Independent Science Advisory Panel Evaluation of 2019 ESA Adaptive Management Compliance Report for the Missouri River Recovery Program

20 March 2020

Introduction

The ISAP[1] was tasked with reviewing the draft *2019 ESA Adaptive Management Compliance Report for Endangered Species Act Compliance, Adaptive Management Implementation, and Fish and Wildlife Mitigation* (AMCR) in a memo from the Corps on 7 February 2020. The review material included both the report document and technical appendices. In full the Corps offered forward guidance, noting that "Draft and Appendices will be the content for the upcoming Adaptive Management Webinar presentations (February 19-21, 2020) and Workshop discussion (March 10-13, 2020). With that as the background, the Panel should be ready to speak to the Report during the AM Workshop, with written comments due March 20, 2020. The expectation is that the Draft will be finalized based on comments received and Workshop discussions. The final report will be available on or about April 24, 2020 and will be used to facilitate the development of the Strategic Plan, which is scheduled to be released around October 2020."

The enabling memo from the Corps offered four questions to guide ISAP comments and feedback on the AMCR document (presented in this report's following sections). The first three questions suggested that the AMCR should 1) provide analyses of available monitoring, research, and habitat-condition data and relate the available data to the performance of management actions that have been undertaken, 2) relate findings drawn from those analyses to whether program targets and objectives are being achieved, and provide a forecast of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process, 3) describe candidate management options under consideration and their implications for the listed species and their habitats, for agency staff who will implement selected actions, and for stakeholders who may have concerns regarding the effects of those actions on "human considerations."

The AMCR is uneven in its presentation, which can be expected given the differing status of the bird, fish, and human considerations action planning in the current Missouri River Recovery Plan (MRRP) program. The current level of understanding for each component also differs greatly. Focused management actions targeting piping plover are ongoing or planned. Survey and monitoring efforts have produced time-series data that have informed an effects analysis and

[1] ISAP members contributing to this review included Dennis Murphy and Steve Bartell (co-chairs), Steve Dinsmore, Chris Guy, Melinda Daniels, John Loomis, and John Norder.

have addressed information needs of resource managers. Models have been developed that use available data on piping plovers and their habitats to predict the outcomes of alternative management scenarios set against the dynamic Missouri River environment. The piping plover is ready for adaptive management. In contrast, uncertainties challenge management planning for pallid sturgeon. A heroic captive breeding and rearing program allows for time to evaluate hypotheses regarding the ecology and behavior of the fish, which is necessary to identify, design, and prioritize a comprehensive adaptive management plan for the species. Adaptive management of pallid sturgeon awaits results from an ambitious research, modeling, and monitoring agenda, which may require a long-term effort because the species is long-lived with delayed age of first reproduction.

A course adjustment is necessary for addressing human-considerations (HCs). Assessment and incorporation of human considerations has largely been limited to the planning stages of management actions, including the NEPA process. This appears to be working well for improving modeling for the Fort Peck test flows, though stakeholders have expressed interest in seeing monitoring results for any action implemented that would document levels of actual impacts. Significant efforts to work with lower-river stakeholders in planning IRCs have left some wary, particularly of uncertainties in the 2-D hydrodynamic models being used for planning IRCs. Only recently have data been presented on monitoring of actual physical effects of constructed IRCs, and these data have not been clearly linked to HC indicators of concern to stakeholders, nor to decision paths that could lead to adjustments of the action if needed. As a result, some stakeholders are wary of what they perceive as unknowns and would like to hold up completion of additional IRCs until those perceptions are addressed. For purposes of near-term program implementation and future AMCR reporting, relevant human considerations pertinent in management of each of the two listed species need to be acknowledged in the AMCR and incorporated into planning and assessment as described in the first section below.

The overlapping of the ISAP report review period with edifying and clarifying presentations at the AM workshop in Nebraska City (March 10-13, 2020) has resulted in this report offering a mélange of new observations, comments conveyed to Corps staff a week ago, and some input that may be already contributing to agency action planning. While the core sections in this review are not structured in parallel and some duplication of observations and directed comments can be found, the report does respond to the questions asked of the ISAP. As well, it should be noted that the section immediately below was made available to the AM workshop planners and contributed to the successful presentation format for that meeting. This section can serve as a model approach for future AM workshops.

AMCR presentation format and organization

The AMCR report falls short of meeting the Corps' objectives listed above for a number of interacting reasons. The following references piping plover as an example for discussion purposes. First, management actions undertaken to date have been mainly opportunistic and reactionary responses intended to reduce immediate threats to the birds during the nesting season. Adaptive management of targeted resources has not yet been initiated. Second, while information on the status of the bird is being used to trigger actions on the river and the results of conservation efforts are being reported, that information is not being incorporated into the structured approach to adaptive resource management described in the SAMP – the guidance document that serves as the basis for the "no jeopardy" finding for piping plovers in the 2018 Biological Opinion. Third, it should be noted that both the management actions that were carried out in 2019 and recorded in summary statistics in the AMCR are consistent with programmatic objectives and commitments. It appears that the Corps is in compliance with legal obligations for operations of the dams on the Missouri River, however, management actions undertaken are not fully consistent with the intent and direction in the Science and Adaptive Management Plan.

Those points observed, an integrated monitoring program in support of adaptive management and program compliance can provide information serving multiple purposes – 1) focused data collection that informs actions to be taken on each of the management-actions described above, 2) data on the status and trend of the target species and their habitats, 3) data on program compliance, and 4) information that facilitates the identification of uncertainties that limit an understanding of the state of the system – that is, species, habitats, and stressors – or uncertainties that can confound adaptive management decision-making. While the current document is missing some essential elements, the adjustments needed to make the bird and fish sections of the AMCR successful in meeting its reporting purposes are mainly organizational. The format of the report and presentation of information makes the task of answering the review questions posed to the ISAP challenging. The panel recommends that future reports be re-structured and expanded to provide the information necessary to complete the adaptive management cycle as described in the SAMP and understood to fulfil reporting obligations as described in the questions provided to the ISAP to guide its review. The AMCR needs to be presented as a collaborative product generated by field biologists, science staff, and the resource managers responsible for implementing the species-focused conservation agenda. The format of the (potentially very useful) dash-board presentation of monitoring information needs to be amended to clearly convey the state of the natural resources (and HCs) of concern in the MRRP; understanding that the program can be in compliance with management obligations, while resources are in states or conditions that are not favorable and the targeted species might not be on a path to recovery.

The AMCR report should be structured mainly as *two sections, one for piping plover and one for pallid sturgeon*. Human considerations and Tribal interests pertinent to implementation of

adaptive management should be reported in the species sections. A third section can be included in the AMCR to summarize key HCs in an accessible location, and to address HCs that are not directly related to the management of the listed species, but important to stakeholders.

The section for piping plover, as an example, could be *organized by current or anticipated management action*. Piping plovers would require five lines of reporting:

- *Emergent Sandbar Habitat (ESH) construction* adding to the extent of habitat available to piping plovers when habitat targets are not being met by natural development and degradation of sandbars and islands in the project area.
- *ESH maintenance*, including vegetation removal, and other activities that increase habitat availability and quality (condition) on sandbars, islands, and reservoir margins.
- *Nest rescue* in response to rises in river elevation that might drown nesting birds.
- *Predator control* actions to reduce losses of nests, eggs, juveniles, and/or adults to any and all predators when it is anticipated that local losses are likely to exceed a predetermined level.
- *Human disturbances to habitat and direct take of nests and offspring* that may require increased signage, or even enforcement attention at times of high activities.

For each management action, *data, analyses, and observations should be reported to describe the state of the system* – the system includes the birds, their habitat, and impacts on both from environmental stressors. The information for each reported management action should include – 1) historical information from research, monitoring, or observations, presented in the form of spatially explicit (e.g., maps) time-series data and 2) should emphasize data collected in the reporting year that is essential to interpreting the state of the system, targeted resource(s), and environmental-stressor conditions. Uncertainties relating to the status of the targeted resource (the bird, its habitat, or a specific essential resource) should be reported to help adapt monitoring efforts or trigger additional research/directed studies in support of adaptive management.

Understanding that certain summary statistics relating to 1) the *status* and *trends* in adult numbers and other demographics and 2) the *distribution, extent, and quality* of habitat patches are cross cutting, data presented in the AMCR can assess more than one management action. Cross-cutting information should be presented once, say in the reporting for the *ESH construction* management action (reporting track one, as identified above), then subsequently referenced (with page number), if the same information pertains to reporting, for example, *predator control* (reporting track four).

