PowerPoint slides on its review of the MRRP Draft Biological Opinion. It provides MRRIC and the authors of the Draft BiOp with additional detail behind points conveyed in the PowerPoint presentation with the intent that this additional information can help the authors improve the final BiOp.

Incidental Take Statement

The ISAP recognizes that it received a Draft Biological Opinion absent the required Incidental Take Statement. The Endangered Species Act section (4)(C)(i) (as per the Endangered Species Consultation Handbook – March 1998) describes the ITS as specifying "the impact of such taking on the species." The ITS determination also should be informed using the best scientific and commercial data. That portion of the BiOp is not yet available for ISAP review.

Observations regarding the use of technically accurate terminology

Evaluating a biological opinion (BiOp) as to whether it is based on or is consistent with "the best available science" depends on the accurate and consistent use of terminology, supported in part by language in the Endangered Species Act and accompanying guidance documents. The BiOp must use technical terms correctly and consistently to allow the ISAP to determine whether results of the analyses of the effects of current river operations and proposed management actions are supported by or are consistent with the best available science.

The use of two terms that are fundamental and essential to the BiOp – **population** and **habitat** – is unclear, therefore confusing to the ISAP. Both terms have explicit meanings in the biological sciences, have regulatory implications, and implications directly related to MRRP program objectives. Unfortunately, neither term enjoys definition in the Act or in the FWS's *Consultation Handbook*. Both terms have "biological" definitions that are distinct from common usages. While a *population* in everyday use can be any collection of items, an acceptable biological definition of population is "a discrete collection or assemblage of individuals with a greater chance of interbreeding with each other than with other individuals in other such groups." In common usage *habitat* can be the place inhabited or occupied by anyone or anything, but the biological definition of habitat is more exacting. As described below, biological habitat is both geographically defined and includes the essential resources that are required by an organism for its survival.

Additionally, the terms *population* and *habitat* are used in regulatory designations under the Act. The Act recognizes "Distinct Population Segments" and "Critical Habitat Designations" – which are defined in the statute, but not in ways that are strictly consistent with their "biological" definitions. The regulatory uses of the terms population and habitat are not the central issue of ISAP concern here.

The ISAP's concern is that the two terms are not rigorously defined or consistently used in the draft biological opinion. The two terms are used in a manner that is confusing and in a number of cases the terms are used incorrectly. Although confusing and incorrect usage of population and habitat are common to the BiOp sections addressing both the fish and the birds, the ISAP here focuses attention on the piping plover section to clarify its concerns. The Panel anticipates that the draft biological opinion's authors can readily adjust the use of the two terms as needed throughout the draft BiOp.

Regarding the use of the term **population** in describing piping plover demographics, it is clear in the document that the FWS recognizes nested demographic entities ranging from the dozens of piping plovers that occupy the in-channel islands and reservoir margins in northern and southern portions of the MRRP management action area, to the thousands of plovers distributed across the expansive plains and prairies portion of the species' North American range. But, as just a few examples from the text indicate, the BiOp refers to groupings of piping plovers at all spatial scales as populations, which leads to contradictions and confusion, encumbering the ISAP review.

Page 60 – *The three breeding populations are recognized and treated separately in the final rule listing the piping plover across its range: the Atlantic and Northern Great Plains (NGP) populations are classified as threatened and the Great Lakes population as endangered (Service 1985).*

Page 61 – *The proximity, relative stability, and environmental influences of the piping plover U.S. Alkaline Lakes recovery region (Figure 4) help to buffer populations on the Northern Rivers recovery region on the Missouri River. The two regions do not typically share common environmental drivers and populations in the U.S. Alkaline Lakes region are typically more stable than populations nesting in riverine and reservoir habitats on the Missouri River.*

Page 61 – *The criteria of the Service's Draft Revised Recovery Plan for the Northern Great Plains piping plover (Service 2016) call for stable or increasing populations and sufficient habitats spread throughout the range of the population.*

Page 63 – *As with the alkaline lakes region in the north, in the Southern Rivers region, the Platte River subpopulation appears to act "as a stabilizing buffer regardless of the high-flow return interval" on the Missouri River. This population relies on human created off-channel habitats for its persistence due to the "limited potential for consistent" nesting success at on-channel sites (Farnsworth et al. 2017, p. 10; Catlin et al. 2016, p. 13; Zeigler et al. 2017, p. 12-13). Moreover, this piping plover population is small with 43 breeding pairs counted in 2016 (Keldsen and Baasch 2016).*

Page 63 – *These threats emphasize the importance of maintaining viable populations among all regions currently inhabited by the species, including Missouri River habitats.*

Page 63 – *Although piping plover populations on alkali lakes and other habitats outside of the Northern Rivers region of the NGP contribute substantially to the population's viability, they are not without significant threats.*

Pages 65 and 66 – *The absence of habitat on Lake Sharpe and Lake Francis Case, between Oahe and Fort Randall Dams (RM 1,072−880) creates a dispersal barrier between the northern and southern portions of the piping plovers' range and therefore the range has been divided into two subpopulations*.

Page 70 – *Management decisions will be based on whether populations are growing, stable, or declining; population productivity; and, whether habitat is above or below ESH targets (USACE 2016, p. 246-247). In response to an anticipated 25% probability that ESH levels will fall below targets in 2018 and 2019, for example, the USACE plans to construct ESH in those two years (USACE 2018, p. 24).*

Page 70 – *Maintain a population of Missouri River piping plovers with a modeled 95 % probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.*

And, continuing on pages 72 and 73 (surrounding Figures 7 and 8) are references to "population targets" for northern (below Fort Randall Dam) and southern (above Oahe Dam) "regions" on the Missouri River, and references to region-specific population viability models, population growth rates, population densities, and population targets. But the two groupings of birds on the occupied sections of the Missouri River are not distinct biological populations.

