Missouri River Recovery Program
Independent Science Advisory Panel

Final
ISAP Evaluation of the Effects Analysis
Draft Interim Reports (EA #6)

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Preface

This report presents the findings and recommendations of the Missouri River Recovery Implementation Committee (MRRIC) Independent Science Advisory Panel (ISAP), a team of six scientists selected for their expertise in pallid sturgeon biology, piping plover and least tern biology, conservation biology, riverine ecology, river hydrology/geomorphology, quantitative ecology, and the use of these sciences in decision making. The independent expert panel was selected by the Third Party Science Neutral (TPSN) with input from MRRIC, and was instructed to conduct its business according to procedures outlined in the "MRRIC ISAP Approach Structure Ground Rules."

At the request of MRRIC, the panel evaluated three draft EA #6 Interim Reports (a Hydrogeomorphology report, a Pallid Sturgeon report, and a Piping Plover and Least Tern report) produced by the Effects Analysis (EA) Team and delivered in October 2014. These reports integrate the results of the previous year's efforts by the EA Team (EA deliverables 1-5) for use by the Management Plan Product Delivery Team in crafting specific management actions and alternatives, including adaptive management actions.

The charge to the panel was developed by the MRRIC Strategic Planning and Assessment (SPA) Task Group including the lead agencies and in coordination with the TPSN. Panel members divided writing tasks, answering the charge questions according to expertise within each question. Panelists then read, aggregated, commented on, and revised each answer to the charge questions. The TPSN reviewed all drafts, asked clarifying questions, offered suggestions, and edited the report.

This report represents the understanding and recommendations of the six independent experts as a snapshot in time of a dynamic and constantly evolving process as all parties (the EA Team, Corps, U.S. Fish and Wildlife Service, MRRIC, and PrOACT[1] coach) worked to develop and share the knowledge needed to refine species objectives, develop alternative management actions to benefit the species, and outline an adaptive management (AM) program that would provide, assess, and use additional data to improve management actions in the future. Many of the panel's draft findings and recommendations, shared in monthly calls and quarterly MRRIC meetings over the past year, have already been incorporated into the draft EA reports, influenced revisions of species objectives, aided in the development of preliminary management actions, and steered AM discussions.

The ISAP anticipates that continued discussions among agency planners, MRRIC members, and the panelists, as new information and interpretations emerge, may change conclusions and merit revising the suggestions made by the ISAP. This is how an AM process should work. Thus this report, like the EA interim reports, is a step in an evolving process.

Findings and recommendations presented here generally are agreed to by all ISAP panelists. Panel members may disagree on some details, but they have not identified major areas of disagreement among themselves regarding how the Corps and MRRIC are, or should be, progressing in the EA and planning processes.

Robb Turner, Third Party Science Neutral, January 16, 2015

[1]The PrOACT name derives from the key steps in the structured decision-making process – determining the Problem, Objectives, Alternatives, Consequences, and Tradeoffs – described in Hammond JS, Keeney RL, Raiffa H (1999) Smart Choices. Harvard Business School Press, Boston, MA.

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Background

The ISAP recommended in 2011 an adaptive management plan for the Missouri River that should be "preceded by and based upon an effects analysis that incorporates new knowledge that has been accrued since the 2003 Biological Opinion." The lead agencies and MRRIC subsequently have undertaken development of a Missouri River Recovery Management Plan that will include an adaptive management approach and that is based on a year-long (and ongoing) effects analysis.

As described in the Effects Analysis Guidance Document, "The purpose of the ongoing effects analysis (EA) effort is to conceptualize and quantify the effects of system operations and actions on the listed species (piping plover, interior least tern, and pallid sturgeon). The EA is evaluating the effects of the Missouri River Project and operations (dam operations), Bank Stabilization and Navigation Project (BSNP) Mitigation, and Biological Opinion management actions on the status and trends of the listed species and their habitats, within the background of hydrologic and fluvial processes on the Missouri River. The analysis is using existing data and models where applicable, developing new models as needed, and is relying upon the best scientific information available."

The EA Guidance Document goes on to say "This structured analysis is being used to assess the effects … of alternative management actions on the listed species. The effects of management should be described in terms of the likelihood of species persistence or recovery. Much of the data necessary to inform an analysis of the effects of alternative management actions can be drawn from research, monitoring, and assessment efforts that have been undertaken in the Missouri River system over the past decade. This information will inform Adaptive Management (AM) efforts and several key portions of the Management Plan and its future implementation within an adaptive management framework."

An EA Team has spent the past year plus performing the effects analysis. The draft EA #6 Interim Reports (a Hydrogeomorphology report, a Pallid Sturgeon report, and a Plovers and Terns report) integrate the results of those efforts (EA deliverables 1-5) for use by the Management Plan Product Delivery Team in crafting specific management actions and alternatives, including adaptive management actions. The effects analysis highlighted many gaps in our knowledge, and additional EA products are anticipated in the future as the AM Plan is implemented.

Charge to the ISAP

MRRIC and the lead agencies asked the ISAP to review the draft EA #6 Interim Reports (including update presentations by the EA team leads at the November 2014 MRRIC meeting), and provide an evaluation of the extent to which the EA delivers what was expected and what is needed to move forward with the Missouri River Recovery Management Plan (MRRMP) and the AM Plan. This document is the ISAP's initial response to the six questions posed in the charge and repeated before each answer below. Answers are based on the three interim draft reports by the Hydrogeomorphology, Pallid Sturgeon, and Piping Plover and Least Tern EA teams delivered in October 2014, and on

additional information provided in presentations and less-formal discussions with the ISAP by the teams at the November 2014 MRRIC meeting in Omaha-LaVista. This response thus represents a snapshot in time of an ongoing process, and the ISAP recognizes that some of the thoughts presented here are already being incorporated into revised drafts and ongoing planning for continuing effects analyses as input into an AM program for the Missouri River Recovery Project (MRRP).

Response to Questions

Status and Trends of Hydrologic Conditions and the Listed Species and their Habitats

1. To what extent does the EA convey a clear understanding of the Missouri River hydrologic conditions and the status and trends of the listed species and their habitats in the program planning area?

Hydrogeomorphology

A fundamental understanding of present Missouri River hydrologic conditions is implied in the modeling framework that is described in the Hydrogeomorphology EA Team report. The EA Team has developed this understanding based on 128 previously compiled and reviewed publications, models, and data sources relevant to the Missouri River. This activity was completed as an integral part of the EA process and reported in an April 2014 deliverable. As stated in the current report, the EA Team continues to update this information in support of its understanding and modeling of hydrologic conditions in the Missouri River.

The report describes a set of existing hydraulic, sediment transport, water quality, and ecosystem function models that have been variously applied to the Missouri River. The effort by the EA Team focused on developing the models that will subsequently be used to test potential effects of management actions on hydrology, hydraulics, and geomorphology of the system.