Given limited management actions for pallid sturgeon, the AMCR report should document individual actions, pertinent available data *and* on management actions, for which Level 1, 2 or 3 data are being gathered in anticipation of initiating a specific management action. Data being gathered to evaluate management actions and other pertinent information should be reported

along management action lines, even if the anticipated management actions are yet to be implemented.

The information presented in each management-action report track should be 1) sufficiently detailed and focused on data and analyses necessary to evaluate the management action or suggest adjustments, and 2) presented in logical order to inform an adaptive management framework by following three steps – First, the report should present *data and analysis* from monitoring, research, and habitat-condition assessments and relate those data to the performance of and/ or need for implemented or anticipated management actions. It should *characterize uncertainties* that may require adjusting the current model(s) that informs the management action, initiating a directed study or research effort, and/or modifying the monitoring program.

Second, *relate findings that can be drawn from the analyses from step (1) directly to program targets and objectives*, and provide a forecast of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process.

Third, *describe management options under consideration and their implications for the listed species and their habitats*, for agency staff who can implement selected actions, and for stakeholders who may have concerns regarding the effects of those actions on human considerations, including Tribal interests.

Future AMCR reports should emphasize the use of the Conceptual Ecological Models (CEMs) that have been previously developed for the birds and pallid sturgeon to organize, present, and interpret new information obtained through monitoring or research efforts. The AMCR should minimize general referrals to "big questions" as justification for presenting material. Rather, each presentation should directly relate data descriptions, analyses, and interpretations of both to specific processes, state variables, and outputs identified in the relevant CEM. The adaptive management content of the AMCR should be management-driven, with "learning" being relevant only as it directly informs the refinement of the CEMs or specifically guides resource management. This focus on management can economize the presentation in the AMCR with more generalized information either appended or included in compliance reporting. There should be clear distinction and separation between and the AM and the CR in the overall AMCR report structure. Adaptive management and reporting on the performance of management actions implemented in an adaptive framework are not synonymous with "science in general."

The management-action reporting should clearly *identify the contributions of new information* to (1) the derivation of management-response functions (MRFs), where they are currently absent (particularly for pallid sturgeon); (2) evaluation of existing MRFs (for example relating to ESH construction), along with suggested revisions to improve their accuracy and precision in projecting outcomes anticipated for specific management actions; or (3) measurement of the effectiveness of implemented management actions in producing results that directly relate to achieving the MRRP objectives. Such an approach rightly emphasizes the development of

sufficient empirical understanding of resource relationships and dynamics to project the expected outcomes of management (MRFs), which we have for birds (via ESH modeling), but not for pallid sturgeon (for which population models are still in development). Lacking an MRF, the results of Level 1 and 2 studies targeting pallid sturgeon should be directly related to the CEMs and presented in terms that clearly articulate how the information reported contributes to and makes progress in developing the requisite management-response function.

Material presentations of data and analyses in the AMCR that address ongoing management actions (reported along management-action lines, as indicated on page 2 above) should identify the specific management action addressed and quantitatively describe the level of implementation during the reporting year. Wherever possible, the presentation should detail the expected results of management actions in specific terms of management objectives for the birds and pallid sturgeon. Reported analyses and other information should directly relate to species objectives for birds (e.g., fledge ratios, lambda) and pallid sturgeon (e.g., recruitment to age 1, individuals per management segment). The effects of the species management actions on relevant HC metrics (described below) should be made. If there are no measurable effects on HC metrics or changes in HC metrics are not statistically different than the pre-management action baseline trend, the AMCR should state that.

For management actions currently implemented, the AMCR should use the difference between expected outcomes projected by MRFs and monitoring results for the reporting year to recommend continued implementation of, adaptation of, or termination for each management action. This requires the results of monitoring to be quantitatively translated, presented, and interpreted explicitly in units of the specific management objectives stated for the birds and pallid sturgeon.

The three sections that follow provide responses to the four questions provided to the ISAP, and related observations and suggestions.

Piping plover

Chapter two of the AMCR provides a summary of data drawn along with Corps activities in the MRRP action area, which are intended to be used to inform future management actions. As noted above, it would be helpful if future reports were reorganized to better conform to Science and Adaptive Management Plan (SAMP) guidance to facilitate the "evaluate" portion of the adaptive management cycle. Logically, the report should begin with a summary of what has been done, the management actions in response to ambient habitat conditions and monitoring data gathered, then report various management options under consideration, the trade-offs for each management option, a listing of decision criteria (SAMP, Section 1.1.1), outlining a *process* for making next and future management decisions, and then reporting on progress towards compliance. The current format unnecessarily emphasizes the latter; the AM process should be the primary focus

of the report. The AMCR should include salient scientific information, but also reference budget constraints (real and anticipated), and some degree of prioritization of alternative management actions, given that there are seldom enough resources to cover all needs.

The ISAP has previously emphasized – most recently in its comments on the Piping Plover Monitoring Plan – the need for the Corps to implement the adaptive management approach to piping plover management on the Missouri River as described in the SAMP. Process steps should include identification of population benchmarks, the criteria that trigger specific management actions, information needs that should be met through monitoring and research, and feedback loops wherein findings from monitoring and research are incorporated (and adapted as necessary) into management actions. The 2019 AMCR includes many of these components, but they are disconnected and do not demonstrate adherence to an AM framework that is explicitly designed and implemented to avoid jeopardy to the piping plover. Information in the Executive Summary (especially Figures ES 2a and b) is focused on compliance, contains a wealth of information about benchmark and program status, and could be improved for clarity. That information is useful but would be immeasurably more so if it were linked to specific management actions and clearly articulated decision criteria.

With respect to piping plovers, the ISAP has organized our comments to begin with a list of issues and recommended changes. These are followed by additional observations on issues from the AMCR and raised in discussions in Nebraska City. Our observations include elements of the AMCR that are central to conveying information into the adaptive management endeavor targeting piping plovers. Topics addressed below include (a) issues relating to Emergent Sandbar Habitat (ESH) construction and vegetation management, (b) developing a defensible AM approach to piping plovers in the project action area, (c) accompanying model predictions with measures of uncertainty, and (d) framing and prioritizing "research" questions within an established plover monitoring program. This section closes with comments on the charge questions that were provided to ISAP.

Comments on specific points and passages

1. AMCR Introduction. In section 1.3, the AMCR reviews in detail the recent extreme hydrologic conditions in the basin, highlighting that 2011 and 2019 were the two highest runoff seasons in the 121-year historical record. The 2019 conditions prohibited most previously planned adaptive management actions and monitoring efforts. Yet this flow also represented a natural scenario/experiment that can serve as tests for several program hypotheses. While the ESH projection flow modeling approach is appropriate for ESH management decision and resource positioning (budgeting), the Corps needs a full hydrologic regime forecast to provide the context (probabilities) of specific scenario occurrence (dry, storage, wet) in the near-term future (next 50 years). Annual flow regime forecasting based on statistical analysis of the historical record is no longer appropriate for the Missouri River basin. As a priority serving beyond MRRP interests,

the Corps should be working to project flow regimes based on modern watershed land use conditions and downscaled climate scenarios for the basin, rather than to look to the historical record. The watershed, climate, and flow regime have changed, and projections need to account for this (new) reality.

2. Figure ES 3. Population dynamics (λ) is not meaningful in this context because the piping plovers on the Missouri River are part of an "open" population that extends beyond the river. Lambda might well reflect shifts in birds recorded on and off the river, rather than emphasizing intrinsic population changes.

3. Table 2-3. Uncertainties for management. Several of the items have been addressed by previous research. For example, regarding the fourth management question about predation, Catlin et al. (2011) worked on ESH in the Gavins reach, removed Great Horned Owls, and measured the response in plover chick survival. More integration of existing knowledge is needed in the table.

   Management uncertainties and/or questions pertaining to sustainability of mechanically created ESH are relevant to larger system sediment supply and transport discontinuity dynamics that are not discussed in the AMCR. This issue is an "elephant in the room" that neither bird nor fish AM plans really address directly, yet the sediment regime is a primary system process responsible for ESH habitat generation and maintenance. The most sustainable mechanisms of created ESH maintenance would be natural sediment re-supply during high flow events, augmented by mechanical addition of sediment during dry, erosive runoff years. Selecting appropriate locations for placement of mechanically created ESH complexes will determine the likelihood of natural replenishment.