The BiOp cannot communicate clearly the document's understanding of the demographic status of the piping plover, threats to the species, and intent of the management program if the same term is used for 1) the birds in the project area, 2) the actual population to which those birds contribute as individuals, which includes birds from beyond the project area that freely and frequently interact during the breeding season, 3) the birds that reside in landscape areas more distant from the project, which seldom interact with birds that inhabit the project area, and 4) the greater collection of populations and metapopulations that constitute the listed species. These different demographic entities cannot all be referred to as populations. To help clarify terminology, the ISAP suggests the following modifications be made.

The two groups of birds (northern and southern) that are subject to management planning and project actions in the MRRP project area should be called *demographic units* of piping plovers. These demographic units are the primary focus of the effects analysis and future management under the direction of the *Science and Adaptive Management Plan*.

Those piping plover demographic units, which largely reside and nest on in-channel islands and on reservoir margins on the Missouri River, contribute to a piping plover *population*, along with plovers that appear to interact with them from alkali lakes that are located proximate to the Missouri River mostly in North Dakota.

That population is the major contributing population to a piping plover *metapopulation* that includes the birds in the MRRP-targeted demographic unit and the population to which they contribute, and other populations that nest in areas of the U.S. alkali lakes that are more distant from the Missouri River and populations that reside on tributaries to the Missouri River, along with piping plovers in small outlying populations in Kansas and Colorado.

General Comments (including comments summarized in the submitted draft PowerPoint presentation).

Note for remainder of document: BA = Biological Assessment, BO = draft Biological Opinion

The BA provides varying levels of detail in its analysis of the potential effects of river operations and management actions on the listed species. The BA relies substantially on the Effects Analysis studies completed for pallid sturgeon reported by Jacobson et al. (2016b), for plovers and terns as described by Buenau et al. (2015) and for physical modeling as presented by Fischenich et al. (2016). As a result of incorporating these documents by reference, any critical review of best available scientific and commercial data in relation to the BA would require in depth knowledge of these reports (which have already been the subject of ISAP reviews). The draft BO presents selected data and information culled from the previously developed EAs and the general technical literature to build its case concerning the potential effects of river operations and management on the listed species.

As indicated by the quotation below from the BA, the USFWS acknowledges previously developed studies and reports as evidence it has used the best available scientific and commercial data and best scientific analysis in supporting suggested river operations and management actions as described in the BA and draft BO:

> "The effects determinations, conservation measures, and mitigative actions are informed by the EA completed by Jacobson et al. (2016b), Buenau et al. (2015) and Fischenich et al. (2016). USFWS and USACE have agreed that these documents provide a summary of the best available science and descriptions of management actions hypothesized to benefit the least tern, piping plover, and pallid sturgeon." (BA p. 153)

To the extent that the referenced EAs have been evaluated in relation to best available scientific and commercial data and associated analyses, the claim might be made that the BA and draft BO are correspondingly supported by the best available science. Given that the EAs are subject to revisions in relation to newly developed science and information, the BA and draft BO could enjoy de facto updates (and possible modification of planned management actions) via modifications to the framework, context, and implementation management under the Science and Adaptive Management Plan – which emphasizes a continuing and evolving process for identifying and incorporating new knowledge and information.

The draft BO identifies sources of error related to analysis of effects and management of the piping plover. But these sources are not always described in sufficient detail nor addressed in terms of recommendations to reduce uncertainty.

Pallid Sturgeon:

Section 4.3.1 in the BA and section 3.1 in the draft BO describe the status of pallid sturgeon. Both documents use the best available scientific and commercial data to describe the current status of pallid sturgeon in the Missouri River, which includes wild pallid sturgeon and hatchery-origin pallid sturgeon. However, in light of the recent science regarding pallid sturgeon movement between the lower Missouri River and the Mississippi, status and trend analyses of pallid sturgeon should include data from the Mississippi River (i.e., especially for the entire Interior Highlands Management Unit). This is especially relevant given the action area defined in the draft BO (page 18) states "The action area is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." Also, the draft BO should explain why the action area includes the Yellowstone River and Kansas River, but not the Platte River, Powder River (given recent science information on use of the Powder River), and the Mississippi River. Does the status and trend information include the Kansas River, Yellowstone River, Powder River, and above Fort Peck Reservoir (Figure 2-1 in BA)?

The science reported in the documents refers to publications that are using the most contemporary capture-recapture models to estimate population size. Certainty estimates vary between hatchery-origin and wild pallid sturgeon and among management units, those distinctions should be identified. The recent increase in peer-reviewed literature on estimating abundance is encouraging and continued efforts will provide more information on uncertainty in estimates. Table 1 in the draft BO illustrates the status of pallid sturgeon with corresponding uncertainty throughout the basin.

Population trend for pallid sturgeon is not as clearly delineated in the BA and draft BO. However, both documents acknowledge the lack of recruitment in the upper Missouri River and the subsequent decline in wild pallid sturgeon. In the lower Missouri River, it was acknowledged that recruitment is occurring in the lower basin, albeit it limited, and whether the trend in wild pallid sturgeon abundance is stable or slightly increasing, seems to be an unresolved issue. Hatchery-origin fish make up the majority of pallid sturgeon sampled in both areas. The trend in hatchery-origin fish is variable depending on location, and can be a function of reduced stocking rates or poor survival.