The EA Team did not, however, summarize the status and trends of the physical processes of the river system such as changes in the hydrograph of the Missouri River, changes in the tributaries, changes in the sediment budget, or changes in the geomorphology of the system. Considerable work has been done by numerous scientists in documenting and quantifying the effect of the dams and other ongoing river management (e.g., dredging, bank stabilization) on the hydrology and sediment dynamics of the system, most notably the work by the USGS Columbia Environmental Research Center (USGS-CERC). These previous studies have been well documented and published, and represent a fairly robust understanding of how the system has been changed over many decades.

That said, this understanding is not reflected in the current EA report. It remains unclear (or at least unarticulated) how the system today differs from what it was historically, or how the different operations have affected the system differently. For example, how did the dams affect the river in comparison to how bank stabilization affected the river?

In an ideal situation, the EA would include a review of the status and trends in the physical conditions of the river, thus providing an agreed-upon foundation for what historic conditions were, what has changed, the degree of change through time, and the likely (or modeled) causes of those changes. Presuming that the system will not return to historical conditions, knowledge of them might help in designing modern conditions that would be suitable to the listed species.

Pallid Sturgeon

The Pallid Sturgeon EA report adequately outlines the status of the pallid sturgeon and, to a lesser extent, the habitat (at a large scale) in the "Background of the Missouri River and the Pallid Sturgeon" section of the report. The report does not delve into detail regarding the trends in pallid sturgeon and habitat in the planning area. It is not necessary for the EA Team to repeat in detail these trends in the current report, given that other readily available publications (e.g., USFWS 2007 and USFWS 2014) contain trend information for the species and its habitat. We are confident that the EA Team understands the contemporary status and trends of the pallid sturgeon and the large-scale habitat changes in the Missouri River.

In an ideal situation, the agencies would have long-term data on the pallid sturgeon pre- and post-dam construction (and pre- and post-BSNP) to better understand the effects of project operations on pallid sturgeon demography. Unfortunately, long-term reliable demographic data for pallid sturgeon pre-dam construction and pre-BSNP does not exist, thus it is unrealistic to expect the EA Team to conclusively describe trends and correlations. Future EA efforts might consider using newly developed hydrogeomorphology modeling capability in a hind-casting mode to explore hypothesized relationships between system hydraulics and pallid population dynamics (see hydrogeomorphology discussion for Question 2 below).

Piping Plover and Least Tern

The EA report states that few data exist on the bird populations prior to dam construction. The report presents robust data, collected since the U.S. Army Corps of Engineers (USACE) started monitoring the river in 1986, that describe the demographic status and trends, and provides an understanding of the relationships among river hydrology, in-channel nesting habitat, and reproductive success of the two species. Bird numbers appear highly correlated, although lagged in time with sandbar availability on the Missouri River. As sandbar extent and numbers increased – for example, following the floods in spring and summer of 2011 – plover and tern numbers increased in subsequent years. As available sandbar area slowly erodes during years of low or normal flows, bird numbers subsequently decline. This pattern, reflecting the landscape condition-bird response relationship, offers evidence that sandbar nesting habitat is limiting for the birds, and provides validating support for the conceptual models that serve as the foundation for the effects analysis. Importantly, this demonstrated empirical relationship linking hydrology, habitat, and bird population response allows for development and implementation of numerical models linking hydrological conditions to plover and tern population dynamics.

Effects of the Corps' Actions (Water Management and BSNP) on the Listed Species and their Habitats

2. To what extent does the EA provide evidence of cause and effect relationships between the Corps' actions (in the context of other factors) and the listed species and their habitats?

Hydrogeomorphology

The Hydrogeomorphology EA report does not attempt to establish cause-and-effect relationships between the Corps' actions and the listed species or their habitats. As discussed in the Hydrogeomorphology EA report, these relationships are outlined in the separate conceptual ecological models (CEMs) developed for the terns, plovers, and pallid sturgeon. Importantly, the Hydrogeomorphology EA presents the mathematical tools that can be used to help translate past and future Corps management actions into expected habitat changes, and from there to potential species responses based on the hypothesized causal relationships described in the CEMs.

The hydrogeomorphology models have not been applied in the EA in a form that can assess how the projects and operations have historically affected the status and trends of the species. However, these types of models have been used in the past to support retrospective assessments, and have generated important results for evaluating what types of changes may be important to the species (e.g., Jacobson and Galat 2006). Moreover, the physical models can be used to help understand the hypothesized relationships between alternative management actions (e.g., controlled flows and elevations) and corresponding effects on riverine habitat quality, quantity, and distribution of importance to terns, plovers, and pallid sturgeon. The models that are being developed are essential tools for evaluating the links between Corps' actions and changes in the physical system.

To the extent that bathymetry and flow (discharge) data are available for pre-construction conditions of the Missouri River, the models could presumably be calibrated to these historical conditions. Comparing and contrasting the pre- and post-construction model calibrations might suggest key differences in river conditions that could have influenced population dynamics of the listed species, particularly the pallid sturgeon. The EA report demonstrates substantial post-construction modeling capabilities; however, any existing modeling of pre-construction conditions remains to be incorporated into the EA. Discussions with the EA Team following the November MRRIC meeting in Omaha-LaVista indicate that pre-construction physical modeling has been undertaken to some degree, but not yet been integrated into the EA.

As discussed in the Hydrogeomorphology EA, the physical models can be used to translate proposed management actions (e.g., reservoir releases, channel structures, habitat construction) into corresponding values of flow, velocity, sediment movement, and acreage that can, in theory, provide information for developing the functional linkages to population dynamics models for the listed species. For example, simulated changes in emergent sandbar habitat (ESH) resulting from managed flows can serve as inputs to the population models for terns and plovers, as indicated in the Piping Plover and Least Tern EA. At present, the physical models are limited to projecting habitat-attribute

changes presumed beneficial to pallid sturgeon. Physical model results could potentially be used to quantify pallid demographic model parameters that define early life-stage survival and survival of older age classes.

Pallid Sturgeon

The Pallid Sturgeon EA report provides no evidence with regard to cause-and-effect relationships between project construction/operation and pallid sturgeon demographic vital rates. However, this is largely a function of insufficient data to develop relationships and not an oversight by the EA Team. The EA Team acknowledges the lack of inter-relationships among habitat attributes and conditions (left side of the conceptual ecological models; CEMs) and pallid sturgeon demographic vital rates (right side of the CEMs), and this lack of knowledge was the impetus for use of the expert elicitation process and development of the management-action hypotheses. The Pallid Sturgeon EA provides a synthesis of ideas and hypotheses about the various pathways through which the project may have impacted the pallid sturgeon. Studies conducted over the last 10 years have begun to characterize processes that may have been important, and potentially limiting factors, in some portions of the Missouri River (e.g., drift distance and anoxia in the upper river). By and large very little information exists concerning project cause-and-effect relationships, especially information that might be useful for estimating the magnitude of project impacts and the amount of management/mitigation that will be required to offset those impacts (i.e., avoid jeopardy).

The EA Team is working under severe constraints imposed by data scarcity and lack of system knowledge. Additional time will be needed to further develop and quantify the sturgeon models, couple them to hydrogeomorphology models, and begin analyzing the river system at the locations and spatial scales necessary to gain a more in-depth understanding of pallid sturgeon population dynamics in a large, complex river. In the meantime, it would serve clarity and understanding among partners to recognize that for the pallid sturgeon, 1) no quantitative estimates of the magnitude of project impacts exist; 2) currently, only hypothesized management actions exist, and only expert judgments of intensity of implementation that may be required to offset project impacts and avoid jeopardy; and 3) the Recovery Program effort will have to cope with high uncertainty until more-quantitative relationships are established and better predictive tools can be developed.