   Another source of uncertainty centers on ESH dynamics. In the pre-engineered river, bars would form and change on an annual basis, shifting their location as planform adjusted, debris accumulations shifted, and sediment yields varied. Mechanically created ESH is fixed in location, and predation levels have been shown to increase over time with age of the ESH feature. Self-sustaining or replenished ESH may over time become unsuitable habitat due to excessive predation. Plans for ESH construction and vegetation management should include shifting project locations to counteract the static-habitat predation problem. Engineering and design planning could be performed on a number of reaches and implemented in a rotating pattern to keep the mechanically created habitat shifting. The inability of the ESH model to predict bar elevations limits model certainty regarding ESH availability under various flow scenarios (Table 2-3, section 2.2.2.). ESH model dependency on yearly surveillance is limited by the timing and frequency of those observations. In years of continuous high water, boat-based bathymetric surveys could provide vital validation data sets to reduce the uncertainty of ESH model estimates.

4. Table 2-5. The table is the closest to an "adaptive management" product in the bird section. The table explores the influence of several variables on species outcomes. The table should be followed by a decision/action matrix accompanied by specific action pathways, rather than "needs" that are not clearly defined or actionable.

5. Section 2.2.2.1. The section presenting standardized ESH, including Figure 2-2, raises several questions and needs to be better contextualized. The report does not clearly state whether the ESH estimates are derived from actual measurements of available ESH or from model estimates of ESH. Furthermore, the discrepancies in behavior between the Northern and Southern regions with respect to ESH habitat area responses following large runoff years (consistent in 2012, opposite in 2019) are not adequately explained. Are the substantial differences in behavior driven by differential flow sequencing, different sediment availability, or limited observational ability to monitor ESH? The absence of adequate contextualization or explanation leads to questions regarding the validity of the input data and/or lack of confidence in the models producing the ESH projections.

6. Section 2.2.2.3. Regarding reservoir elevation and inundation controls on shoreline ESH, Figure 2-4 again presents some confusing, unexplained information with respect to pool elevations and available shoreline habitat. In 2009-2011, declining lake levels are accompanied by increased shoreline habitat, with a peak in 2013 despite increased pool elevation that year. In 2016-2017, lower elevations did not produce similar increases in shoreline habitat. Such discrepancy would benefit from explanation.

7. Section 2.3.6. Life history theory suggests that nest-protection efforts will have less impact on population growth than efforts designed to maximize adult survival. Protecting nests has a relatively small impact on population growth in many long-lived birds.

8. Figure 2-8a. How can the geometric mean for 2014 be higher than any of the three estimates that were used in the calculation? It seems like there are problems with other years too.

9. Figure 2-9a. Most losses are to flooding, predators, and unknown causes. This sets up clear information needs and management actions. Efforts should be instituted to reduce the proportion of unknown-cause losses – more crew training, nest cameras, etc. Management actions should be focused on predators and managing water where the greatest impact can be realized. This also suggests that current efforts to manage people and pets may be sufficient.

10. Section 2.3. Adaptive management context is missing in this section. What were the specific AM decision criteria for the last four management actions (nest and chick relocation, predator removal, nest caging, and human restrictions)? What occurred in 2019 that prompted 15 of 42 at-risk plover nests to be raised? What is meant by "in response to rising water levels" with respect to these moves (lines 1087)? Why were 34 nests on the Fort Randall reach caged?

11. Section 2.5. The hydrologic projections strategy (Section 2.5) approach uses years of similar historical runoff regimes to develop dry, storage, and wet regime scenarios to project ESH habitat given those hydrologic regime assumptions. Those types of scenarios allow the Corps to evaluate both "worst case" and "likely" scenarios for flow regime influences and are far more useful than a projection based on the mean of the total historical flow record. Regarding the "wet" projections - given recent extreme deviations from the historical record, the means of hydrologic scenario production should include the 2011 and 2018-2019 runoff regimes within the "wet" regime scenario generation process. Large uncertainties remain unresolved in the projections, including the starting point of the projection curves (uncertainties regarding 2019 ESH availability). The lack of explanation accompanying the scenario plots generates confusion in interpreting the model predictions.

12. Table 2-8. How can the total number fledged be so large with such low counts of broods? For example, Gavins Point had 94 successful nests, zero broods, yet 50 fledged.

13. Section 2.6.1 raises a more fundamental question that relates to EHS regards availability. This precedes an assessment of habitat quality; just because ESH is above the water surface does not necessarily mean it is available to plovers. It seems as if 1a has already been partially addressed, unclear is whether 1b has, 1c has some information, and 2b is on-going. More information is required to further refine estimates of ESH availability.

14. Line 1023 in appendices. Why is this phenomenon unknown? Burning was done in 2017 and, based on other vegetation management actions (such as spraying), the best opportunity for use was probably during the 2018 breeding season. Was this area not checked for nesting plovers in 2018? If not, this was a missed opportunity to make that management action an AM action.

15. Figure 2-16 in the appendices offers an example of data that can be incorporated into an AM framework. In the lower panel, beyond 50% previous year cover, the benefit of treated sites stabilizes at around a 20% increase over controls. This could be used as a trigger point for the management action, especially in years distant from a high flow event, and could also vary spatially in response to other conditions.

16. [not in report] The subject of adult banding was revisited during the AMCR workshop. The Corps dismisses this need because it estimates apparent, not true, survival. However, apparent survival is also useful. Alternatives to banding need further discussion. The use of MOTUS might be serve as an alternative, although it introduces additional concerns – detection is unlikely to be anywhere near 100%, the towers and radios are expensive, birds must still be handled – and would still not estimate true survival. Life history theory suggests that population growth in long-lived birds, such as the piping plover, are most sensitive to changes in adult survival. Adult survival should be included in MRRP monitoring efforts.

Further observation on adaptive management efforts

As the above comments suggest, the ISAP appreciates the presentation of accumulating data on piping plovers, river hydrology, and a suite of management actions that can be used to benefit the plover. However, a framework to integrate this information into a functional AM process is not apparent. That noted, there are several topics of concern with respect to the piping plover management planning that are worthy of attention here. Each of the issues discussed below should be considered in an adaptive resource management framework.

At the AMCR workshop in Nebraska City (10 March 2020) the presentations on Management Actions 1 and 2 (ESH and vegetation management) generated considerable discussion of available management tools and prioritization of management actions. The discussion was useful and points to a path forward for future reporting on management activities, monitoring, and research in annual AMCRs. The presentation on ESH clarified distinctions between the construction, modification, and augmentation of piping plover habitat. Construction is the most expensive option; the others are less expensive, but their benefits to plovers are less well understood. Vegetation management (chemical spraying, burning, or mechanical removal) occurs in fall and is relatively inexpensive compared to ESH actions. These actions together represent a suite of options to manage plover nesting and brood-rearing habitat on the Missouri River. So, what is the best management strategy? This requires prioritization and an ability to respond to greater system perturbations such as high flows. A key challenge for the MRRP is determining management priorities and generating a clear process for making decisions. In earlier ISAP reports these decision criteria have been referred to as "trigger points" – what condition(s) in the system will be used by the Corps to make decisions? A specific example of adaptive management is choice between delineated and modeled ESH habitat and which metric is used for justification of future ESH construction actions. What is the decision process by the Corps that leads to choose one over the other? The process needs to be presented with a clear summary of the pros and cons of each metric, followed by an assessment of risk of each choice, and ending with the preferred course of action. During the AMCR workshop the discussion also highlighted many information needs – How do we manage for the best quality habitat? Why is

there no equivalent ESH effort on the reservoirs? Does ESH ever reach a point where it creates a plover population sink because it attracts predators?

ISAP re-emphasizes the need to fully embrace an AM framework with respect to learning. Management actions should be implemented only in frameworks that facilitate learning directed towards adaptive management – conservation planners pay attention to design considerations, ensure that actions are replicated to maximize inferences, and avoid unnecessary mid-action changes that could compromise future learning. It was clear from the AMCR workshop that many of the vegetation management actions, for examples, have been conducted in an ad hoc manner that has, not intentionally, reduced the ability to learn. Even the most basic questions – How much area needs to be treated to attract plovers? Which treatment is most effective in attracting plovers to a site? – are unanswered. A similar discussion about predation management revealed that the annual budget (~$20K) is spent on removal actions without any plan or data collection to assess effectiveness or efficiency. With diminishing resources, the Corps cannot afford to forgo future opportunities to learn from its management actions for the plover.