Less clear in both documents is the connection between status or trends and environmental factors. This issue has plagued biologists since the species was listed as endangered. In the upper basin, both documents recognize that the lack of natural recruitment is probably a function of limited drift distance and drift into anoxic conditions in Lake Sakakawea, which results in a declining trend in wild pallid sturgeon abundance. In the lower basin, the environmental factors limiting pallid sturgeon recruitment are not known. Similarly, the environmental factors that influence survival of hatchery-origin in the lower basin are not resolved. Thus, the lack of understanding regarding the specific environmental variables connected to survival of wild and hatchery-origin fish in the lower basin is consistent with the current state of the science.

It is hypothesized that the effects of Missouri River operation on pallid sturgeon differ by geographic region. For example, in the upper basin, the effect is probably related to river fragmentation and drift distance given there is evidence that the species spawns in the Missouri River (under specific discharge events) and in the lower Yellowstone River, but no evidence of natural recruitment has been documented. In the lower basin, it may be more complex and could be a combination of fragmentation, channel modifications, historic harvest, and changes in species abundance (invasive and native). The BA and draft BO used the best available scientific and commercial data at the time both documents were written. Recent evidence (reported after the documents were written) imparts additional support for the drift-distance limitation in the upper basin. An age-1 pallid sturgeon from the 2016 drift experiment was collected in 2017 indicating that if pallid sturgeon spawn near Fort Peck reservoir then recruitment is possible. This information should be in the updated BO.

Given the current state of uncertainty linking river operations and management on the pallid sturgeon, a Science and Adaptive Management Plan (SAMP) was developed that provides a roadmap for better understanding the factors that influence pallid sturgeon recruitment. The SAMP and the supporting documents were developed using the best available scientific and commercial data and appropriate analyses. Continually updating the understanding of river operations on pallid sturgeon recruitment is fundamental to program success. The adaptive management workshop, process for assessing new information, and the governance process are essential to the success and should be unwaveringly followed.

The BA and draft BO acknowledge uncertainty regarding river operations and pallid sturgeon recruitment, but largely through referencing the Effects Analysis and the SAMP. Furthermore, the BA and draft BO recognize that uncertainty concerning the effects of river operations and management on recruitment of pallid sturgeon is largely unknown hence the need for the SAMP. That is, at this time, data are lacking that clearly link river operations to recruitment of pallid sturgeon. The understanding of uncertainty varies by location in the basin. For example, multiple lines of evidence have increased the certainty that reduced drift distance as a function of pallid sturgeon spawning locations and reservoir transition zones is limiting recruitment in the upper basin. However, the specific alterations to river operations necessary to ameliorate recruitment failure are currently unknown. Through the SAMP, hypotheses will be tested to increase the knowledge regarding river management on pallid sturgeon recruitment. A similar process is occurring in the lower basin, for example through the experimental evaluation of IRCs. Explicit description of uncertainty in the BA and draft BO is for the status of pallid sturgeon (i.e., confidence intervals on abundance estimates), but that uncertainty is not related to river operations.

The BA lists propagation and augmentation, pallid sturgeon population assessment project, level 1 and 2 studies, spawning habitat construction, channel reconfiguration for interception and rearing complex habitat, and habitat development and land management on MRRP lands as management actions for pallid sturgeon. Similarly, the draft BO lists the actions that were in the BA (section 1.6 Pallid Sturgeon Management Actions and in the Effects of the Action section 4 and 4.2.2, 4.2.4, and 4.2.4). The management actions for pallid sturgeon are supported by the best available scientific and commercial data, which is primarily in the form of products from research projects and monitoring program – little information is from modeling exercises.

Propagation and augmentation was implemented to prevent extirpation in the upper and middle basin until management actions to improve recruitment were developed. Level 1 and 2 studies, spawning habitat construction, channel reconfiguration for interception and rearing complex habitat were developed and prioritized based on work from the EA team. The prioritization of some studies was based on expert elicitation, which was the best approach at the time given the knowledge gaps in pallid sturgeon ecology. Habitat for development and land management on MRRP lands is beneficial to the implementation and evaluation of Level 1 and 2 studies.

Adaptive management in the BA (section 3.6) is also based on the best scientific and commercial data and establishes a logical framework for better understanding the uncertainties associated with river operations and pallid sturgeon recruitment. Most importantly is the method by which new information can be incorporated into the MRRP to increase the pace of gaining reliable knowledge about river operations and pallid sturgeon recruitment.

Currently, the scientific and commercial data indicate that pallid sturgeon body condition declined after 2011, but increased slightly in the most recent years. Although pallid sturgeon body condition exhibited a decline historically in some segments in the lower Missouri River, the best scientific and commercial data do not support the argument that changes in pallid sturgeon body condition are related to river operations and that the declines in pallid sturgeon body condition are related to the absence of pallid sturgeon recruitment. That is, pallid sturgeon recruitment was limited in the lower basin when pallid sturgeon body condition was above the low levels that caused concern. However, sub-objective 2 (page 71 BA) states “Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.” It has been hypothesized that extremely poor body condition can result in mortality. If this is the case, then a direct connection to sub-objective 2 is reasonable.