Although not described as a cause-and-effect relationship in the Pallid Sturgeon EA, the EA Team did demonstrate that the Corps' action of stocking pallid sturgeon (Pallid Sturgeon Conservation Augmentation Program; PSCAP) has contributed to pallid sturgeon population growth in the Missouri River and that the program appears necessary for the continued persistence of the species given the lack of pallid sturgeon natural recruitment in the Missouri River. This finding has also been recognized by others and is described by the U.S. Fish and Wildlife Service in the pallid sturgeon 5-year review (see USFWS 2007). The ISAP recognizes that this is not part of water management or BSNP, but it is important to recognize the importance of the conservation augmentation program in relation to other Corps actions.

Piping Plover and Least Tern

The Piping Plover and Least Tern EA report provides evidence of longer-term trends in habitat availability that might explain cause-and-effect between Missouri River dam operations and the status of piping plovers and least terns. The EA report recapitulates a widely accepted accounting of piping plover and least tern population trends linking them to island creation and degradation, a phenomenon described in the 2003 Biological Opinion for the two species. The narrative describes the Missouri River as historically providing abundant sandbar habitat for plovers and terns, which was regularly refreshed by high spring discharges. Construction of dams and reservoirs inundated large areas of riverine sandbar habitat that historically provided those circumstances. Dam operations also contributed to reducing the quantity and quality of downstream sandbar habitat by modifying the hydrograph and trapping sediment, thereby limiting the ability of the river to transport sediment needed to form and maintain sandbars. Reproductive success and population levels of plovers and terns have tracked downward trends in sandbar area following the construction of dams on the Missouri River.

A somewhat different understanding of the historic and current system takes into account potential detrimental effects of the pre-dam hydrograph on listed bird populations. Jorgensen (2009a) analyzed historic hydrographic data and postulated that although the historic river may have frequently supported ample sandbar area, sandbars would have been flooded in many, if not most, years during the June discharge pulse from snowmelt in the mountains. Consequently, the historic river actually may have been a population sink in many years, because the shorebirds initiate nests prior to the June pulse, and those nests would have been subject to destruction by inundation. This issue was debated by Catlin et al. (2009) and Jorgensen (2009b), and taken together show that no overwhelming evidence exists either way concerning historic trends in plover and tern numbers in order to assess and more finely resolve Missouri River project impacts on the bird species. Hence, the EA report sheds no new light on this question, especially in terms that might be used to support the establishment of bird species objectives for mitigating project impacts. However, the EA has produced the modeling tools necessary to analyze pre-dam scenarios, and conducting such an analysis (we understand that this is ongoing as this report is being written) may offer insights pertinent to the development of management objectives and strategies (see more discussion of this topic in our response to Question 3).

The Fish and Wildlife Service has suggested using minimum viable population (MVP) analyses to set bird objectives for the Missouri River. The supposition behind that suggestion is that if the MRRMP were able to support and maintain minimum viable populations through management, project related impacts would be offset. MVPs, however, are ecological parameters that do not themselves address historic Missouri River project impacts. Piping plover and least tern populations will have associated MVP estimates that are conceptually unrelated to the magnitude of historic project construction and operational effects on their populations. Achieving an MVP for the bird species that also provides the right magnitude of mitigation for project impacts would be a coincidence.

3. To what extent does the EA set the stage for development of a viable strategy (adaptive management plan) for reducing uncertainty in understanding of the cause and effect relationships between the Corps' actions, other potential factors, and the listed species and their habitats?

As stated in the answers to Question 2 above, the EA reports do very little toward documenting specific cause-and-effect relationships between the Corps' actions and the species' habitats or population responses. Thus, reducing uncertainty in such relationships may not be possible until the relationships are defined.

Hydrogeomorphology

The Hydrogeomorphology EA report does not directly present a plan to reduce uncertainty in understanding the cause-and-effect relationships between the Corps' actions and the listed species and their habitats. Rather, the EA focuses on approaches to reduce uncertainties, primarily through revision of current model parameter values, scale in applications, and specification of boundary conditions associated with physical model projections of Corps management actions in terms of hydrologic factors (e.g., flows, elevations, sediment transport, and deposition) that are hypothesized to influence the listed species and their habitats. The EA does not discuss how the 1-D or 2-D models might be used to better assess the effects of dam or BSNP operations on changes in habitat over the past half century or more.

Pallid Sturgeon

As noted in Question 2 above, the Pallid Sturgeon EA report indicates that insufficient historical data exist on which to base quantitative cause-and-effect relationships between the Corps' river operations, habitat changes, and pallid sturgeon population demography. Science sometimes provides surprises, and it is possible new insights can come from further work with existing data. It appears likely, however, that developing the cause-and-effect relationships and predictive capability associated with them will depend on experimental work and/or monitoring of field-scale studies yet to be designed and carried out. The EA Team has outlined in broad terms an EA Phase 2 (to assist in the short term with alternatives development) and an EA Phase 3 (to be implemented over the longer term in association with AM). Details of either of these have yet to be specified. The ISAP has had some concern regarding the exclusion to date of other potential cause-and-effect factors such as contaminants. The EA holds such other hypotheses in a "reserve" list for use if the selected hypotheses are shown or predicted to be ineffective at avoiding or removing jeopardy for the listed species.

Piping Plover and Least Tern

The Piping Plover and Least Tern EA report does not directly present a plan to reduce the cause-and-effect uncertainties, but the continuing EA surely could do so. The EA deliverables could include not only the assessment of hypothesized management actions, but an articulation of species-specific information needs (including analysis and/or modeling of cause-and-effect relationships between infrastructure and operations with species and habitats), which, if met, could provide future useful guidance to management and policy decisions in the next program steps.

The EA could be expanded to estimate the likely magnitude of impacts that project development had/has had on least tern and piping plover populations on the Missouri River. This might be accomplished, for example, by modeling the historic river-channel configuration in conjunction with the historic natural hydrograph to explore scenarios based on assumptions about likely sandbar elevations and the frequency with which June runoff discharges might have inundated nesting habitat. Such an analysis has been discussed recently among technical staff and several members of the ISAP and the results may shed much new light on the objective-setting process.

Effects of Current and Future Management Actions to Protect the Listed Species

4. To what extent does the EA provide credible models capable of predicting (and distinguishing) the relative efficacy or likelihood of success of current and alternative management actions for precluding or eliminating jeopardy?

Hydrogeomorphology

The physical model applications described in the Hydrogeomorphology EA report appear credible and useful for simulating flows, changes in elevation, and alteration in habitat (e.g., ESH) defined by potential alternative management actions. However, the relationships between physical model performance and preclusion or elimination of jeopardy depend on the integration of the physical models with equally credible models of habitat changes and species response. This integration of models is underway for the listed species to varying degrees determined largely by the availability of the habitat and species response models.