The AMCR workshop included discussions about uncertainties that vex piping plover management decision-making; specifically, statistical uncertainty in modeled predictions about the system. As an example, consider the projections of ESH (standard and available). There was considerable discussion about the Period of Record (POR) and Construction lines in the report (Figures 2-11 and 2-12). The Corps was focused on the points where lines crossed target probabilities, minimizing any (possible) differences in how accurately each line was estimated. This also occurs in Section 2.5.3.2 of the appendices. The 95% confidence intervals broadly overlap for all projections from 2020 onward (Figure 2-28), indicating that either metric can be used. A measure of uncertainty (95% CI) should also be included for the hydrological scenario projections (Figures 2-29 and 2-30), to more fully understand whether the lines are "different." By including the precision of these predictions, the resulting decisions are inherently more transparent and objective, helping the Corps evaluate trade-offs between the scenarios, and then prioritize subsequent actions.

An option discussed in the AMCR involves the use of (a) real-time monitoring, versus (b) models, to predict outcomes from monitoring snapshots. There is good value in continuing (a), which was discussed at length during the Fall Science Meeting and is discussed at length in the 2020 ISAP evaluation of the Piping Plover Monitoring Plan. This discussion included many design issues, metrics to be measured, timing, and other consideration. One advantage of a real-time monitoring scheme is that research questions that are linked to management actions can be incorporated into data collection efforts and later used to establish and modify feedback loops. This is in fact adaptive management. Approach (b) can be more problematic. An example is the relationship between ESH and population metrics such as nest and chick survival. It is tempting to use a research approach to identify these relationships, and then subsequently use estimated ESH as a proxy for bird population status. This might work if the model is robust – we measure the "right" variables, field data span the range of environmental variability, and management

actions can replicate the habitat. But relying on modeling as the go-to assessment tool is risky in the Missouri River basin where annual variation in salient environmental conditions is high. It might be better to focus on approach (a) where a valid sample of the system is recorded, plover demographic responses are directly measured (adult counts, nest success, etc.), and real trends and subsequent compliance are reported.

Long-term studies of the piping plover on the Missouri River have resulted in numerous papers in the peer-reviewed literature, in addition to agency reports. The appropriate sections of the AMCR highlight recent research findings on Piping Plovers. At the same time certain previously published papers have information that is relevant to addressing uncertainties that are identified as warranting research attention. Catlin et al. (2011, *Journal of Wildlife Management* 75:458-463) worked on ESH in the Gavins Point reach, removed great horned owls, and measured the response in plover chick survival. The study addresses one of the uncertainties in Table 2-3. Another example relates to the discussion in Section 2.3 with regard to predation management. Catlin et al. (2015, *Wildlife Monographs* 192:1-42) in an investigation on the Missouri River concluded "Although nest exclosures and predator control sometimes can improve reproductive output, these interventions might do little to increase population size unless there is additional habitat to capture enhanced productivity." That speaks to the interplay between predator management and the extent of ESH; the details of that study should inform future discussions on the topic. Similarly, Catlin et al. (2016, *Movement Ecology* 4:6) concluded that plover dispersal increased with high flows, reproductive output increased following high-flow events, and long-term persistence depends upon availability of at least small amounts of ESH. The truth is that we know a lot about Piping Plovers on the Missouri River, and should strive to make the best use possible of available information.

A key topic of discussion at the AMCR workshop (and at the recent FSM) concerns on-going efforts to better understand the role of immigration and emigration on population dynamics of the plover. Mounting evidence indicates that movement rates are higher than previously assumed, with implications for the definition of the Missouri River piping plover "population," the interpretation of plover dynamics on the river, and the need for and anticipated results of future management actions. The Corps and U.S. Fish and Wildlife Service should partner – funding, coordination, and more – in a concerted effort to better understand piping plover dispersal in this system.

Considerable discussion at the AMCR Bird meeting focused on future information needs. The conversation generated good ideas, identified contingent priorities, and engaged hard conversation about resource availability. The ISAP encourages research decisions be made within an AM framework, consistent with the SAMP. Decisions concerning research should begin with clear hypotheses that frame specific data deficiencies (see Table 2-24 in the AMCR appendices). Management actions should be prioritized. Research topics should logically be embedded within the yet-to-be finalized Piping Plover Monitoring Plan, which was discussed at the 2019 FSM and reviewed by ISAP. That monitoring program should be the primary source of

new information needed to support management decisions for the plover. There may be time-sensitive information needs that might require targeted studies, but most investigations can be accommodated within the monitoring program for the piping plover and its habitat.

Responses to questions

The narrative above contributes to the responses to the task questions below.

1. *Does the draft Adaptive Management and Compliance Report (AMCR) provide analyses of available monitoring, research, and habitat-condition data and relate those data to the performance of any management actions that have been undertaken? Are findings drawn from those analyses related in the report directly to achieving program targets and objectives?*

The draft AMCR provides a breadth of summary information on bird monitoring, ongoing research, and modeling efforts addressing habitat (ESH) and habitat-generating processes in the MRRP area. Much of that information provided falls short of an "analysis" in terms of rigorous statistical findings and the appropriate inferences. Line 926 provides an example. While the report references "a 27% increase in estimated available acres," it fails to provide a measure of uncertainty for the estimate (standard error, confidence interval, etc.). The general absence of data interpretation in service of adaptive resource management should be corrected in the next year's AMCR.

2. *Does the draft AMCR provide a forecast of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process?*

The piping plover management program and agenda, and ongoing data-generating activities have yet to be integrated into a structured adaptive management framework. The Corp's affirmative response to the ISAP's recommended format for the AM workshop in Nebraska City (described starting on page 2 above) indicates that management planning, its implementation, and data collection in coming months, the formative activities to be reported in the next AMCR, will be prioritized, justified, and carried out to allow for the forecasting "of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process," as the Corps intends.

3. *Does the draft AMCR describe candidate management options under consideration and their implications (including challenges and uncertainties encountered) for the: listed species and their habitats; agency staff who will implement selected actions; and stakeholders who may have concerns regarding the effects of those actions on "human considerations"?*

Not really, or at least not in a useful format. Regarding the creation of ESH, where the Corps provides modeled predictions about future ESH scenarios and timing for initiation of ESH construction stands as a frustrating example. The information provided in the AMCR is muddied by lack of clear communication of complex hydrological scenarios, missing essential information on the precision of model predictions, and lack of clarity regarding differences between delineated ESH and modeled ESH as the better metric to serve the purposes of management planning.

4. *Does the draft AMCR provide an updated review of the status of scientific information from research, modeling, and monitoring and how it is relevant to management decision-making, including published and unpublished sources?*

The draft AMCR includes a table (Table 2-7) and summary of science efforts in the MRRP area in 2019. The four hypotheses addressed therein are assessed for the period 2015-2019 and key findings are reported. Section 2.4.2 summarizes the details of on-going and completed studies and associated publications and includes an update on the proposed monitoring plan. Progress addressing key uncertainties is summarized (Section 2.6), with emphasis on knowledge gained. A summary of key issues for management (Section 2.7.1) includes "Research development and prioritization", but the referenced table is not shown. Section 2.1.3 identifies uncertainties, many of which could be rephrased as hypotheses and incorporated into monitoring efforts or targeted research studies. For some of those hypotheses, existing studies offer relevant data and information.

Pallid sturgeon

Review of the pallid sturgeon sections of the report and its appendices is presented here as direct responses to the four questions accompanying the assignment from the Corps. It should be appreciated that certain material observations from the ISAP do not respond directly to a specific question, but they are sufficiently important to program direction or decisions that they have been included in answering the questions.

1. *Does the draft Adaptive Management and Compliance Report (AMCR) provide analyses of available monitoring, research, and habitat-condition data and relate those data to the performance of any management actions that have been undertaken? Are findings drawn*

from those analyses related in the report directly to achieving program targets and objectives?

The AMCR begins by discussing Missouri River basin conditions for the reporting year and emphasizes that runoff and discharge were uncharacteristically high compared to the historical period of record. Those high flow conditions constrained implementation of the MRRP throughout the Basin. Accordingly, the MRRP needs to prepare for circumstances where 2019 might represent the new "normal." For example, how will monitoring be adapted to contemporary changes in flows and discharge? Programmatic changes are not needed immediately, but adjusting for the potential new "normal" hydrologic regimes in the face of a changing climate should be considered in developing monitoring plans.

The pallid sturgeon adaptive management section begins with a program overview where there is a discussion of sub-objectives 1 and 2. The uncertainty in targets noted in lines 1561 and 1563 and again on lines 1570 and 1572 question whether the MRRP has adequately described success in relation to sub-objective 2. Clearly defined and established benchmarks are prerequisites to a successful AM program. Correspondingly, the discussion of genetic diversity in section 3.2.2.2 seems irrelevant, if diversity is not translated to a management target. It was unclear during the AM workshop if N_e or N_c is being used as a population-level target; this confusion was shared within and among participating agencies at the AM workshop.

