

# Review of the Recovery Program for the Endangered Pallid Sturgeon in the Upper Missouri River Basin

A Report Prepared by the Western Division of the American Fisheries Society for the Upper Basin Pallid Sturgeon Workgroup

## Authored by

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# Review of the Recovery Program for the Endangered Pallid Sturgeon in the Upper Missouri River Basin

**Molly A.H. Webb, Jack E. Williams and Larry R. Hildebrand**

## EXECUTIVE SUMMARY

The pallid sturgeon (*Scaphirhynchus albus*) is one of the most critically endangered species in the United States. Habitat for the pallid sturgeon has been fragmented, inundated by reservoirs, channelized or otherwise degraded. Remnant adult populations are isolated, small, and composed of older individuals. Attempts to propagate and rear the species in hatcheries and reintroduce them into remaining habitat areas have been plagued by disease and uncertainty in propagation and handling protocols. Although habitats in the Upper Basin of Montana, the Dakotas and Nebraska have been substantially modified by seven large mainstem dams and tributary impoundments, the limited remaining riverine habitats provide the best remaining opportunities within the entire range of the species for restoring natural and essential habitat conditions to foster natural recruitment.

Recovery efforts for the pallid sturgeon are coordinated by the U.S. Fish and Wildlife Service through a Recovery Team. Recovery implementation occurs primarily through the activities of three workgroups that function in the upper, middle, and lower portions of the Missouri and Mississippi river systems. The Upper Basin Workgroup consists of federal and state agency biologists, state representatives, and university scientists from North Dakota, South Dakota, and Montana. In August 2003, the Upper Basin Workgroup requested that the Western Division of the American Fisheries Society (WDAFS) review the existing pallid sturgeon recovery effort in the upper basin and make recommendations for its improvement. The WDAFS assembled a Pallid Sturgeon Recovery Review Committee to assist the Upper Basin Workgroup in functioning more efficiently and effectively. The purpose of this report is to provide the findings and recommendations of the WDAFS committee.

The WDAFS Pallid Sturgeon Recovery Review Committee is concerned that despite diligent efforts by the Workgroup, existing pallid sturgeon recovery efforts are inadequate to prevent functional extinction of the species in the upper Missouri River Basin. It is imperative that substantial recovery occur during the next five years to prevent extirpation of the species in the upper basin. Many factors contribute to this critical situation, including lack of adequate leadership from the Recovery Team, lack of federal agency support of recovery efforts, inadequate funding, organizational problems within the Workgroup, technical uncertainty relating to capture and propagation of pallid sturgeon in hatcheries, disease problems, and lack of progress in addressing habitat restoration.

The WDAFS Pallid Sturgeon Recovery Review Committee believes that the following tasks are highest priority to prevent extirpation of the pallid sturgeon in the Upper Missouri Basin:

- Encourage strong leadership and proactive support of recovery efforts from the U.S. Fish and Wildlife Service and Recovery Team (Recommendation #11);
- Develop and implement new broodstock mating protocols (Recommendation #15);
- Maximize each fish's contribution to future generations (Recommendation #16);
- Provide broodstock security through use of multiple facilities and safety systems (Recommendation #28);
- Immediately works towards releasing a high seasonal pulse of water from Fort Peck Dam to stimulate pallid sturgeon recruitment (Recommendation #31);
- Develop and implement a step-down recovery plan for RPMA 2 (Recommendation #33);
- Develop a reliable molecular test for pallid sturgeon iridovirus (PSIV) (Recommendation #40);
- Manage for elimination of PSIV from hatcheries and juveniles (Recommendation #41); and
- Determine baseline blood chemistry of pallid sturgeon to aid in assessment of fish health and survival of broodstock (Recommendation #47).

Many other recommendations are offered under a variety of subject areas. A total of 52 recommendations are offered in this report to address recovery needs, organizational problems, funding shortfalls, and technical concerns.