The physical modeling efforts to date emphasize the implementation of models developed primarily by the Hydrological Engineering Center (HEC) and include the HEC-ResSim, a description of main-stem flows in relation to USACE management constraints (e.g., flood protection, navigation); the HEC-RAS, a river analysis system; and the ecosystem function model, HEC-EFM. The ResSim and HEC-RAS models are based upon well-accepted one-dimensional flows and represent a basic understanding of Missouri River hydrologic conditions within the hydrologic constraints of these model constructs. The Corps has decades of experience in the application of these models to large river systems throughout the United States. In addition to the well-accepted models, a large number of stream gauges also exist along the main stem and tributaries, providing a relatively large capability to calibrate the models.

The Hydrogeomorphology EA also presents results of 2-D models. The 2-D models have been used to describe and quantify in greater spatial detail the habitat creation (e.g., emergent sandbars, pallid foraging, and spawning habitats) that might benefit the listed species in relation to potential management actions. These 2-D models will be instrumental in some of the more detailed decisions that will need to be made in the coming years related to whether habitat creation is feasible, and if so, the specific aspects of its design. These 2-D models (e.g., ADaptive Hydraulics, ADH) have been implemented for only a few reaches in the Missouri River, and do not have the same level of calibration/correction that is possible with the 1-D model, although the Hydrogeomorphology EA

Team does have a high level of expertise with these models as well. Descriptions of the 2-D models were not included in the draft EA report. It is not clear whether the EA team considered other 2-D modeling approaches, and whether they think this would matter for the model applications.

The ResSim and HEC-RAS models are well-established 1-D physical models that enable the EA team to effectively distinguish between potential alternative management actions that influence flows and elevations. The preliminary applications of the models to address free-embryo drift and the efficacy of management actions aimed at reducing free-embryo losses from the Missouri River to drift demonstrate the relevance of these models to the overall EA. While the models are simplistic, as acknowledged by the EA Team, their applications have provided important insights into whether drawing down reservoirs or otherwise managing flows would be effective in reducing free-embryo pallid sturgeon losses from the system.

The 2-D physical models (e.g., ADH) provide the EA Team with an ability to examine specific questions about the role of weirs or chutes in providing certain types of habitat, as well as similar types of actions in affecting dispersion and retention of larval pallid sturgeon. This modeling has provided some important insights, including some more recent simulation runs which suggest that a significant number of modeled particles (a proxy for larval sturgeon) may be retained for considerable periods of time within the side chutes. The ability for pallid larvae to enter constructed chutes is a critical element of their success as a management action. To date, the EA team has used 2-D modeling to analyze different chute entry possibilities (two at Hamburg, and two at Lisbon-Jameson). This is an important first step, but as the EA team recognizes, additional experiments and analysis will be important for developing better understanding of how different types of chutes at different locations along the river may perform.

The 2-D models allow description of hydraulic habitat attributes that are presumed important to pallid sturgeon for selected river reaches where high-resolution data are currently available. However, as acknowledged by the EA Team, such habitat modeling is only as useful as it is realistic in linking physical conditions to performance of pallid sturgeon life stages. Without empirical or mechanistic links from hydraulic-habitat attributes and conditions to sturgeon population dynamic responses, the efficacy of the available model for distinguishing potential success of alternative management actions will remain unknown. Note that continuing efforts to construct shallow-water habitat is vexed by the same disconnect; no empirical justification can be made for that program without data linking enhanced pallid sturgeon performance to construction of landscape circumstances that have been asserted to contribute to habitat extent and quality for the fish.

The ability of the 2-D models to project the extent of ESH in relation to natural and managed flow regimes is encouraging, particularly as ESH relates to piping plover and least tern population dynamics. The approach appears quite credible and useful in describing sediment transport processes that influence ESH, despite being empirical rather than solely based on complex multi-dimensional process modeling. The EA Team has rightly focused their analysis/modeling on a highly empirical approach and has generated surprisingly accurate results that can be directly integrated with the bird habitat-based effects analysis.

Pallid Sturgeon

The Pallid Sturgeon EA report describes credible CEMs, hydrological simulation models, and quantitative population models. These models provide an important foundation for eventual assessment of the potential effects of river modifications on pallid sturgeon vital rates. The complementary models dealing with demographics, bioenergetics, hydrodynamics, dispersion, and functional habitat are appropriately introduced in the Pallid Sturgeon EA to develop a picture of potential limiting factors in the Missouri River system. Although these models provide valuable insights to the options for pallid sturgeon management, the models are difficult to implement in the absence of quantitative information for the pallid sturgeon. Data are especially lacking for pallid sturgeon early life stages, a clear limitation given that the pallid sturgeon population models are largely sensitive to the survival rate at these early life stages. The majority of the management action hypotheses have moderate to high uncertainly associated with them, suggesting the need for continued acquisition of relevant new data. Refinement of the models in Phase 3 of the EA, and thereafter in further assessment of the management-action hypotheses, will be necessary to improve predictions and application to pallid sturgeon management throughout the Missouri River system. In addition, integration of the different models described in the Pallid Sturgeon EA is needed to provide a more cohesive view of the challenges facing pallid sturgeon recovery. The implications of the presented assumptions for the accuracy and reliability of model predictions are not addressed in any detail; sensitivity analysis to examine the implications of these model assumptions should be undertaken.

As mentioned in the report, an expert elicitation process was undertaken to assess a limited number of the hypotheses related to pallid sturgeon management in the lower Missouri River. The expert elicitation process, although conducted separately from the EA activities proper, has provided useful insights despite the considerable uncertainties associated with describing pallid sturgeon population dynamics in this large river system. The experts evaluated alternative hypotheses using a limiting factor approach. They then offered their expert opinion on what intensity of an action would be required to make that factor not likely to be limiting to one life stage or another. However, it remains a challenge to relate the outputs of the expert elicitation framed within a limiting factor approach to projected management impacts on pallid sturgeon population dynamics in absolute terms. As an alternative approach, it might prove beneficial for future expert elicitations to focus on estimating the potential effects of alternative management actions on values of the uncertain parameters of the existing demographic pallid model. Then, the model could be used directly to project the population implications of alternative management actions.

Piping Plover and Least Tern

The Piping Plover and Least Tern EA report provides credible sub-models for purposes of assessing alternative management actions for the two birds, although the hydrology and bird sub-models have not been coupled together (as of the date of the interim report) in a manner that would maximize their utility. However, relationships have been explored between river discharge and sandbar area that can be coupled via hydrology and habitat models to available demographic models for the birds, thereby supporting EA simulations in an appropriate stochastic, dynamic context (as per model capabilities that were presented at the November 2014 MRRIC meeting versus those conveyed in the interim report).

The focus on habitat generation and degradation processes in models for piping plover and least tern is adequate for the effects analysis and in near-term support for adaptive management.

Some structural changes in the bird population models may provide some additional utility. Eggs and newly hatched birds are aggregated into the fledgling model state variable; consequently, management actions that directly influence only one of these early life stages cannot be addressed directly. For example, alterations in river (water) elevations might more realistically impact egg survival and hatching; small mammals might focus predation effort on eggs. This limitation might prove to have minimal impacts of the usefulness of the models, and if the need arises, modeling efforts might incorporate eggs and hatchlings into the overall model constructs.