The AMCR presents temporal-spatial monitoring results for abundance, genetic diversity, catch per unit effort, length structure, and occupancy of age-0 sturgeon; the main document relates those data to management targets. The report also describes the science activities that are needed to support the evaluation of the management actions. The dashboards in the Executive Summary summarize useful information and if further developed may be the reporting vehicle to connect monitoring, research, and habitat-condition data with the expected performance of management actions in relation to objectives and targets.

While the dashboards can serve as useful summaries, there is a need to ensure that the sub-objectives in the dashboard track exactly with what is reported in the species sections in the AMCR. For example, sub-objective 2 (ES-vi) for pallid sturgeon in the dashboard does not appear to match sub-objective 2 for pallid sturgeon in the flow chart (page 49); that is, is the abundance and catch rate only for wild pallid sturgeon? Although perhaps a minor point, inconsistencies in metrics and targets in the AMCR and among participating agencies can impact the success of the AM program. Similarly, it is not clear why the Ft. Peck Management Action is not in ES-5. Also, the uncertainty concerning management objectives presented in section 3.1.2.1 does not match the summaries presented in the dashboard figures for pallid sturgeon management objectives.

Data are presented in the AMCR that generally relate to management targets. However, clear linkages between the data reported and performance of related management actions are difficult

to determine from the document. This limitation likely results from management actions that have not been fully implemented (e.g., IRCs, Ft. Peck flows, spawning habitat) or the short time period since management actions have been undertaken (e.g., Intake). At some point there will need to be a link between a management action and the sub-objective targets. For example, how many age-1 pallid sturgeon were recruited (or were predicted to recruit) as a result of the Ft. Peck management action? How many age-1 pallid sturgeon were recruited as a result of passage at Intake? These are essential questions, because the management actions have monetary and potential HC costs that need to be evaluated in relation to pallid sturgeon recruitment.

The increase in the number of wild pallid sturgeon monitored in the lower Missouri River (lines 143-145) should have been highlighted in the AMCR and at the AM workshop. It is similarly important to AM to determine why the wild pallid sturgeon population is increasingly represented in the monitoring data without full implementation of any management actions proposed in the SAMP. The wild pallid sturgeon data suggest that an alternative factor(s) affects the pallid sturgeon population in the lower river. Monitoring may be detecting the effects of the Similarity of Appearance action placed on shovelnose sturgeon harvest – plausible given the life-history characteristics of pallid sturgeon, that is, long recovery response time to no harvesting. The ISAP has previously recommended that the Similarity of Appearance action be evaluated by the USFWS toward pallid sturgeon recovery. Currently, the Similarity of Appearance action is treated as a harvest regulation without evaluation, which is unacceptable in a large-scale managed fishery. The ISAP recommends the same degree of attention to increasing trends in the wild pallid sturgeon monitoring data. Such increases might indicate that the by-catch harvest of pallid sturgeon caused the population decline in the lower basin. There are several studies that indicate sturgeon in the genus *Acipenseriformes* are negatively influenced by even low amounts of fishing pressure.

It is confusing how section 3.1.4 fits into the AM framework and how the information presented relates to the previously developed pallid sturgeon CEM and EA. Section 3.1.4 should refer back to those documents. Furthermore, each new potential limiting factor listed in section 3.1.4 should identify a corresponding management action to address the limitation. Newly identified limiting factors should be vetted according the governance process detailed in the SAMP prior to identifying and implementing a corresponding management action. Figure 3-6 illustrates an example of what might be considered mission creep. That is, in what sense is poor fish condition a limiting factor, and how does fish condition relate to stated management objectives and inform the development of a corresponding management action? Additionally, the stocking program should not be a limiting factor. If stocking is limiting, then the augmentation program need not continue as part of the AM process. Unless clearly related back to the CEM, EA, and SAMP, section 3.1.4 might be omitted in future AMCRs.

Table 3-1 is informative but needs to be linked to specific management actions. Again, the management actions are in the early stages, but predictions regarding the influence of a management action on achieving a corresponding management target are needed. For example,

how many age-1 pallid sturgeon are expected to be produced from 12 IRCs? How many age-1 pallid sturgeon are necessary to achieve 5,000 genetically diverse individuals per management unit? This management-response concept is considered by the authors from the "Predicted Population Response of Combined Actions" box in Figure 3-4. However, there is no evidence in the report that these kinds of predictions have been made. Decisions concerning the design and implementation of management actions are based on the predicted outcomes in relation to management objectives. This characteristic is absolutely fundamental to the process of adaptive management (Conroy and Peterson 2013).

2 *Does the draft AMCR provide a forecast of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process?*

No specific forecasting modeling of pallid sturgeon responses from management actions (in the form of quantitative values) appears in the AMCR. The AMCR alludes to the use of the pallid sturgeon population model to project expected outcomes of alternative management scenarios related to Fort Peck releases. The pallid demographic model has been updated and used to compare alternative flow scenarios for Fort Peck releases; however, the details of the model are referenced to Reynolds and Colvin (2019), which has not yet made available to the ISAP. The modeled projections will apparently be available in the upcoming Fort Peck DEIS; however, there are no projected outcomes for creation of spawning habitat or IRCs in relation to pallid sturgeon management objectives for the Missouri River.

Every management action should have a corresponding model developed to help understand the likelihood of achieving management targets and program goals. Consistent with Conroy and Peterson (2013, Chapter 7), "Decisions must be based on predictions that incorporate structural uncertainty. Often this will be represented by two or more alternative models or hypotheses about system functionality." The AMCR and supporting appendices indicate plans to apply the population model to address alternative management actions; however, the timeframe for developing and implementing this modeling capability appears to be years from realization. The Intake management action could be evaluated similarly to the Fort Peck action with regards to drift and survival, with less monetary investment than for other management actions given data availability. The AMCR states "Steady progress has been made on the model implementation since 2015, with significant advancement in 2019." Why has model implementation taken this long? Are resources limited? Quantitative evaluation of the management actions is urgently needed to determine whether the proposed actions will produce the desired benefits to pallid sturgeon in the Missouri River. For example, if models indicate that drift distance in the Yellowstone River is insufficient to enhance recruitment, despite passage at Intake, allocation of resources to measure a response in the Yellowstone River would be of questionable value. Correspondingly, it is unclear what is meant by "...expanding the model to

account for the potential of recruitment stemming from spawning on the Yellowstone River" (Line 2703). Is it assumed that increased drift distance will automatically result in recruitment? Quantitative modeling and projected effects of a given management action are needed to establish expectations for that management action. Ranking of projected contributions of alternative management actions to desired AM program outcomes for pallid sturgeon can be used to design monitoring programs in times of limited funding.

Unsurprisingly, the demographic pallid sturgeon model results are sensitive to age-0 survival (a common observation of fish demographic models). And age-0 survival is among the most difficult parameters to estimate with sufficient precision to resolve the model-sensitivity issue, which will continue to challenge model applications. Regardless, it is imperative that pallid population modeling be directed at projecting the expected outcomes of other possible management actions (e.g., IRCs, spawning habitat), with particular focus on self-sustaining populations of 5,000 individuals per management unit

3 *Does the draft AMCR describe candidate management options under consideration and their implications (including challenges and uncertainties encountered) for the: listed species and their habitats; agency staff who will implement selected actions; and stakeholders who may have concerns regarding the effects of those actions on "human considerations"?*

The AMCR identifies and describes candidate management actions for pallid sturgeon to include population augmentation, IRC habitat development, spawning habitat creation, spawning cue flows, and fish passage at Intake dam. Population augmentation was implemented for the lower river in 2019, but no stocking occurred in the upper river due to a lack of brood stock. A key challenge remains in determining the contribution of stocking to achieving population management objectives. The observation of four age-0 pallid sturgeon in the lower Missouri demonstrates reproduction, yet survival to age-1 (sub-objective 1) remains to be demonstrated. Additional focus remains on maintaining genetic diversity in stocked pallid sturgeon. It remains largely undetermined whether the augmentation programs can produce the management objective of 5,000 self-sustaining, genetically diverse pallid sturgeon per management unit throughout the Missouri River.