## INTRODUCTION

In 1990, the U.S. Fish and Wildlife Service listed the pallid sturgeon (*Scaphirhynchus albus*) as an endangered species because of declining populations throughout the species range, which stretches along the mainstem Mississippi and Missouri Rivers (U.S. Fish and Wildlife Service 1990). Initial declines appear to be correlated with commercial harvest but subsequent failures of population recruitment appear to be caused primarily by extensive modification of river corridors by dam construction, reservoir development, and river channelization. Keenlyne (1989) summarized the modification and fragmentation of pallid sturgeon habitat along the Missouri River as follows: approximately 28% has been impounded by mainstem hydropower dams, 51% has been channelized for barge traffic, and 21% is downstream of dams where temperature, flows and turbidity have been greatly altered. Fundamentally, the free-flowing, turbid and warm, large river habitat necessary for the pallid sturgeon to reproduce successfully has been eliminated (Bramblett and White 2001; Snook et al. 2002).

The U.S. Fish and Wildlife Service prepared a recovery plan for the species that guides recovery efforts and divides the remaining habitat throughout the species current range into six Recovery Priority Management Areas (RPMA) (Dryer and Sandvol 1993). Three subbasin workgroups (Upper, Middle and Lower) have been established to implement management and recovery efforts in their respective areas. Workgroups are composed of state and federal agency and academic representatives with expertise and/or management responsibilities for pallid sturgeon. The Upper Basin Pallid Sturgeon Recovery Workgroup (hereinafter termed the Upper Basin Workgroup), for example, includes representatives from Montana Fish, Wildlife and Parks,

North Dakota Game and Fish, South Dakota Game, Fish and Parks, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, Bureau of Reclamation, U.S. Geological Survey, Western Area Power Administration, and Montana State University. The Upper Basin Workgroup coordinates and implements recovery actions for pallid sturgeon in RPMA 1, 2, and 3, which consists of the upper Missouri River from the mouth of the Marias River to the headwaters of Fort Peck Reservoir (RPMA 1), the Missouri River from Fort Peck Dam to the headwaters of Lake Sakakawea, including the Yellowstone River upstream to the mouth of the Tongue River (RPMA 2), and the Missouri River from 20 miles upstream of the mouth of the Niobrara River to Lewis and Clark Lake (RPMA 3).

Probably the best remaining habitat for pallid sturgeon throughout its range occurs in RPMA 1 and 2. Recovery efforts in 2002 consisted of monitoring wild and hatchery-reared pallid sturgeon, continued development of a hatchery propagation program, and research into fish health, life history, and habitat requirements (Upper Basin Pallid Sturgeon Recovery Workgroup 2002). Population estimates of adult pallid sturgeon in RPMA 1 (Missouri River upstream from and including Fort Peck Reservoir) range from 40 to 100 (Bill Gardner, Upper Basin Workgroup, personal communication) in 2003. In RPMA 2 (Missouri River between Lake Sakakawea and Fort Peck as well as the Yellowstone River), the adult population estimate in 2003 is 151 (Kevin Kapuscinski, Upper Basin Workgroup, personal communication). Efforts toward hatchery propagation and reintroduction of juveniles into the wild are proceeding but have been hampered by small numbers of adult sturgeon available for broodstock, uncertainties associated with pallid sturgeon reproductive physiology, and disease problems in the hatcheries. In the past decade, populations of the pallid sturgeon have continued to decline and the species faces functional extinction in the wild. According to the Upper Basin Workgroup, there has not been any documented natural reproduction of pallid sturgeon in the upper basin of the Missouri River for at least the past 35 years (Henckel 2003), except for a few larvae captured in 2002 and 2003 at the confluence of the Missouri and Yellowstone Rivers (Pat Braaten, Upper Basin Workgroup, personal communication). Program Specialists with the U.S. Fish and Wildlife Service consider the pallid sturgeon to be on the brink of extinction with efforts that will be made during the next five years as crucial to preventing extinction (Balis-Larsen and Motivans 2003). According to Ken McDonald, leader of the Upper Basin Workgroup, remaining adults are likely to die off by 2016.