The EA demonstrates the (primary) sensitivity of the bird population models to estimates of adult survival rates. The management actions for least terns and piping plovers emphasize actions that increase fledgling survival; however, uncertainties associated with adult survival might cause model results to "mask" the effects of management alternatives on population dynamics. This parameter sensitivity could reduce the ability of the model to differentiate among management alternatives. A simple remedy might be to hold constant adult survival rates while evaluating management actions; such a strategy would permit the management effects to be demonstrated in terms of fledgling success and bird population projections.

5. To what extent does the EA provide a comprehensive list of potential management actions and an assessment of their likelihood of benefitting the listed species and their habitat?

Hydrogeomorphology

The Hydrogeomorphology EA report does not directly provide a comprehensive list of management actions, nor does the EA assess the likelihood of the actions benefitting the listed species and their habitats. Importantly, the EA demonstrates an ability to apply physical models to translate potential management actions into corresponding values of environmental factors (e.g., flows, elevations, ESH) that can be evaluated in terms of likely benefits to the species and their habitats.

The suite of models identified in the report suggest that the EA team will ultimately be able to help design alternative management actions that address flows, elevations, and ESH, as well as spawning and foraging habitat, water quality, and food web/ecosystem issues relevant to the listed species. Now that the models are available, they are being used to assess different 'classes' of actions. That is, rather than assessing specific actions, the models allow 'backing out' the habitat-attribute conditions that need to be created. It is less necessary at this point to provide a list of management actions than to assess what conditions need to be created for the species, and then determine the types of actions that might create those conditions. In this sense, the models already developed, and being developed, are appropriate.

The current EA focuses on pallid sturgeon free-embryo drift and ESH creation for the birds. Little is provided to help the ISAP understand the capabilities of other applicable models to address water

quality, pallid sturgeon habitats (e.g., spawning, interception, and foraging), and food web or ecosystem implications of management actions. The remaining potential management actions and associated models will apparently be addressed and documented in subsequent phases of the Hydrogeomorphology EA activities.

Pallid Sturgeon

The Pallid Sturgeon EA presents 21 "working management hypotheses" for challenges facing the pallid sturgeon in the Missouri River and its tributaries. These hypotheses were selected from a more comprehensive list of hypotheses based on criteria laid out in the report, and are meant to guide potential management actions to address those challenges to pallid sturgeon recovery. This list is thorough and includes background literature, current data for the Missouri River where available, uncertainty assessment, and potential impacts on river operations and uses. The EA holds other hypotheses in a "reserve" list for use if the selected hypotheses are shown or predicted to be ineffective at avoiding or removing jeopardy for the listed species.

Overall, the Pallid Sturgeon EA presents a set of management hypotheses to be further modeled, tested in the field, and/or if implemented as a management action, adaptively managed for recovery of the species. It does not recommend a specific course of action, but rather lists a set of actions hypothesized to be beneficial to the species along with the associated uncertainty and risk of each. The uncertainty of success associated with some of these management actions is high, which may make justification for implementation of those actions difficult at this time. For example, in the upper river, reduction of flows at Fort Peck and drawdown of Lake Sakakawea may still not provide sufficient drift distance for survival of free embryos. Further modeling and gathering of empirical data for these complex relationships are needed to reduce uncertainty. In the lower river, efficacies of management actions at Gavins Point are constrained by uncertainty concerning the fate of embryos, larvae, and juveniles in the Mississippi River. The EA does not delve directly into pallid sturgeon dynamics in the Mississippi River and the influence of the interaction between the Missouri and Mississippi rivers on recruitment of pallid sturgeon. Based on genetic information and the likelihood of advection of free embryos into the Mississippi River, the lower Missouri River population may well be influenced by Mississippi River conditions. It is therefore important for the Pallid Sturgeon EA to explicitly consider the Missouri and Mississippi rivers as connected systems that influence the survival of pallid sturgeon and to generate models that integrate this linkage.

As stated in several places above and in the EA, the quantified relationships that would enable testing the benefits of hypothesized management actions for the pallid sturgeon population or its various life stages, or distinguishing between the effects of different possible actions, do not currently exist. Though the EA presents a weight-of-evidence assessment of each management hypothesis using available knowledge, it points out that much work remains to be done to assess the likelihood of each hypothesis to benefit the species.

Piping Plover and Least Tern

The Piping Plover and Least Tern EA report incorporates a near comprehensive list of management actions for the bird species and describes the weight of evidence for each. Little information is

presented, however, regarding the results of numerical assessments of the actual benefits of implementing specific management actions. The paucity of assessment information stems from the fact that bird models had not yet been coupled to hydrogeomorphology models in a manner that would permit analyses (see also comments on Question 4 above).

Modest improvements might be made in the format used to present results from the analysis of management actions. Some of the "actions" presented are really categories of actions (e.g., managing water levels in reservoirs). To be more explicitly applicable in assessing alternate management actions, alternatives should be defined more specifically (e.g., managing water levels in Lake Sakakawea). Certain management actions are described as being particularly costly; but rather than making such judgments, the report might address costs per unit application of the action. In addition to cost per unit of application, the analyses might portray for each discrete action, 1) where the action will be employed, 2) when the action will be employed (what system state is required for the application), 3) units of application (acres, feet), 4) constraints on the application (the minimum number of units and maximum number of units that can be employed), 5) interactions that can be expected with other management actions (always applied with, never applied with, or optionally applied with), and 6) expected bird responses per unit of activity.

It was suggested during the November 2014 MRRIC meeting in Omaha that management of off-channel nesting habitats might be included in the EA. Many such habitat areas, created and sustained by sand and gravel operations, exist along the Platte River and are the only reliable sources of piping plover and least tern reproduction in that system. However, Missouri River main-stem soils are less sandy, few sand and gravel operations are found along the lower river (at least in Nebraska), and consequently few, if any, off-channel areas currently provide suitable nesting habitat. Nonetheless, future phases of the EA might consider incorporating off-channel nesting areas into the analyses if inventories indicate that such habitats exist and are utilized by nesting piping plovers and least terns. Experimental construction of off-channel nesting areas might demonstrate that piping plovers and least terns would benefit from such areas if created and maintained.

The ISAP understands the programmatic focus on restoring natural in-channel sandbar building process, but off-channel refugia for the birds and potential reproduction in areas adjacent to the Missouri River may support the survival and persistence of in-channel demographic units, effectively contributing to achieving bird objectives on the contemporary, modified river system. The Missouri River channel is now an engineered system, supporting the notion that off-channel areas that provide suitable nesting sites may be no less "natural" than in-channel ones. Off-channel habitats could be important buffers during high-flow years when in-channel nesting habitats are not available. Birds produced in off-channel circumstances adjacent to the channel may provide a base of recruitment in years that in-channel circumstances are unavailable or nests and young are lost to high water. Off-channel habitats may be more cost-effective to establish and maintain, and opportunities might exist to acquire suitable off-channel areas that could be managed to produce productive nesting habitat in the context of the ongoing mitigation program.