IRC construction did not occur during 2019 pending the outcome of the report to Congress. Initial estimates of interception potential have been developed using particle tracking models, but the 12 IRCs required to evaluate this potential with suitable statistical power have yet to be realized. For similar reasons no conclusions can be drawn from preliminary CPUE data from the two existing IRCs. The relationship between increased CPUE in treatment IRCs, if measured, and any associated increase in recruitment remains to be developed. The number, size, and location of IRCs required to achieve population-level management objectives remain unknown. There has been no attempt to relate the anticipated performance of the 12 planned IRCs to the

corresponding population dynamics of pallid sturgeon in the lower Missouri River. The primary human considerations associated with IRCs include possible impacts on navigation, dredging, and flood control. Detailed hydrodynamic modeling and recent presentation of monitoring results indicate no significant effects of existing IRCs on flow vectors or water levels and associated HC indicators.

The actual need for spawning habitat remains uncertain and spawning habitat was not constructed in 2019. The Level 2 study has yet to determine if spawning habitat is a key limiting factor for pallid sturgeon reproduction in the Missouri River. No quantitative relationship has been derived between spawning habitat quality and quantity and reproductive output from pallid sturgeon. Additional surveying outside of the Missouri River main stem, ideally via telemetry coupled with direct sampling, could be beneficial to understanding current and potential spawning habitat as well as tributary cueing (flows and/or turbidity and/or temperature) of migration and reproduction. There appear to be no expected impacts of spawning habitat construction in relation to human considerations.

Management of flows to cue spawning depend on the results of opportunistic Level 1 monitoring and modeling studies in the coming nine years. The likely effectiveness of flows from Fort Peck and Gavins Point dams in cueing pallid sturgeon have been previously reviewed by the ISAP. High flows appear to stimulate pallid sturgeon movement upriver, but functional relationships between the characteristics of managed flow regimes and pallid sturgeon reproduction remain to be developed. There are currently no projected outcomes for managed flows in relation to pallid sturgeon population objectives (i.e., recruitment, self-sustaining population). A robust passive telemetry network would greatly increase the likelihood of useful learning resultant from any test flow release. Concerns regarding flow management have been expressed in the upper river mainly by agricultural (irrigation) and hydropower interests. The Corps has worked closely with stakeholders to improve predictive modeling for the Fort Peck DEIS.

Construction of the fish passage at Intake Dam began in 2019 and project completion is anticipated in 2022. Key uncertainties remain in assessing the population-level significance of pallid sturgeon that navigate the eventual fish passage. No attempt has been made to estimate the number of reproductively active individuals required to pass upriver, reproduce, and contribute measurably to recruitment sufficient to achieve population-level management objectives.

4 *Does the draft AMCR provide an updated review of the status of scientific information from research, modeling, and monitoring and how it is relevant to management decision-making, including published and unpublished sources?*

Progress continues to varying degrees in addressing Big Questions for pallid sturgeon in the upper and lower Missouri River. It would facilitate evaluation of progress towards adaptive management of pallid sturgeon if emerging results and information were directly related to the pallid sturgeon CEMS, focusing on developing projected outcomes of management actions or

evaluating the performance of management actions underway in relation to programmatic goals and objectives. For example, the information summarized in Figure 3-16 could be more usefully presented in relation to the pallid sturgeon CEMs, particularly in specific terms where each link or piece of information directly contributes to either projecting an expected outcome of one or more management actions or provides information in evaluating the effectiveness of monitored actions in relation to specific management actions and objectives.

Similarly, the Evidentiary Framework (EF) needs to map 1:1 onto the CEMs and EA developed previously for pallid sturgeon AM. The usefulness of the EF will largely derive from its contribution to producing quantitative projections of the outcomes of proposed management actions or interpreting the results of monitoring data in relation to management objectives for pallid sturgeon. The EF should be management-driven and focused, rather than used as a generalized tool for pallid sturgeon "learning."

The AMCR updates the status of scientific information relevant to pallid sturgeon in the Missouri River (e.g., Section 3.6). A considerable amount of newly obtained data and other information has been created as a result of the MRRP. The ISAP commends the participating staff for the effort. At the same time, it is noted in the AMCR (e.g., Executive Summary, Table 1-6) that a primary program need concerns sufficient resources to analyze existing data, particularly those on pallid sturgeon survival and growth rates. Sophisticated monitoring programs in support of AM are of questionable use, if collected data are not analyzed in a timely fashion to inform decision-making.

Of particular importance is the 2019 drift and dispersal experiment. That study confirmed previous research and established the proof of concept that pallid sturgeon early life stages can settle in benthic habitats prior to drifting into Lake Sakakawea, if spawning occurs near Wolf Point, Montana – directly related to sub-objective 1. The field experiment is a model for fisheries research efforts throughout the basin and elsewhere. The results from the drift study should be more directly linked to management and decision-making.

Focusing large-scale efforts on a single hypothesis can generate more reliable and insightful results compared to lower-intensity efforts dispersed among alternative competing hypotheses regarding pallid population dynamics in the Missouri River. The lower basin could benefit from coordinating large-scale efforts to test specific hypotheses, such as releases of free embryos to quantify interception and retention in IRCs. A large-scale approach is occurring to some degree with telemetry efforts. However, telemetry could be scaled-up (in the upper and lower river), especially with efforts to determine pallid reproductive status. Tracking pallid sturgeon without knowing the reproductive status of individual fish is not an effective use of resources, because monitored pallid movements cannot otherwise be linked to reproductive targets defined for sub-objective 1. One way to more routinely incorporate such large-scale efforts would be to conduct

status and trend monitoring every other year. In-between years could focus on large-scale research efforts.

Recent evidence suggests that the current definition of pallid sturgeon foraging habitat is too restrictive. Thus, it is time to revisit and revise the foraging habitat definition, particularly if foraging habitat is included as a factor in the design and construction IRCs. Furthermore, increasing evidence suggests that food is not limiting to age-0 sturgeon in the lower Missouri River. Correspondingly, pinpoint discussions about IRCs and their benefits to pallid sturgeon recruitment (sub-objective 1) appear timely—this is particularly advantageous given the suspension of IRC construction.

The pallid sturgeon AM program could benefit by incorporating scientific knowledge from other sturgeon species. For example, many of the issues related to pallid sturgeon decline and stocking in the upper Missouri River are similar to white sturgeon management in the Upper Columbia River. Biologists working on pallid sturgeon in the Missouri River should be consulting with other sturgeon biologists throughout the world. Such collaboration ought to be reflected in future AMCRs.

Human considerations

MRRIC stakeholders have made clear throughout the Management Plan planning process and more recently in the IRC implementation process and Ft Peck test-flow planning process that they want more consideration given to impacts on human concerns (HCs) that could be caused by management actions intended to benefit the listed species. Some lower river interests want to halt or delay construction of new IRCs until their concerns are resolved. Irrigation and hydropower interests have worked with the Corps to improve modeling and assessment being performed as part of the Ft Peck DEIS. Stakeholders have expressed interest in monitoring efforts designed to assess actual impacts of the flows against predicted impacts. These situations should be acknowledged in the AMCR, and options discussed for how the Corps will incorporate consideration of HCs into decision making for management actions into the future.

1. *Does the draft Adaptive Management and Compliance Report (AMCR) provide analyses of available monitoring, research, and habitat-condition data and relate those data to the performance of any management actions that have been undertaken? Are findings drawn from those analyses related in the report directly to achieving program targets and objectives?*

The 2019 AMCR does not emphasize monitoring of human considerations in relation to adaptive management as described in the SAMP. HCs are not mentioned in the 10-page Executive Summary. The AMCR does include examples of monitoring of the performance of existing projects that have HC implications. One example is the monitoring of the two existing IRCs

(pages 108-109) for possible impacts on river flows and elevation. Another example is the monitoring of existing shallow-water habitat projects (page 109). These examples demonstrate ongoing monitoring of potential hydrological and geomorphological effects of river management to benefit plovers and pallid sturgeon. However, the AMCR needs to translate monitored physical effects to potential associated HC concerns of interest to stakeholders, including those concerned with navigation, sand mining, flooding/internal drainage, and bank erosion. Without relating the results of the monitoring of physical effects to HC concerns, stakeholders must infer possible relationships from data and information in the AMCR. Resulting inferences frequently derive from informal discussions among constituents, rather than a technical analysis of HC monitoring.

A second example of HC reporting indicates how the Corps will respond to monitoring if results indicate that flows into shallow-water habitat impact navigation or other HC interests. Current conclusions are that "channel conditions remained unchanged;" however, such conclusions could be bolstered by a graphic or other evidence of the extent to which flow through the chute has altered navigation channel dimensions or flow vectors. If there is evidence that channel conditions have changed such that navigation could be affected, plans for how that change will be mitigated should be offered.