To counter the looming extinction of pallid sturgeon, the Upper Basin Workgroup has embarked on an artificial propagation and reintroduction program as a stop-gap measure to save the species from extinction pending restoration of habitat and resumption of natural reproduction. Iridovirus has plagued hatchery stocks and hampered reintroduction efforts as many year classes found to be infected with iridovirus have been destroyed (Wilson 2002). The Upper Basin Workgroup is actively working on protocols to guide culture, disease prevention, and restocking efforts.

In August 2003, the Upper Basin Workgroup requested that the Western Division of the American Fisheries Society (WDAFS) review the existing pallid sturgeon recovery effort in the upper basin and make recommendations for its improvement. The WDAFS assembled a Pallid Sturgeon Recovery Review Committee in October 2003 to assist the Upper Basin Workgroup in functioning more efficiently and effectively. The purpose of this report is to provide the findings

and recommendations of the WDAFS committee. Our intent is to improve on the substantial efforts of the Upper Basin Workgroup by providing recommendations in the following four areas:

- ◆ workgroup composition and functions,
- ◆ propagation and genetics,
- ◆ habitat and population ecology, and
- ◆ fish health.

Providing for survival and recovery of pallid sturgeon in the upper Missouri River Basin is one of the most difficult but important conservation challenges facing resource managers in the West. We hope this report will assist the Upper Basin Workgroup in this valuable effort.

## **METHODOLOGY**

To assist the Upper Basin Workgroup, the WDAFS organized a review committee and developed a workplan and project budget to guide the review effort over a ten-month period. Three committee co-leaders were chosen for their interest and background in sturgeon research and management and in endangered species recovery. The intent of the WDAFS effort was to provide an independent peer-review of the Upper Basin Pallid Sturgeon Recovery Program by reviewing published and unpublished information on the pallid sturgeon and interviewing key personnel involved in the recovery effort. This report has been reviewed by the WDAFS Resource Policy Committee, Environmental Concerns Committee and the Executive Committee. Following WDAFS review, the report was redrafted and provided to the Upper Basin Workgroup for review prior to finalization.

Additional committee members were recruited from the ranks of the WDAFS to provide support in three subcommittee areas: fish health, propagation and genetics, and habitat and population ecology. Committee members and their affiliations are listed in Table 1.

Committee members developed a questionnaire on upper basin recovery that was distributed to all 59 members of the Upper Basin Workgroup. The questionnaire consisted of 12 questions requesting essay-type answers on topics that included workgroup priorities, workgroup function, relationships between the recovery team and workgroup, recovery priorities, and impediments to recovery. Twenty-two completed questionnaires were received and results are summarized in Appendix A. Many replies contained lengthy discussions that are not included in the summary but nonetheless provided important insights.

The three WDAFS committee co-leaders attended the annual meeting of the Upper Basin Workgroup in Miles City, Montana, during December 2003, which provided opportunities to answer questions about the WDAFS review effort, hear the latest findings and concerns about pallid sturgeon recovery, talk individually to concerned workgroup members, and observe operations of the workgroup and relationships between members. Members of the WDAFS Pallid Sturgeon Recovery Review Committee also provided a Handling Protocol for Adult Pallid

Sturgeon Mortalities (Appendix B) and a Parasitological Examination protocol (Appendix C). In addition, the members of the propagation and genetics subcommittee also provided a review of the recently issued (January 2004) draft Pallid Sturgeon Propagation Plan. Most of the recommendations provided in the Propagation and Genetics Recommendations section arise from the review of the draft plan.

Table 1. Subcommittees and Western Division American Fisheries Society participants involved in the review effort of the upper basin pallid sturgeon recovery efforts.