The recently released reservoir report (USACE 2014) seems inconsistent with the Piping Plover and Least Tern EA report. The reservoir report clearly states that actions involving manipulating reservoir

water levels to create additional bird nesting habitat will not be carried forward; i.e., would not be considered further for implementation. Yet, that action remains a prominent hypothesis in the Piping Plover and Least Tern EA.

6. To what extent does the EA set the stage for development of a viable strategy (adaptive management plan) for reducing uncertainty in predictive tools for use in assessing effects of management actions on the listed species and their habitats?

The EA Team was not specifically charged with developing a strategy for reducing uncertainty in predictive tools, although such a task seems implicit given the great deal of uncertainty that has been highlighted by the work of the past year. Each team discussed uncertainty and means of its reduction throughout the discussion in the three reports, and it now is apparent that a near-term task for the MRRMP will be to use that information to develop a strategy for improving our knowledge in numerous areas.

Hydrogeomorphology

The Hydrogeomorphology EA report describes the nature and extent of many uncertainties associated with the physical predictive tools. However, beyond mentioning a Phase 2 and Phase 3 EA, this draft EA does not present a strategy for reducing the overall uncertainties of the integrated physical and species models intended for assessing the effects of management actions on the listed species and their habitats. While perhaps beyond the scope of the current Hydrogeomorphology EA report, it will be necessary to develop a strategy to address the effects of the combined uncertainties of integrated physical and species models.

The models developed for quantifying the hydraulics, hydrology, and geomorphology of the system are well-suited to reducing uncertainty about what actions will affect species habitat. The models (as noted above) are already being used to assess the viability of some management actions, such as reservoir drawdown. The models will also be helpful in identifying potential small-scale experiments to target specific questions concerning the likely outcomes of management actions in relation to species response or habitat alterations.

However, until functional linkages (including uncertainties) between physical conditions and biological response are developed, perhaps as the result of the kinds of focused experiments just mentioned, using the physical models for evaluating the efficacy of management actions will remain constrained and potentially misleading.

Pallid Sturgeon

The EA Team identifies uncertainties throughout the entire Pallid Sturgeon EA and explicitly explains uncertainties in the "Uncertainty Assessment" section for each of the dominant management actions. The EA Team discusses how to reduce uncertainty in an adaptive management context for each of the management actions (sections entitled Action Hypothesis in Adaptive Management Context). For the management actions that have the greatest support, the EA Team developed decision trees to guide

research that will test support for a given management action. The decision trees are useful with respect to guiding directed research parallel with accompanying management action implementation. Given the state of knowledge on pallid sturgeon, this is a logical process and a viable strategy for moving forward within an AM plan with a strong EA component. The EA Team therefore has "set the stage for development" of an AM plan that can reduce uncertainty.

The pallid sturgeon models and the hydrogeomorphology models are currently incomplete, thus they have no predictive power for assessing the effects of the management actions. It is unrealistic to expect the models presented in the Pallid Sturgeon EA to have useful predictive capabilities until the cause-and-effect functional relationships between habitat and pallid sturgeon demographic parameters are better understood and quantified. Once again, this is not a "fault" in the EA Team's efforts; this simply represents the current state of knowledge for the Missouri River ecosystem. As noted above, given the amount of variation inherent in the Missouri River ecosystem it is unlikely that any model employed at the scale of the whole system will have strong predictive capabilities. Predictive models will need to operate in specified locations at appropriate scales for the processes being modeled and where data are available to support the model.

The EA Team did conduct a detailed quantitative sensitivity analysis of the existing pallid sturgeon demographic population. Parameters that describe early life stage survival are of paramount importance as indicated by the sensitivity analysis. The nature and source of the distributions of model demographic parameters that form the basis of the sensitivity analysis were not reported; therefore, it remains difficult to evaluate the results of the analysis. Future EA efforts appear appropriately directed at reducing parameter uncertainty through carefully designed monitoring, experimentation and controlled field studies. It is imperative to understand that the EA and supported management actions may change as more information is gained with regard to the Corps' actions and pallid sturgeon demography. Although the uncertainty makes agencies and stakeholders uncomfortable, the EA process has developed a defensible process for reducing uncertainty in the highly complex Missouri River ecosystem.

Piping Plover and Least Tern

The EA describes the EA process as "identifying the relationships between the operation and maintenance of the Missouri River, the habitats used by the species, and the populations themselves, including stressors, positive relationships, and uncertainties. That information is then used to identify potential management actions and evidence for their effects, then to predict the outcomes quantitatively to the extent possible in order to identify effective management actions or suites thereof and their costs and benefits." This process reflects the steps necessary to allow for the selection of a management action or actions that can be implemented in an adaptive framework, matching the steps to adaptive management articulated in Murphy and Weiland (2014). The EA documents the availability of time-series population data that supports population-habitat models that reflect the generally agreed-upon linkage between sandbar extent and local demographic responses. The EA modeling still needs the output of the HEC-ResSim model to determine reservoir elevations and releases that provide input for the ESH and reservoir habitat models. In addition, the Hydrogeomorphology EA Team has not yet completed the desired updated model for ESH that

addresses the deposition and erosion of sandbars that is based on existing area of ESH and flows (in specific areas of the river). The completion of those models will fill the foundational needs for predictive modeling that can support decision making in an adaptive management framework for the shorebirds on the Missouri River. With completion of anticipated hydrological-habitat tools, the EA for the piping plover and least tern is in position to provide test management alternatives for the birds for further consideration in the MRRMP PrOACT process. It can be expected that "uncertainty in predictive tools" can be reduced as the bird-habitat-hydrology models are refined through further use in the MRRMP and subsequent AM program.

Discussion, Conclusions, and Recommendations

As described in the introduction to the MRRMP "Effects Analysis Guidance Document," the EA should:

- Describe the status and trends of the affected species and their habitat conditions, identifying correlations
- Determine and quantify cause-and-effect relationships between system operations and the success (decline) of the species
- Based on knowledge of those relationships, postulate potential mitigation actions to benefit the species
- Gather or develop models based on those relationships that are capable of projecting and distinguishing the effects of implementing those potential mitigation actions
- Project the likely effects of the potential mitigation actions on the success of the species

A complete EA would enable the management agencies to:

- Identify quantitative species objectives, targets, and means objectives for protecting the species
- Select management actions most likely to achieve objectives at acceptable cost
- Implement actions and monitor results for key indicators
- Assess results and feed information back into the EA steps
- Modify actions as/if needed to achieve objectives

Developing an EA that meets these objectives for multiple species is an ambitious undertaking, especially in an ecosystem as complex as the Missouri River and given the time constraints for its completion set by the agencies. Moreover, the EA is constrained by limited demographic data for the pallid sturgeon, high variation in river abiotic and biotic parameters, and a lack of functional relationships between habitat characteristics and species responses. The EA process has served the MRRMP well to date in describing the current state of knowledge for the species, developing CEMs, building frameworks for demographic models, prioritizing key uncertainties, revising species objectives, identifying and assessing potential management actions, and developing models that begin to forecast the effectiveness of those potential actions – together setting the stage for implementation of AM. Despite considerable progress, significant challenges remain.