2 *Does the draft AMCR provide a forecast of outcomes of potential future management-action scenarios, thereby informing the adaptive management component of the program's decision-making process?*

The draft AMCR provides few forecasts of HC outcomes resulting from potential future bird or pallid sturgeon management actions. Primarily, the AMCR refers to the NEPA process to address the impacts on HCs from such actions. The AMCR documents a NEPA process for the Fort Peck managed flows, where preliminary forecasts of impacts to HCs from fish management alternatives were shared with stakeholders.

HC forecasting, monitoring, and reporting in the AMCR would benefit from data compiled at several spatial-temporal scales to (a) identify baseline conditions for evaluating the HC implications of future management actions and (b) detect changes in HCs that can be ascribed to Corps implemented management actions, as opposed to natural variation in HC metrics or market-related (e.g., price of sand) effects. Correspondingly, HC forecasting results and monitoring data should be developed in formats that directly inform agency decisions to modify ongoing management actions in response to HC concerns.

HC monitoring and reporting in the AMCR should be consistent with prescriptions in the Science and Adaptive Management Plan (SAMP, 2018). In particular the SAMP (2018:436) refers to *"…***specific HC monitoring studies**…" (bold in the original). This section of the SAMP states that HC monitoring studies could produce "...information on any **significant changes in the HC context** that could have implications for decision-making" (bold in the

original). Page 437 of the SAMP (2018) refers to "The **current status of HC metrics/indicators** may also be of interest to decision makers…" (bold in the original).

3 *Does the draft AMCR describe candidate management options under consideration and their implications (including challenges and uncertainties encountered) for the: listed species and their habitats; agency staff who will implement selected actions; and stakeholders who may have concerns regarding the effects of those actions on "human considerations"?*

The AMCR does not address implications for HCs in relation to candidate management actions to the same extent as for the listed species. The brief discussion in Section 4.3.2 on Channel Reconfigurations for IRCs (page 108) emphasizes meetings between the Corps and stakeholders as a primary source of information for 2019. The discussion on page 110 regarding Section 4.3.5 on Fort Peck test flows also lists a series of public and specific stakeholder meetings (including hydropower and irrigators) relied upon for information relevant to assessing implications of management on HC concerns.

In-person meetings are important for soliciting stakeholder input and are often required as part of the NEPA process. However, the HC monitoring chapter suggests that HC monitoring relies primarily on obtaining feedback from stakeholders who say their constituents will be affected by a particular Corps management action. While obtaining stakeholder feedback can provide useful context and a check on collected monitoring data, stakeholder meetings under the MRRP do not constitute an HC monitoring program as described in the SAMP (2018). Sole reliance on stakeholder input makes it difficult for the Corps or USFWS to determine whether the concerns or potential effects described by the stakeholders result from a Corps management action or from exogenous events, for example, low demand for product or industry bottlenecks in navigation.

If stakeholder inputs are to serve as a primary source of information to assess the implications of management actions, it may prove necessary to determine the scale of perceived impacts of the Corps management actions -- a few potentially impacted firms or all firms along the Missouri River. Empirically measured changes in HC monitoring metrics in the AMCR would be a useful "fact check" on whether stakeholder/industry comments at public meetings are related to Corps management actions or by events unrelated to Corps actions.

The implications to stakeholders of HC impacts from candidate management actions, such as implementing the Fort Peck test flows, were described in the AMCR (pages 110-121) as the Corps –

(1) Conducting seven public meetings with the public, Tribes and potentially affected HC interests, such as irrigators and hydropower.
(2) Identifying specific HC concerns related to the adequacy of Corp's irrigation intake inventory, as well as how river flow configurations could affect hydropower production.

(3) Sharing Hydroviz results to estimate the projected effects of each DEIS proposed alternative on irrigations and hydropower.
(4) Sharing preliminary socioeconomic findings – regarding flood risks, irrigation, hydropower, water supply – for each of the DEIS alternatives with stakeholders.
(5) Identifying where the public involvement will occur during the Fort Peck NEPA process.

These previous inputs can contribute to the development of predicted HC outcomes, or hypothesized HC impacts of management actions for the birds and fish. They could derive from HC metrics previously determined to be relevant for the MRRP EIS as updated from input from stakeholders. An HC monitoring program then could be designed to test the predicted or hypothesized impacts of bird and fish management actions as they are implemented.

A specific case in point: a stakeholder recently has raised a concern regarding how the IRC staircase design of 12 IRCs can be considered to be acceptable at a conceptual level (based on best available 2-D hydrodynamic modeling in their conceptual design), when a number of the sites have not yet been selected, and site specific conditions clearly will influence their design and performance. The ISAP has reviewed the IRC conceptual design in the SAMP and MRRMP DEIS, agreeing that the conceptual design reflects best available science and use of best available tools. ISAP agreement to this conceptual design is contingent on the Corps' plans to use those best available models in its site-specific design of individual IRCs to capture site specific variables, and to alter existing river training structures in a way that will minimize changes to navigation-channel flow vectors and dimensions, and river stage/water heights, thereby minimizing impacts on navigation, flooding, and other HCs that could be caused by the IRCs. The ISAP also has recommended, in other reviews and in this one, that the Corps implement a monitoring program that would measure actual flow vectors, navigation channel dimensions, and river stage associated with constructed IRCs to demonstrate as-built effects, and to interpret or assess those effects with regard to impacts on HCs. Results of field monitoring of physical parameters at the two completed IRCs were presented at the recent AM Workshop. These results support the Corps' predicted or hypothesized effects of planned IRCs on navigation-channel attributes and river water heights (none to minimal effects). These results should be extended to HC indicators, reported in the AMCR, and effectively communicated (with similar assessments conducted each year) to provide assurance to all parties that IRCs in fact cause no or minimal impacts on HCs (or how they will mitigate impacts if in fact some are measured).

An HC monitoring and assessment program must specify an implementation schedule for measuring HC metrics in response to bird and fish management actions. The HC monitoring results and their interpretation in relation to predicted or baseline conditions should be reported annually in the AMCR. Stakeholder evaluation of monitored HC metrics could help to inform the design and implementation of future bird and fish management actions in relation to potentially impacted HCs.

4 *Does the draft AMCR provide an updated review of the status of scientific information from research, modeling, and monitoring and how it is relevant to management decision-making, including published and unpublished sources?*

As noted in the SAMP (pages 421-422), the agency has direct access to many HC-related variables that have already been collected and are described in the Master Manual (Annual Report on Project Benefits, hydropower generation, water quality). The USDA National Agricultural Statistics Service, individual state and local agencies, along with universities and industry associations all collect data that can contribute to HC monitoring. Those sources can provide data that include property and sales taxes, and farm income in states adjacent to the Missouri River at the county level. Consultation with Tribal interests regarding operationalizing HC metrics of concern to them is an essential element in HC monitoring program design.

Selection of a small number of HC metrics and proxies, as was done in the MRRP EIS, would allow the Corps to develop a cost-effective HC monitoring program. Such HC metrics can be tracked and reported in each year's AMCR, helping to institutionalize collection and reporting of current HCs as part of the overall Corps monitoring program. Ideally, the AMCR would provide the foundation necessary to integrate Bird, Fish and HC metrics in pursuit of identifying any positive or negative interactions among them. Monitoring those metrics could also help MRRIC and members of the HC Workgroup differentiate between changes in HC metrics due to year-to-year natural variability and changes in HC metrics caused by bird and fish management actions.

The current absence of HC monitoring metrics results in MRRIC members not having a common and agreed upon dataset as a frame of reference when discussing HC impacts from bird and fish management actions. The following HC metrics are examples that could address high priority bird and fish management actions; several of these metrics are routinely measured by the Corps or were tracked for the MRRMP EIS:

- Navigation:
    - Hypotheses suggested at AM Workshop HC meeting:
        - IRCs will not affect navigation safety: Metric is reported navigation accidents including shoaling, by location in vicinity of IRCs versus Control Sites
    - Metric: Tonnage shipped each year (source: Waterborne Commerce Center)
- Hydropower: working with WAPA, several metrics could be monitored that relate to fish and bird management actions, including
    - Hourly generation data from each dam as recorded by the Corps
    - Value of Hydropower based on the same valuation procedure used in the MRRP EIS (Locational Marginal Pricing, which may require coordination with WAPA).
- Municipal and Industrial Utility Water Supply

    - Metric: number of days the Missouri River and reservoir water levels fall below water supply intake elevations
    - Missouri River Upper Basin Fort Peck Test Flows. Metric: number of days water levels fall below water supply intakes elevations prior to, during, and after test flows
- Reservoir Recreation
    - Missouri River Upper Basin Fort Peck Test Flows. Metric: number of days during recreation season water levels fall below boat ramp elevations prior to, during, and after test flows
- Thermal Power throughout the Missouri River
    - Metric: number of days water levels fall below shut down thermal power intakes elevation

HC data are rarely collected and, if available, are typically reported in the preparation of environmental documents, such as for the MRRMP or Fort Peck test flows. Environmental Assessments on smaller projects such as IRCs only contain a cursory qualitative discussion of HCs. Several of the HC monitoring metrics suggested above for future AMCRs could be incorporated into future EAs of IRCs.