The BA and draft BO are largely silent concerning the substantial efforts undertaken by Wildhaber (e.g., Wildhaber et al. 2015, 2017) and colleagues (e.g., Moran et al. 2016) in modeling pallid sturgeon populations dynamics in the Missouri River. These investigators have developed bioenergetics-based models of individual pallid sturgeon with an emphasis on juvenile age fish. The Wildhaber et al (2017) paper is mentioned in the draft BO in relation to characterizing the potential effects of climate change on pallid sturgeon population dynamics in the Missouri River. Note that the complete reference is not provided in the literature citations, however. Although not evident in the BA and draft BO, there has been considerable interaction among Missouri River pallid sturgeon modelers and much of the data and information in the Wildhaber et al. models have been evaluated for incorporation into pallid sturgeon modeling underway in support of the MO River science and adaptive management project. However, the project modeling effort has emphasized using an individual-based pallid sturgeon model to help define effective and economic pallid sturgeon monitoring plans in support of adaptive management. The model has not been used to forecast the likely outcomes of proposed pallid management actions and developing this capability depends importantly on the results of several Level 1 and 2 studies planned for pallid sturgeon.

Piping Plover:

The BA and draft BO use the best available scientific data to describe the historical and current status of the Missouri River piping plover population. The draft BO incorporates information from recently completed and ongoing studies, and the draft BO clearly describes new information that underscores the likely importance of the U.S. Alkali lakes region to continued persistence of the population of plovers that nest on the Missouri River.

Plovers that breed in the Alkali lake region were thought to be a separate population unit of the Northern Great Plains metapopulation, and they were treated as such in the most recent revision of the recovery plan (U.S. Fish and Wildlife Service 2016). Ongoing studies being conducted by the USGS, and funded by the Corps, are shedding new light on the population structure of plovers, however, and it now appears that the river, reservoirs and alkali lakes plovers may be part of the same population because plovers make frequent inter-annual movements between these nesting areas. If additional data collection continues to support this more recent understanding of plover population structure, this outcome would further underscore the contribution of the Alkali lakes region to success of achieving management targets on the Missouri River.

Whereas the draft BO (pages 61, 89) clearly describes the likely contribution of the Alkali lakes region and the factors that likely contribute to persistence of the Missouri River population, the plover model(s) that were utilized to conduct the effects analysis and to estimate habitat targets (Buenau 2015) do not incorporate the newly illuminated population structure. This is understandable because model development began long before the recent plover population data came to light. The possible consequences of not directly addressing the more complex population structure is that the model may significantly overstate ESH targets required to achieve population persistence objectives. Or conversely, incorporating the alkali lakes and reservoir habitats into a model with a more realistic population structure may lead to a reduction in the amount of ESH and management expenditures needed to achieve the specified persistence objectives for the Missouri River. This is a potentially serious scientific and economic issue and the Service may want to address it directly in the draft BO by including an additional item in Conservation Recommendations (page 106) recommending that AM priorities be assigned to monitoring, and re-analysis of Missouri River habitat target estimates as they may be affected by addressing the plover population unit as a whole, including river segments, reservoirs, and alkali lakes.

Neither the BA, the draft BO, nor any of the supporting documents produced in the Missouri River planning effort have provided a rationale for the analysis of the effects of river operations on the piping plover. The Service, on more than one occasion during development of the effects analysis and the AM plan, promised to produce a "white paper" that would shed light on this topic, but these papers have fallen short for one reason or another, and it is unclear 1) how analyses were conducted to quantitatively assess the effects of project operations on the piping plover, and 2) how those were used to support the judgment that achieving stated plover management objectives would sufficiently mitigate project effects to the point of avoiding jeopardy.

Failure to provide a clearly stated rationale for the analysis of project effects opens the door for competing, and perhaps counterproductive views of the system (i.e., there may have been little pre-dam plover use of the river due to the late spring snow-melt flow pulse) and is likely an underlying cause of continued expressions of discontent among Missouri River stakeholders.

The draft BO, however, references information that could be used to make clear, supporting arguments to bolster the Services judgments concerning project impacts and jeopardy avoidance. This pertinent material is presented on pages 85-87 of the draft BO in a Section entitled Flow Management and Its Effects on Piping Plover Habitat Dynamics. Buenau 2015 analyzed four scenarios – Existing Conditions, No Operations, Unregulated, and Calibrated – target and plover persistence probabilities were estimated for each of the four. The probabilities are presented in a disjointed fashion on page 87, and this section of the report is unfocused. But, the quasi-extinction probabilities for all scenarios could be presented in a brief Table, and supporting text could make the following points: i) the project impacts are approximated by the difference between the Existing Conditions scenario and a baseline condition (either the No Operations of Unregulated scenarios), ii) implementing a plan that emulates the Calibrated Target scenario would mitigate most of the impacts and return the system to a state that approximates the pre-dam condition. Perhaps, making such an argument was the authors' intent on pages 85-87, but if that were the case, the message may have been lost. The panel realizes that this analysis is imperfect, but that the channel morphology and dynamics represented by the No Operations and Unregulated scenarios may not match those of the pre-dam river. But these model analyses represent the best available science, and perhaps used with some caveats could support the Service's judgements concerning project impacts, mitigation, and jeopardy avoidance.

Modeling:

The draft BO describes historical abundances of plover from a low of 82 (1997) to a high of 1,832 (2016) based on the USACE (2017); Figure 6 illustrates census numbers of fledglings and adults for 1993 - 2017. The draft BO bases its quantitative characterization of historic (1995-2017) and current plover demographics on data described for fledge ratios in USACE (2017) for the southern (Figure 7) and northern (Figure 8) regions. Trends in numbers of fledglings and adults vary from increasing to decreasing depending on the subset of years as Illustrated in Figure 6.