Implications of Historical Unknowns

The lack of long-term historical ecological data, before construction of the dams (or the BSNP) on the Missouri River, makes establishing species objectives based on pre-dam/BSNP conditions unrealistic. In addition, it is difficult to articulate important terms such as "avoiding jeopardy," or to develop recovery goals, if it is unclear what changes have occurred in physical and biotic attributes of the system and the listed species. While certain aspects of the historical conditions are unknown, the effects analyses could benefit from the addition of sections that summarize the available information regarding larger-scale pre-project conditions, that is, the circumstances in which the listed species evolved and persisted. Absent quantitative information relating pre-project conditions to bird and fish numbers and population dynamics, description of the historical setting, and inferred ecological context could be helpful in establishing programmatic species objectives, which are necessary to choose among potential management actions in efforts to fulfill obligations under the federal Endangered Species Act. Under the assumption that the system will not return to pre-project conditions and that we do not know them in any case, the MRRP will have to discover whether any modern conditions may be suitable for sustaining the species. Design of the science that will be necessary to support MRRP actions to come could be aided by additional characterization of historical ecological conditions and relationships.

Uncertainty in Physical-Biological Relationships and the Effects Analysis Models

Critical missing elements in the ongoing effects analysis are quantitative relationships between river operations, species management actions, and species responses. In the case of the two listed bird species, with a good understanding of the process of in-channel habitat creation and degradation and corresponding demographic responses, the ISAP is confident that the necessary management-response functions can be developed. In the case of the pallid sturgeon, critical gaps in understanding of the species-habitat relationships make it currently impossible to quantify the likelihood of specific management actions to enhance pallid sturgeon population in the Missouri River. That is, it is not possible to distinguish likelihoods of success of different management actions in avoiding jeopardy from river operations, or in contributing to the potential recovery of the pallid sturgeon population. While this is understandably a concern for MRRIC stakeholders, the ISAP is confident that the EA teams have vetted the pertinent data that are available and have conveyed the basic understanding of the species-habitat relationships that are necessary to establish those links to the extent possible at this time. The expert elicitation process and alternatives development process that the agency product delivery team has adopted (as the ISAP understands them), appear to be logical short-term approaches to "fill in gaps" in current knowledge.

The EAs require appropriate modeling tools to evaluate the likelihood of success of potential or hypothesized management actions. The EA Teams have assembled the elements of models that will be able to compare different management-action scenarios, but critical gaps in scientific knowledge for the pallid sturgeon currently preclude their application. While the models cannot link management actions to population responses, they might be used to project expected results of specific management actions on incremental habitat responses in portions of the planning area. These types of models can be implemented individually or in combination, and the model results used to assess risks, benefits,

and tradeoffs of at least some alternative management actions. Alternatively, the models as they exist might be used to assist in designing smaller-scale field studies and/or focused monitoring schemes to help evaluate hypotheses regarding the potential efficacy of select management actions in relation to specific species responses. For example, what characteristics of 'chutes' would maximize retention of pallid sturgeon free embryos in certain river reaches?

Close examination of the models, as well as reported results of model sensitivities, raises questions concerning their application. It remains to be demonstrated that, in the face of substantial ecological uncertainties, the current EA models will be able to distinguish among the outcomes of alternative management actions in terms of species responses. Some additional consideration of spatial specificity in the analyses is required to allow confidence in the potential efficacy of the models to guide selection of management action scenarios on a site-specific basis. In addition, integration of the physically connected ecosystems (e.g., off-channel habitat for birds, Mississippi River for pallid sturgeon) into the models will improve predictability of population dynamics in response to future physical and ecological manipulations of the system.

To that end, the EA reports present no discussion of the precision and accuracy needed in the models to distinguish among the likely outcomes of proposed management actions or alternatives. Absent such discussion, it is difficult for the ISAP to determine whether the overall modeling approach and the models currently developed are sufficiently predictive to distinguish among management alternatives. The EA teams recognize that functional relationships between the modeled physical habitat characteristics that will define alternative management actions and subsequent biotic responses by the listed species, particularly pallid sturgeon, remain to be established. The EA teams, as well as the agencies, should clearly articulate the implications of those uncertainties and how they affect management action decisions, both in the near term and beyond.

Uncertainties and Adaptive Management

Adaptive management is a process designed to achieve desired management goals and objectives in the face of uncertain outcomes of management actions. Fundamental to adaptive management is the capability to manage. The ability to manage presupposes established quantitative relationships between well-specified management actions and expected, albeit uncertain, outcomes. Lacking such relationships, no logical basis exists for management and any manipulation of the system is simply an experiment. The role of the EA is to provide the quantitative relationships, including characterization of uncertainties, between proposed management actions and their anticipated measurable outcomes. Those relationships serve as the basis for selecting and implementing management actions in an adaptive framework.

Identification of those relationships has been accomplished to a promising extent for the terns and plovers, but has not yet been done for pallid sturgeon. For pallid sturgeon, the EA has challenges to be met. Management-response relationships must be quantitative to the extent possible in order to 1) implement management actions of sufficient scale (i.e., magnitude, spatial extent, duration) to produce a response that can be measured to an acceptable degree of accuracy and precision given finite monitoring resources, and 2) guide changes in management actions (i.e., to adapt management) if the

expected outcomes of implementation do not manifest. Absent these management-response relationships, it is not possible to manage, let alone manage adaptively. For example, assume a simple linear response in pallid sturgeon early life-stage survival as a function of available foraging habitat. Assume additionally (and realistically) that there is a threshold in the magnitude (area) of additional foraging habitat necessary to generate sufficient numbers of survivors to enable their measurement through a practical (affordable) monitoring program. Implementing a foraging management (creation/restoration) effort based on a plausible qualitative hypothesis, without characterizing the management-response function, might not produce a measurable response, simply because the scale of the managed increase in foraging habitat failed to exceed the unknown threshold. Under such circumstances, no information (no learning) would have been produced to guide changes to (or adapt) the management approach. Should managers do more of the same and hope? Or should they try an alternative action also hypothesized to enhance pallid survival? Even if a species or habitat response to the management action is measured, if it cannot be evaluated against some expected (and uncertain) magnitude, no strong inference can be drawn that the response was the result of the foraging habitat manipulation or some other coincidental influencing factor.

In contrast, even an uncertain characterization of a foraging area management-response function, including an even preliminary estimate of a threshold, would help to implement habitat manipulations of sufficient magnitude (scale) to increase the likelihood that a response will be measurable, and provide a context to evaluate any measured change in pallid survival as a likely causal response to foraging area management, and thereby provide information to guide any required adaptation in managing forage habitat. This simple example underscores the paramount importance of directing the ongoing EA efforts toward derivation of the necessary management response functions for both bird species and pallid sturgeon, recognizing adaptive management is the desired end product of the MRRMP effort.