<u>Fish Health</u>
Molly Webb, Subcommittee Chair, Oregon State University
Richard Arthur, Professional Consultant
Richard Heckmann, Brigham Young University
Stephen Raverty, British Columbia Ministry of Agriculture and Food
Charlie Smith, Professional Consultant
<u>Propagation and Genetics</u>
Larry Hildebrand, Subcommittee Chair, Golder Associates Ltd.
Paul Anders, S.P. Cramer and Associates
Ron Josephson, Alaska Department of Fish and Game
Joseph Kozfkay, Idaho Department of Fish and Game
Paul Olin, Interim Director, University of California Sea Grant Extension
Paul Wagner, KWA Ecological Sciences
Gregg Tranah, Harvard School of Public Health
<u>Habitat and Population Ecology</u>
Jack Williams, Subcommittee Chair, Southern Oregon University
Stephen Ahern, Professional Consultant
Chuck Berry, South Dakota State University
Bob Bramblett, Montana State University
Daniel Bouillon, Alcan, Inc.
Lou Carufel, Professional Consultant
Matthew Dare, Boise State University
Carl Schilt, BAE Systems
Webb Van Winkle, Professional Consultant

## RECOMMENDATIONS

We provide the following 52 recommendations to the Upper Basin Workgroup for their consideration and action. For each recommendation, a brief statement is provided of the concern or opportunity that prompted the recommendation, then the recommendation itself, followed by a rationale statement. Recommendations are divided into the following four subject areas and without priority order: workgroup composition and function, propagation and genetics, habitat and population ecology, and fish health.

## ***Workgroup Composition and Function Recommendations***

1. Develop mission statement for Workgroup.

**Concern/Opportunity:** The mission of the Workgroup seems unclear to some members and there is some confusion on the needed course of action.

**Recommendation:** The Workgroup should develop a mission statement that all members can strongly support. This mission statement should be printed and posted prominently at all Workgroup meetings.

**Reason:** Many Workgroup members responded in our questionnaire that the primary purpose of the Workgroup was to recover the pallid sturgeon in the upper basin. This was stated in different ways and some members provided divergent perspectives or more detailed descriptions of recovery goals that were important to them. Although a rough consensus on the Workgroup mission may exist in the minds of many members, it is important for the Workgroup, in a common effort, to develop a mission statement that all members agree on.

2. Develop a more effective decision making process for Workgroup.

**Concern/Opportunity:** Many Workgroup members appear frustrated by the group's decision-making process, which can appear long, drawn-out, and cumbersome.

**Recommendation:** Develop a more effective decision making process for Workgroup that is understood and agreed to by members.

**Reason:** Many Workgroup members expressed the concern that the large size of the Workgroup impeded effective decision-making. Although it is important to involve the entire Workgroup membership in the exchange of information related to latest monitoring and research programs, strategies for funding, and future research and recovery needs/actions, there are other decisions best made by a smaller core-voting group or executive committee. We found the discussion of this topic that occurred in the December 2003 Miles City meeting to be very productive. We strongly supported the decision to develop the smaller core-voting group. At the same time, we appreciated the discussions of the entire workgroup surrounding WAPA funding. There was a supportive atmosphere among the entire membership that assisted in finding innovative ways to fund needed recovery actions that might have been lost had these decisions been made by a smaller core group. Nonetheless, it would be counterproductive for the entire workgroup to review draft documents for the Workgroup leader's signature or to be involved in time-sensitive decisions that are required between meetings of the entire Workgroup. We urge caution and adaptive management as the core-voting group moves forward. It is important to communicate decisions made by the core-voting group to the larger Workgroup in a timely and effective manner.

3. Develop an Advisory Group/Subcommittee structure to improve efficiency.

**Concern/Opportunity:** Due to the complexity of the pallid sturgeon recovery effort and the size of the Workgroup membership, the Workgroup has recognized the need to form Advisory Groups/Subcommittees that are tasked with specific subsets of the recovery effort.

Advisory Groups/Subcommittees are an essential component of the Recovery process but at present, their existence, roles and responsibilities have not been formalized within the existing structure of the Upper Basin Workgroup.