In contrast to time series constructed for the bird populations, pallid sturgeon abundances are described for each of the Missouri River management units for different points in time in the draft BO. Table 1 summarizes hatchery and wild pallid sturgeon abundance data for the Upper and Lower basins based on different studies. The draft BO identifies the Pallid Sturgeon Population Assessment Project (PSPAP) as providing descriptions of population trends, but trends are not succinctly described or illustrated in the draft BO. The BA also identifies the PSPAP, which began in 2002 as the principal source of pallid sturgeon population trends. The BA importantly describes the PSPAP 2.0 as a revision to current monitoring that will also inform pallid sturgeon population modeling efforts and evaluate the effects of alternative management actions on pallid sturgeon population trends. The PSPAP 2.0 promises to emphasize early life stages in its sampling and provide better estimates of stocked fish in order to assess the contribution of the augmentation programs to pallid sturgeon population trends.

The draft BO describes the application of the predictive ESH model (i.e., USACE 2015a in BA) and the piping plover demographic model (i.e., Buenau et al 2015 in BA) to evaluate the likely extinction of plovers (<50 birds in 50 years) in relation to selected scenarios, including the existing conditions, no-operations, unregulated and calibrated target (similar to the Proposed Action). The results suggest an extinction probability of 0.082 for continued existing conditions and values of 0.001 for no-operations, and 0.012 for the calibrated target. The modeling and analysis appear appropriate within the strengths and limitations of the ESH and bird demographic models. The sources and implications of uncertainties in these models have been addressed in the EAs and other documents, but are not readily identified in the BA or draft BO.

In contrast to the analysis for the birds, the projected impacts of river operations and proposed management actions for pallid sturgeon have been developed more qualitatively and presented more within the context of hypothesis testing and generating answers to “Big Questions.” A modeling approach parallel to the analysis of the listed birds remains under development (Mike Colvin, personal communication). In fact, much of the proposed pallid sturgeon Level 1 and 2 studies, hypothesis testing, and population monitoring has been developed with an objective of providing needed data to complete the pallid modeling to the extent that it might be used to project likely outcomes of management actions (e.g., flow manipulations, spring pulses, IRC construction). The draft BO and BA provide minimal detail concerning the pallid population modeling. However, the stage-specific demographic pallid population model described in the EA has been revised to more of an individual-based modeling approach and this effort has been facilitated in part by collaboration with other pallid sturgeon modeling efforts underway, particularly in relation to parameter estimation for early life stages (e.g., Wildhaber et al. 2015, 2017 and Moran et al. 2016). Progress in manifesting a pallid modeling capability commensurate with the ESH and bird modeling has been delayed in part because current pallid modeling has emphasized using the individual-based model to help design effective and efficient monitoring programs in relation to adaptive management. In addition, several relationships between proposed management actions (e.g., IRCs) and pallid sturgeon response, particularly for early life stages, remain to be quantitatively described. Much of the science required for managing pallid sturgeon populations in the upper and lower Missouri River remains to be completed. The conclusions in the draft BO concerning pallid sturgeon appear to rest on the promises of advancing the science sufficiently for managing these fish in the long term, as implied by adaptive management program. Near-term survival of pallid sturgeon in the Missouri River appears to depend critically on continued population augmentation.

The BA document includes the word “uncertainty” about 30 times over its 216 pages. However, the usage lies primarily in identifying poorly understood or quantified relationships between management actions and possible effects on the species of concern, particularly pallid sturgeon early life stages. From a perspective in quantitative analysis and modeling, there is minimal discussion of explicit uncertainties in specific data or modeling as they might influence the anticipated outcomes of management actions. One example to the contrary (BA p. 61), is the description of varying amounts of ESH forecasted by the physical modeling and its implications for bird management targets. Uncertainty is also discussed in terms of the role of adaptive management in addressing various kinds of uncertainties largely in relation to poorly anticipated management outcomes with the objective of reducing those kinds of management uncertainties.

Similarly, from a perspective in quantitative analysis and modeling, the draft BO is largely silent on uncertainties associated with specific data or models and the implications of such uncertainties on model results and projected effects of river operations and management actions on the listed species. One counter example (draft BO p. 107) does identify the need to address uncertainty in annual bird survival rates to predict more accurately the impacts of managed river flows and corresponding ESH creation. For the most part, the draft BO parallels the BA discussions of uncertainty and frames uncertainty mainly in terms of uncertain management outcomes and in relation to adaptive management as a process to reduce these kinds of uncertainty. The more detailed identification and consideration of uncertainty regarding data, models, and model results are confined to the EAs for the physical models, as well as models of bird population dynamics. Pallid sturgeon uncertainties are addressed more qualitatively in the pallid sturgeon EA, the BA, and the draft BO.

Additional Comments for Consideration

p. 19, para 2: What is the nature of best available scientific information for invasive species and why shouldn't that be included at the end of this paragraph?

p. 20, para 2: The authors set the stage for water and for construction, but not for the equally important topic of sediment. Sediment (as a material, not a water quality measure) is important to the overall opinion, its scientific support, and long-term landscape and ecosystem change that affect the species in question.

p. 22 (section 1.6.5): The assumption that IRCs will produce invertebrate food ("food-producing habitats") for young pallid sturgeon is untested and will not be confirmed by solely measuring responses in age-0 sturgeon that may obtain their food from a variety of sources. Exactly what is the evidence for the expectation that the IRC will be food producing? Convincing text would be useful.