Analysis and presentation of HC information and data developed for a monitoring program in support of the AMCR reporting could include an HC Dashboard. The Bird Incidental Take Dashboard (AMCR, 2020: ES-iii) might serve as an example for evaluating HC metrics, given its emphasis on minimizing impacts. A similar minimization approach appears appropriate for HC metrics, because minimizing the effects on HCs has been a long-stated goal of MRRP. Specifically, the MRRP EIS Record of Decision (ROD) indicated that the selected alternative meets the needs of the species while *"… avoiding and minimizing adverse impacts to stakeholders (USACE, 2018:2)."*

There is a great deal of literature available regarding use of stakeholder processes and HCs in decision making that merits examination by the Corps. For example, Gregory and Keeney (2017) describe how to incorporate uncertainty in decision making involving stakeholder processes. Several alternative approaches for dealing with uncertainty are provided, ranging from quantitative approaches to more qualitative ones. One of the methods involves rankings of alternatives by stakeholders from best to worst (see page 498). This approach is similar to the first iteration of a MRRIC exercise during previewing of MRRP DEIS alternatives. This journal article suggests how a second and third iteration of this exercise could lead to refinement of the initial alternatives to reduce the disparity in stakeholder rankings by developing new variants of each of the original alternatives. This can work, if stakeholders don't circumvent the stakeholder process, as has happened twice in MRRIC's history (Mac and Palmer 2020).

In regard to Tribal interests and the incorporation of Indigenous environmental science into natural resource conservation and restoration decision-making and management actions by MRRP, there are two further types of publications that merit review by the Corps. The first highlights common barriers and uncertainties that Federal agencies and scientists face in understanding, valuing, and applying Indigenous science as a complementary scientific analytical tool. Ross et al. (2011) provide a comprehensive list of these issues (see Table 3.1, pages 96-97), which are broken down into Epistemological Barriers and Systemic or Institutional Barriers. Other relevant publications that highlight these issues include Ellen et. al. (2000), Menzies (2006), and Ramos (2018) which provide specific Indigenous case studies. The second are publications that provide examples of specific natural resource conservation and restoration decision-making and management actions where either quantitative scientific comparisons are made between Indigenous and Western science (see Polfus et al. 2014) or work towards hybrid Indigenous/Western scientific decision-making and modeling approaches to conservation and restoration projects comparable in general approach to MRRP (see Wehi 2009 and Slaton et al. 2019). The Slaton et al (2019) publication is of particular interest for MRRP as it is a USFS initiative that focuses on the interlinkages between larger forest habitat restoration, targeted species for conservation and restoration and HC/Tribal interests. It further articulates well with the point below regarding "citizen science" initiatives.

There is a growing literature describing the 'power of crowds' to monitor weather, urban street flooding, and water quality. One of these pathways is "citizen science" (https://www.citizenscience.gov/#) in which citizens are trained and equipped to collect data in a temporal time frame and spatial grid far denser than would be feasible for local, state, or federal agencies. That holds promise for HC monitoring of metrics such as water temperature.

Additionally, for consideration, one of the already demonstrated technologies is using georeferenced, but otherwise anonymous digital pictures uploaded by visitors to quantify visitor use, particularly related to how recreation visitation, is related to water quality of lakes (Keeler, et al. 2015) and in a dispersed recreation (Fisher, et al. 2018). Comparisons of visitor use estimated using georeferenced photos uploaded to Flickr and traditionally measured visitor use estimates (using counters, surveys) have shown that uploaded photos provide reasonably accurate estimates of visitor use (Keeler, et al. 2015), even in relatively dispersed recreation settings.

Given the difficulty for the Corps in measuring up to date, seasonal river recreation use in the stretches of the Missouri River between dams when it needs this data for EISs, it is worth investigating this technology, and associated requirements of social media companies to access this type of georeferenced, but otherwise anonymous visitor data source.

Summary observations and recommendations

The following summary and recommendations for continuing the MRRP AM process and developing future AMCR documents derive from the review and evaluation of the AMCR and supporting appendices, as well as from presentations and discussion at the AM Workshop in Nebraska City.

1. The continuing AM process and the publication of future AMCRs should be consistent with the concepts expressed in the SAMP and by Conroy and Peterson (2013) in conducting adaptive resource management: *"When management decisions reoccur over space or time (e.g., annual harvest regulations), model probabilities are updated by comparing model-specific predictions to observed (actual) future conditions. The adjusted model probabilities can then be used to predict future conditions and choose the optimal decision for the following time step. This adaptive feedback explicitly provides for learning through time and, ideally, the resolution of competing hypotheses with monitoring data."*

2. The AM process should require projected outcomes for all management actions with results that directly pertain to management targets for the sub-objectives for plovers and pallid sturgeon and hypothesized impacts to HCs. This forecasting should be a key priority for strategic planning, because the projected outcomes can focus resource allocation towards implementing and monitoring the most promising management actions while minimizing impacts to HCs.

3. Model-based predictions and presentation included in the AM process should include a measure of statistical uncertainty. In addition, model projections should carry through to estimates of metrics specific to the sub-objectives for plovers (e.g., fledge ratio), pallid sturgeon (e.g., lambda), and HC effects (e.g., cost to irrigators to move water intakes).

4. The Corps should fully embrace an AM framework for the plover and pallid sturgeon. That should include a full treatment of *all* management options being considered, transparent decision criteria, and a prioritization of potential options/action(s).

5. Information (research) needs should be discussed and prioritized as part of the Fall Science Meeting. In turn, those needs should be addressed preferably through the piping plover and pallid sturgeon monitoring programs, or, if needed, through additional research efforts.

6. Future work should examine the possible mechanisms underlying the reported increase in wild pallid sturgeon in the lower Missouri River. Those mechanisms should be reviewed and evaluated in relation to the Big Questions for lower river pallid sturgeon and related management actions.

7. Reevaluation of the benefit of IRCs in relation to sub-objective 1 should include estimation of anticipated increases in recruitment of age-0 pallid sturgeon to be produced by IRCs. The estimated increases in recruitment should be extrapolated using the population model to corresponding projections of lambda and population size in relation to the Nc of 5,000 individuals per management segment.

8. Future work should consider focused large-scale experimental and management efforts comparable to the drift study in the upper river. For example, a drift study could be undertaken in the Yellowstone River to develop forecasting and management capabilities for the Intake Management Action

9. HC impact modeling and monitoring data presentation, analysis, and evaluation should be reported in bird and fish sections and the resulting decision space for bird and fish actions compared with the bird and fish management needs. The extent of overlap of management needs and HC concerns should stimulate discussion at the AM Workshop regarding options for meeting species needs and/or options for expanding the management decision space in a manner acceptable to HC interests.

10. Modeled and monitored HC impacts from implementing each of the bird and fish management actions also should be summarized in a separate HC portion of the AMCR to aid HC stakeholders in quickly locating the assessment of HC effects. Clear distinction should be made between modeled/hypothesized effects and monitored effects from actual management actions; the two should be juxtaposed such that stakeholders can easily tell for themselves and their constituents whether management actions as carried out had the minimized impacts that were predicted. An HC dashboard should be constructed and added to the AMCR Executive Summary.

11. If the new Information Management System (IMS) is going to serve as a template for future AMCRs, then inclusion of HC metrics in the core database is needed. HC metrics should be integrated into the IMS where the bird and fish management actions are displayed in their respective modules. In addition, a separate HC metrics monitoring and assessment module needs to be included in the IMS that can draw from the core HC database. The impacts to these HC metrics from bird and fish management actions would allow stakeholders to quickly identify past levels of HC indicators, predicted current year impacts, and actual current year impacts, if any, to HCs. This HC portion of the IMS would then facilitate analysis and writing of that respective year's HC section of the AMCR.

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