Need to Update and Extend the Effects Analysis

Continued work on the effects analyses, in concert with the adaptive management program, will reduce the uncertainties in our understanding of the Missouri River and the three listed species. Each year, management actions and associated monitoring change the amount and type of data available; models are re-evaluated and updated; and the basic understanding of the system and the species changes, either gradually or potentially dramatically. As such, the implementation agencies and MRRIC should recognize that the EAs will need to be continuously revised and updated as new information and understanding is accumulated. As the ISAP has suggested previously, the agencies should consider the process by which new information, data, and science will be inventoried, assessed, and incorporated into an 'official' (regulatory) understanding of the system and species, reflected (presumably) in regularly updated EAs. As evidenced with the earlier biological opinions for the three species, our understanding of the system and species evolves as previous hypotheses are addressed and potentially falsified using new knowledge, making documents outdated and irrelevant, yet still binding and potentially regulatory. To avoid this, establishing a process by which new science will be reflected in institutional understanding of the species, their habitats, the contemporary hydrodynamics and landscape, and the effects of operations on them all, is important, and indeed will be a centerpiece of the eventual AM program.

In implementing that process, it is important that both lead agencies be visibly engaged in the direction of the continuing EA and its integration with the AM process. It is in the purview of the USFWS to have made the jeopardy calls under section 7 of the Endangered Species Act, and to make eventual decisions to de-list the species, should management actions lead to recovery. By rights, the USFWS should be directing the EA (and co-directing the adaptive management work that follows), although circumstances are that the EA team is funded by the Corps and much of the work is being carried out by Corps personnel. The emerging governance structure for the AM Program could more explicitly provide and highlight the role that the USFWS is playing in developing and implementing scientific and management elements of the MRRMP. The ISAP recommends that the USFWS invest the necessary resources into developing the capabilities for determining species objectives that will be used to direct AM and define program success, and will provide the criteria for ultimately de-listing the species. This may require leveraging available USFWS personnel beyond the current representatives to MRRIC, or building a team of experts analogous to the EA team and the soon-to-be-developed implementation team for the AM Program. This critical task should be undertaken soon, ideally within six months, because management targets for the AM program need to be established forthwith. The ISAP believes the MRRMP program (and the MRRIC stakeholders) has been operating without clear species objectives for too long and the USFWS needs to complete the task. An agency-based team, not made up solely of USFWS staff, might garner more support from stakeholders, although a final determination clearly lies with the agency. The Corps has invested significant resources in the MRRMP process; the ISAP suggests greater investment by the USFWS, especially in areas where it is the responsible agency.

Summary Conclusions and Recommendations

1) The EA process has served the MRRMP well to date in describing the current state of knowledge for the species, developing CEMs, building frameworks for demographic models, prioritizing key uncertainties, revising species objectives, identifying and assessing potential management actions, and developing models that begin to forecast the effectiveness of those potential actions – together setting the stage for implementation of AM. Many aspects of the EA process have exceeded the expectations of the ISAP, and the panel believes this EA could become a model for how an EA is done.

2) The limited long-term data on historical changes in the biophysical system and populations of the listed species since before construction of the dams (or the BSNP) on the Missouri River, whether measured, modeled, or inferred, makes establishing species objectives or articulating important terms such as “avoiding jeopardy” difficult. The EAs could benefit from additional assessment and synthesis of the available information regarding changes that have occurred since pre-project conditions. Such an articulation of the historical setting and inferred ecological context could be helpful in establishing programmatic species objectives and design of the experimental or discovery work that will be necessary to define or refine response functions needed by the models. Under the assumption that the system will not return to pre-project conditions and that we do not understand those conditions in any case, the MRRP will need to determine whether there are modern conditions that may be suitable for the species.

3) A primary missing element in the ongoing effects analysis is the articulation of relationships linking river operations and management actions to species responses. Solid progress has been made in development of the hydrogeomorphology models defining physical processes. For the piping plover and least tern, a quantitative understanding is emerging of the linkage of in-channel habitat creation and degradation with bird demographic responses. In the case of the pallid sturgeon, however, critical gaps in understanding of the species-habitat relationships make it currently impossible to specify management actions that have a quantifiable likelihood of enhancing the pallid sturgeon population in the Missouri River. Available models cannot distinguish likelihoods of success of different management actions in avoiding jeopardy from river operations or in contributing to the potential recovery of the pallid sturgeon population. Experimental work should be planned to develop the necessary quantitative relationships. The expert elicitation process and alternatives development process that the agency product delivery team has adopted (as the ISAP understands them), appear to be logical short-term approaches to "fill in gaps" in current knowledge.

4) A clear plan for extended work on the EA and how this work will dovetail with the AM program should be articulated. This plan should define how research, scaled field tests, "increment one" management actions, ongoing or new monitoring, and any other means of learning will combine to further establish the necessary quantitative relationships among the species, their habitat conditions, and management action scenarios. The plan should specify how the EAs will be kept updated and communicated, and how new knowledge will be incorporated into a programmatic understanding of the species, their habitats, the contemporary hydrodynamics and landscape, and the effects of water-project operations on them all. The extended EA work should be a central piece of the eventual AM program.

5) The EA documents are necessarily long, complex, and never complete. They summarize and synthesize substantial scientific literature. As a whole they begin to provide the knowledge and tools needed by scientists and engineers to better manage for the three listed species on the Missouri River. However, as three long and complex separate documents they do not tell an integrated story in language understandable to non-technical readers who wish to understand and be engaged in decisions regarding management of river operations and protective or restorative actions for the listed species. The agencies should consider a means for "translating" the EA into language and media that are friendly to interested stakeholders.

References Cited

Catlin, D., R. Jacobson, M. Sherfy, M. Anteau, J. Felio, J. Frazer, C. Lott, T. Shaffer, and J. Stucker. 2009. Discussion of "Natural Hydrograph of the Missouri River near Sioux City and the Least Tern and Piping Plover" by Donald G. Jorgensen. Journal of Hydrologic Engineering 14:1076-1078.

Jacobson, R. B., and D. L. Galat. 2006. Flow and form in rehabilitation of large-river ecosystems: an example from the Lower Missouri River. Geomorphology 77:249-269.

Jorgensen, D. 2009a. Natural hydrograph of the Missouri River near Sioux City and the least tern and piping plover. Journal of Hydrologic Engineering 14:1365–1373.

Jorgensen, D. 2009b. Closure to "Natural Hydrograph of the Missouri River near Sioux City and the Least Tern and Piping Plover" by Donald G. Jorgenson. Journal of Hydrologic Engineering 14:1078-1080.

Murphy, D., and Weiland, P. 2014. Science and structured decision making: fulfilling the promise of adaptive management for imperiled species: Journal of Environmental Studies and Sciences 4:200-207.

USACE (U.S. Army Corps of Engineers). 2014. Draft Study of Potential Least Tern and Piping Plover Habitat Enhancement on the Reservoirs of the Missouri River Main Stem Reservoir System. U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.

USFWS (U.S. Fish and Wildlife Service). 2007. Pallid sturgeon (*Scaphirhynchus albus*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Denver, Colorado.

USFWS (U.S. Fish and Wildlife Service). 2014. Revised recovery plan for the pallid sturgeon (*Scaphirhynchus albus*). U.S. Fish and Wildlife Service, Denver, Colorado.