p. 29-30 (section 2.6.2): Confusion exists in the section about pallid sturgeon (1) embryonic developmental times, (2) the same incubation periods seemingly applied to different life stages, and (3) terminology of embryo, free embryo, and "hatched" free embryo. Because early life history is so crucial to recruitment, we suggest more clarity in this section, possibly accompanied by a simple graphical time line of developmental stages during early life history. There are also numerous places where word choice is less than technically accurate or appropriate, is incorrect, or both. For example, "Once released, the embryos float downstream for 9-17 days (Kynard et al. 2007; Braaten et al. 2008) and sink and stick to objects on the river bed to incubate." We are unclear where the evidence is that larvae stick to objects.

p. 33-34 (section 2.11): In this section, the draft BO appears to both dismiss the hypothesis that climate change could impact pallid sturgeon ("Under the scenarios produced by the models, the Service's assessment is that a change in temperature consistent with the scenarios does not represent changes that can be reasonably expected to impact the status of the sturgeon.") and then to caution about potential impacts in the very next paragraph ("Additional work is necessary to identify the potential consequences of climate change on the Missouri River ecosystem and the species that depend on it.”). Given the uncertainty in the model predictions, it would seem prudent to acknowledge that climate change and its associated impacts to water temperature, runoff, and discharge could potentially impact Missouri River biota.

p. 37: Pallid sturgeon condition appears to be trending upwards after the decline following the 2011 floods, or at the least shows considerable year-to-year variation. Therefore, the following statement may need some revision to acknowledge more recent information: “Adult wild reproductive pallid sturgeon using the Nebraska reach are now in increasingly poor condition and fewer reproductively ready fish are being sampled (Steffensen et al. 2014).”

p. 42 (section 3.2.3): Claims of beneficial effects of BSNP mitigation projects need substantiation with evidence. As an example: “The habitat that is restored by the use of this program has overall beneficial effects to the pallid sturgeon.” is unaccompanied by evidence in the form of quantitative data.

p. 43, para 1: Continued degradation of the channel in a reach will result in a change in gradient since the entire channel length is not declining. The draft BO would be strengthened with an extended discussion of gradient in the channel downstream from Gavin’s Point Dam.

p. 50-51. The potential effects of ‘hydropeaking’ on the biota of the (shallow) river margins are briefly acknowledged here: “This suggests that daily fluctuations associated with hydropower production may affect the diversity and abundance of Missouri River macroinvertebrates.” However, flow fluctuations over short time intervals (hours to days) receive relatively little attention in the document given the potential importance of invertebrate production in shallow river margins, with implications for IRC performance.

p. 52, para 5: What is the sediment imbalance referred to here, what is its cause, relative magnitude, and significance for the draft BO? Its effects are not limited to turbidity but also include altering the geomorphology of the channel and near channel systems.

p. 58, para 5: Sediment regime is highlighted here, but it has not been discussed up to this point in the document, so that its presentation at this point doesn’t effectively support the BO conclusions. We need more text describing the sediment system and its connections to other systems before this page.

p. 69: The last full paragraph states that the degree of immigration between the northern river and the alkali lakes is not yet understood with the precision needed to inform plover habitat targets. The draft BO then leaves the topic without returning. Given the potential scientific and economic significance of this topic, however, the BO might at least identify the data gaps and address the need to fill these gaps in the yet undeveloped monitoring plan.

p. 71, Table 3: The acreage targets for sub-objective 2 differ substantially from recovery acreages developed with the model by McGowan (2014) and published in the latest version of the Recovery Plan for the piping plover (USFWS 2016). The disparities (e.g., 630 acres in draft BO vs. 3270 acres in the Recovery Plan for the Northern region) are large enough that the draft BO should attempt to reconcile the respective values for clarification and to avoid problems of interpretation in the future.

p. 86, para 2: This paragraph states that the population viability model developed by McGowan et al. 2014 was used to examine flow effects. This is incorrect. Buenau 2015 developed a separate model for the Missouri River.

p. 89, para 1: This paragraph states that the focus of the draft BO is to determine whether the Proposed action would jeopardize the continued existence of plovers that nest on the Northern Great Plains and the *Atlantic Coast* (emphasis added). It is unclear how the proposed action affects the Atlantic population, or how proposed management on the Missouri River might have a positive benefit to the Atlantic Coast population. Certainly, Missouri River program documents produced to date mention nothing about the Atlantic Coast population.

p. 97, para 5: In the last sentence on the page we have a tricky concept for working with the draft BO: return intervals for floods. If we depend on rare major events, we stand only a small chance of seeing them: 1% each year for a 1995-style event, 0.5% for a 2011-style event. And this is only if the hydrologic system is stationary, and we strongly suspect that is not the case. The draft BO would be stronger with a paragraph discussing these issues and their implications.

p. 101, penultimate paragraph: The draft BO section on incidental take of plovers indicates a reliance on historic nest loss data, collected between 1993-2016, to express the anticipated losses that may occur in the future. Monitoring protocols to estimate nest losses will apparently follow those used in 2017. However, there is reason to believe that historic nest losses at reservoirs due to inundation may have been significantly underestimated with past monitoring protocols (see Schafer et al. 2013, page 48). Should the BO include recommendations to strengthen the monitoring protocols at reservoirs to get more accurate estimates of incidental take?

p. 106: The panel agrees with the fifth bullet item in Conservation Recommendations concerning studies to better predict reservoir habitat availability. But there is little or no discussion of this topic in the text of the draft BO and it seems important to address not only predictions of habitat availability but the full range of data gaps that currently limit the ability to model the dynamics of reservoir nesting plovers in a more realistic fashion. Support for accomplishing this can be found in the most recent Recovery Plan for the piping plover (USFWS 2016), which includes some informative discussion of reservoir dynamics and recommends (page 73) the development of a model to quantify how reservoir dynamics impact the piping plover population over time, to determine conditions under which reservoirs are a source or sink, and to identify management actions that could be implemented to reduce the likelihood of them being a sink.