**Recommendation:** Within the Workgroup organizational structure, the following Advisory Groups/Subcommittees should be identified as recognized bodies that report directly to the Workgroup. These Advisory Groups/Subcommittees include Management/Stocking, Propagation, Habitat, Health, and Research. The process for selection of members and the roles and responsibilities of the committee should be clearly defined.

**Reason:** The official recognition of the Advisory Groups/Subcommittees in the Workgroup structure will emphasize the importance of these groups to the recovery program. Clear definition of roles and responsibilities should help in the decision making process in that recommendations of the Advisory Groups/Subcommittees to the Workgroup and the Recovery Team would carry more weight than would individual recommendations.

4. Examine methods to provide increased and consistent funding for upper basin recovery efforts.

**Concern/Opportunity:** Funding for upper basin pallid sturgeon recovery appears to be woefully inadequate for the task at hand. Consistent funding for recovery in the upper basin comes primarily from the Western Area Power Administration. Other agencies should increase their contributions. Increased and consistent funding are necessary for effective recovery.

**Recommendation:** Responsible federal agencies, specifically the Western Area Power Administration, Bureau of Reclamation, U.S. Fish and Wildlife Service, and Corps of Engineers, should increase funding and research support for upper basin recovery efforts. The Workgroup should consider forming an additional Advisory Group/Subcommittee whose main responsibility is to identify and solicit funding for the recovery and management actions. Potential members of this entity could include the Advisory Group/Subcommittee chairs, a representative of Western Area Power Administration, Bureau of Reclamation, U.S. Fish and Wildlife Service, and the Corps of Engineers.

**Reason:** The continuous identification of new funding sources is essential for the success of long-term recovery programs. Even for programs that are assured short or medium funding from government or corporate entities, the ability to identify and obtain additional funding sources can help accelerate recovery timelines. An Advisory Group/Subcommittee tasked solely with exploring potential funding sources or developing creative methods to raise funds would provide a substantial benefit to the Workgroup.

5. Fill critical skill gaps in the Workgroup.

**Concern/Opportunity:** Small pallid sturgeon population sizes and the species relatively poorly-known life history necessitate development of a variety of specialized knowledge sets within the Workgroup to affect recovery. Some needed skills appear lacking among the current group membership.

**Recommendation:** Fill critical skill gaps in the Workgroup, including conservation genetics, reproductive physiology, population statistics and modeling, and environmental education.

**Reason:** Recovery of the pallid sturgeon in the Upper Basin requires a variety of skills and expertise. Although the large and diverse membership of the Working Group has assisted in completing many necessary tasks in the Upper Basin, some skill types that would facilitate implementation of additional tasks are lacking. In particular, we recommend that the following skills be added to the Work Group membership: reproductive physiology, conservation genetics, population statistics, and environmental education. Expertise in reproductive physiology is essential to overcoming limiting factors associated with management of wild adults and their successful reproduction in hatcheries. Sturgeon physiology differs from that of many other hatchery-reared species because of their greater longevity and unusual life history strategies. Similarly, the limited number of wild fish and small effective population size from hatchery-based rearing suggests that skills in conservation genetics are needed. For example, it is critical to be able to weigh the short-term risk of extinction from low population size against longer-term problems of disease. Improved modeling and statistical skills would assist with data analysis and interpretation. Environmental education and communication are critical skills that are addressed below.

6. Develop a stronger environmental education and outreach function.

**Concern/Opportunity:** Public and political support for sturgeon recovery should be enhanced.

**Recommendation:** Develop a public communication and environmental education component within the Upper Basin Workgroup.