Editorial Comments for Possible Action

The Table of Contents as well as section headings in the body of the text are inconsistent in format, which makes for confusion when navigating the draft BO. For examples: 1) all the subheadings under Section 9.1 are bolded, but no other headings at this level are bolded; 2) one of the subheadings in Section 9.2 is italicized and bolded; 3) the Section heading 9.3 is bolded but other headings at this level are not. Consult the appropriate style manual (e.g., Style Manual for Biological Manuals) for guidance on font and formatting styles for section headings.

A pervasive problem in the document is that English and metric units are used randomly, sometimes even in the same sentence or paragraph. These should be standardized to allow for more ready comparison and clarity. As an example from p. 29 (section 2.6.3): "Braaten et al. (2008) estimated that at **1 to 2 feet per second** (fps), free embryos could drift from **246 to 532 km** (153 to 331 miles) in 11 days." On p. 33 (section 2.10): "Garvey et al. (2009) generated an estimate of 1,600 (**0.8 fish/river miles)** to 4,900 (**24.5 fish/river miles**) sturgeon… Estimates of total abundance of age 3+ pallid sturgeon in the Middle and Lower Mississippi River were at least **2.6 - 8.5 and 3.0 - 9.8 fish per rkm**, respectively (Friedenberg et al. 2017)." We suggest that standard metric units be applied in most cases.

It is essential that the correct terms be used in the text (e.g., p. 12). The terms might be defined for writers and readers in a box of text. The terms should include the following shown here with their most common uses in water and earth sciences:

Data: observations or measurements; plural in Latin (as in "those data") or singular in English (as in "the data") – pick one form and use throughout the BO – presently both forms appear.

Information: data with their interpretation.

Facts: data, information, associations – all that are widely accepted.

Hypothesis: a concept or proposition that is tentatively assumed and then tested for validity against the observed facts.

Theory: an explanatory system of propositions, general principles, laws, linkages of facts to each other, generally held to be true as demonstrated by many tests of hypotheses. An example of where this needs correction is page 52, para 4, where the term theory appears often – it should be hypothesis.

Scientific proof: not a term with a formal definition in water and earth sciences – either define here (p. 12) or don't use.

Scientific rigor: not a term with a formal definition in water and earth sciences – either define here (p. 12) or don't use.

Theorize: actually the right term is hypothesize.

Twenty-six percent of 132 publications in a Web of Science search that contained pallid sturgeon or *Scaphirhynchus albus* in the title were included in the draft BO. Although it may appear as if little of the published science regarding the pallid sturgeon was included in the draft BO, after scanning all 132 publications much of the key literature related to current status and trends and effects of river operations was included, and the literature not included would not have a substantial effect on conclusions regarding river operations and the status and trends of pallid sturgeon. Several key grey-literature publications were included in the draft BO, such as Delonay et al. (2009, 2010, 2012, 2014, and 2016) and Jacobson et al. (2016; effects analysis and working hypotheses).

We suggest that the BO minimize the use of personal communication and unpublished data (e.g., Kynard unpublished data on page 28 in the draft BO) because it makes drawing conclusions difficult about the use of best available science. It is not clear what the criteria were for when personal communication, unpublished information, annual reports, and peer-review publications were used in the draft BO.

A number of papers in peer-reviewed journals were conspicuous by their absence and should be considered in the final BO. These include Allen et al. (2007), Bajer and Wildhaber (2007), Deslauriers et al. (2016a, 2016b, 2018), Eder et al. (2015, 2016), Eichelberger et al. (2014), Gemeinhardt et al. (2016), Gosch et al. (2018), Hrabiki et al. (2007), Steffensen et al. (2013, 2016, 2017), Wildhaber et al. (2011, 2017a, 2017b, 2017c). See Recommended References below for complete citations.

In general, a document of this size and complexity should contain a list or table of abbreviations and acronyms. In addition, there are numerous places where the authors of the draft BO speculate without supporting evidence. Examples are provided in this document.

Section 1.9: Conservation Measures – we do not understand this section because it seems to be about tracking fish by USGS.

p. 10, para 3: Use of the term “etc.” is inappropriate for this document because the term does not transmit any information. Either specify the information it is intended to convey or end the list where it occurs. Do a document word search to catch and correct all its uses – there are not many of them.

p. 18, para 2: Given the importance of length of record, the reason for selecting a planning period of 15 years needs more explanation – why do we assume biological responses and changes would be evident in that time period?

p. 18, para 2: Explain why the 82-year period of record is a reasonable length to allow us to separate climate variation from climate change.

p. 24-25: A simple flow diagram would make this list of actions easier to visualize and understand.

p. 26, para 6: This list of large rivers is best not characterized as “of the West” since that term includes the Rio Grande, Colorado, Columbia, and rivers and streams in California. Better to use the term “northern Great Plains rivers.”

p. 26, para 6: What does the phrase “overlapping portions of the Missouri and Mississippi river basins” mean? Drainage basins don’t overlap, they are nested within each other.

p. 27, para 2: This paragraph needs rewriting start to finish. As it is, it is simply a pile of phrases without organization, a start, or a finish.

p. 31, para 5: A unit is actually an area – it would help the reader if a definition for “unit” is included in the text.

p. 31, para 5: It would help the reader if authors were to explain why unit boundaries are not defined so that all the dams are together in one unit. Seems odd to a non-specialist as it is.

p. 33, para 7: This description of potential climate change is at the right level of detail, and this level of detail should be used wherever climate change is discussed. However, change in mountain basins that serve as water source areas should be included.

p. 34, para 3: Wildhaber (2017) is not included in the reference list.

p. 37: Here is an example of a personal communication where it is used to support an argument about the lack of recruitment in the lower basin. There might be a personal communication for another individual that would refute Landon Pierce. “The recent capture of “presumed-wild” pallid sturgeon <800 mm (predicted age = 10 to 13 years old based on size) may be a sign of a very low level of natural recruitment (Steffensen and Huenemann (2016, 2017), but could also simply be older, but slowly growing individuals (Landon Pierce pers. comm. 2017).”

p. 38, table: The table is a mix of model runs, accurate counts, and field estimates, some numbers are numbers per length of channel, others are not. The notes should also be expanded to explain uncertainty associated with the numbers. The notes are a good start, simply need to be extended.

p. 39, para 2: First mention of prey fish – they should be defined and explained earlier.

p. 40, para 1: Water, sediment, and hydrologic regimes are mentioned. Contaminant regimes should be added to the list here.

p. 40, para 2: The discussion of shallow-water habitat is not adequate because sediment is not fully explored yet it is key to SWH restoration. We need much more discussion of the sediment regime and quantities to support the BO.

p. 42, para 3: Mining is listed as a non-point source of contaminants, but it is not – it is a series of point sources. It may not be a source at all. Need more discussion here.

p. 42, para 3: The discussion of arsenic and selenium should also recognize that under pre-dam conditions it is possible that Hg and Se were common.

p. 43, para 5: This climate statement is not the same as the previous one in Section 2.11. Here we see that temperatures will increase and so will precipitation. In the prior statement the changes in precipitation were geographically variable. Water source areas are discussed here, but not previously. Sections 2.11 and 3.2.9 should say the same thing.

p. 50: “Clear linkages were found between river discharge, floodplain inundation and fish recruitment that suggest that reducing floodplain inundation reduces fish recruitment (Dutterer et al. 2013).” This is a classic example of citing a reference for floodplain inundation, but one that has no connection to pallid sturgeon, a main-channel obligate species.

p. 51, para 1: Readers need to know the range of daily flow fluctuations and ramping rates in order to evaluate the BO.

p. 55, para 4: This description of adaptive management is fine as far as it goes, but it should also include the fact that it is hypothesis driven, a step beyond learning by doing.

p. 56, para 1: If the BO mentions that there are nine questions, it should indicate what they are, at least in general summary form. It isn’t helpful to just know there are nine.

p. 63-64 and elsewhere: The term “physical primary constituent elements” is awkward and is not an accepted term in the ecological literature. This could be replaced with simpler and more traditional habitat terms such as “potentially suitable habitat” or simply “habitat.” For example, the last paragraph in page 63 could be worded “On prairie alkali lakes and wetlands plover nesting habitat includes – (1)…”, or more simply “On prairie alkali lakes and wetlands plovers nest on – (1)…”

p. 63, para 1: Two additional major controls on woody vegetation are water and sediment flows that build the base for the vegetation or erode it away.

p. 64, para 4: What are “varying water cycles?”

p. 64, para 3: The topic sentence for this paragraph is not understandable as is. Better provide the regulatory definition of biological constituent element (see also above)? Is this meant to include biological component of habitat, e.g., food organisms? Adding more commonly used ecological terminology would clarify the authors’ intent in this section.

p. 69, para 1: Discussion of sediment particle size should be carefully reviewed and sharpened. Sand is a particular particle size, so a sand bar is an accumulation of predominantly sand sediment. In some cases the text describes sand, in other cases gravel (also a specific size), or cobbles. The sedimentology of the document needs to be as exact as the biology if the document is to support the BO.

p. 72, Figure 7: It would help the reader to know how similar or dissimilar the range of population fluctuations shown in Figure 7 are to natural populations unaffected by dams.

p. 74: References are made to Anteau 2012, but there is no matching reference in the Literature Cited. Are these supposed to be Anteau 2012a? On page 78 there is a reference to Anteau 2013; again, there is no matching reference in Literature Cited.

p. 77, table 4: In the associated text, it would help to indicate what drives the flow targets. Navigation alone? Other uses? Is it relative importance among uses?

p. 83, para 3: Root plows should be mentioned as a technology to control woody vegetation. Root plows, used in southwestern rivers for salt cedar control, cut off the plants at the root, up to 3 feet below the surface, and might be considered here.

p. 86, para 5: Add to the descriptions of the scenarios indications of which ones result in run-of-river flows.

p. 91, para 3: In the entry “30% ground vegetation” it is not clear what area is being considered – do we mean 30% of the site, but what is the site? An entire sand bar, something smaller?

p. 95, para 2: This list of factors affecting the species is fine, but these factor listings for each of the three species should be in a standard format so readers can compare easily. Presently, for pallid sturgeon the factors are in block paragraphs with titles (page 38-39), for plovers they are in a bulleted list with sub-titles (page 68-69), and for terns as bulleted paragraphs without titles (page 95). It doesn’t matter too much what the chosen style is, but it should be the same for all three cases.

References relating pallid sturgeon ecology to river operations that should be considered in the BiOp

Allen, T. C., Q. E. Phelps, R. D. Davinroy and D. M. Lamm (2007). "A laboratory examination of substrate, water depth, and light use at two water velocity levels by individual juvenile pallid (Scaphirhynchus albus) and shovelnose (Scaphirhynchus platorynchus) sturgeon." Journal of Applied Ichthyology 23(4): 375-381.

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