**Reason:** In the long run, restoring pallid sturgeon and improving management of the upper Missouri River Basin will require an informed and supportive public. Water management in the Missouri Basin is a heated and widely debated topic. The more the public understands the dire situation of the pallid sturgeon and the needs of native fishes and natural communities of the Upper Basin, the more support the Workgroup is likely to receive from the public and politicians. Of course, most actions of the Workgroup are not controversial but even routine activities such as population counts and tracking of adults and hatchery-produced juveniles are important to report to the public on a regular basis. To facilitate improved communication with the public, we recommend that an environmental education specialist be added to the Workgroup. A strategy is needed for communicating the needs of the pallid sturgeon, monitoring results, and actions of the Workgroup to the public.

7. Consider hiring an administrative assistant for Workgroup.

**Concern/Opportunity:** The organization and logistical considerations required to set-up and conduct meetings, take and distribute meeting notes, and facilitate distribution of information between the Workgroup and the Recovery Team requires a considerable amount of time.

**Recommendation:** Consider allocating a portion of the annual recovery budget to hire a part-time administrative assistant.

**Reason:** In some recovery programs, the activities described above are often handled directly by Workgroup or Recovery Team leaders, individuals that are already very busy. As a result, communication often suffers, and key people become overworked and less productive. Funding of a part-time administrative assistant could provide a substantial benefit to a large organization like the Upper Basin Workgroup.

8. Develop a prioritized list of recovery actions for funding.

**Concern/Opportunity:** Recovery of a species like pallid sturgeon is a process that may take several decades before the results of the recovery plan can be assessed. Due to the long-term nature of the recovery program, the security of adequate funding is generally not guaranteed beyond two to three years at most.

**Recommendation:** To ensure essential short-term recovery objectives receive adequate funding, the Workgroup should consider developing a prioritized list of recovery actions. Recovery actions should be categorized into short-term (e.g., <5 year horizons), medium (5-15 years) or long-term (>15 years). The use of these time categories allows better prioritization of recovery actions and also allows for more effective allocation of funds available at a given point in time. Such categorization has proven to be an effective tool and has been used by the Upper Columbia White Sturgeon Recovery Initiative to identify project priorities and allocate available funding.

**Reason:** To ensure that present and future needs of the recovery program are identified and adequately funded, a matrix should be developed that lists all known or anticipated recovery components including research needs to address data gaps. These components should be initially rated as to whether they are short, medium, or long-term recovery objectives. For example, short-term recovery actions could be those that focus on programs needed to maintain necessary ongoing programs related to supplementation or immediate research needs (e.g., broodstock collection, culture issues, propagation and stocking, fish health issues, etc.). Medium-term goals would involve research needs such as better definition of actual survival rates, preliminary flow manipulation experiments, etc., with long-term goals encompassing habitat restoration issues leading to natural recruitment and additional research that may fall into the “important but not immediately essential” category. Short and medium term programs should be prioritized and anticipated annual costs, funding sources, and delivery agencies should be identified. For ease of review and distribution, this can be done in spreadsheet format.

9. Reconsider need for new range-wide recovery plan pending progress on upper basin efforts.

**Concern/Opportunity:** The present version of the Pallid Sturgeon Recovery Plan may not provide sufficient guidance for recovery of the pallid sturgeon in the upper basin, may be out of date, or may be otherwise inconsistent with necessary work in the upper basin.

**Recommendation:** In our opinion, the Workgroup has considerable latitude to direct recovery actions for pallid sturgeon in the upper basin as long as actions are consistent with the broad strategies described in the existing Pallid Sturgeon Recovery Plan. It may be prudent and effective for recovery, therefore, to focus efforts on completing Workgroup strategies and reports for the upper basin rather than expending efforts to rewrite and update

the range-wide recovery plan. Also, the critical status of this species requires a focus on immediate recovery actions rather than on long-term planning. The U.S. Fish and Wildlife Service should make available to the Workgroup reviews of the Pallid Sturgeon Recovery Plan that were conducted by their personnel during 2000. A more comprehensive revision of the range-wide recovery plan would be appropriate once strategies have been developed by the three sub-basin workgroups.

**Reason:** The primary problem for the Workgroup appears to be the uncertain relationship between tasks that the Workgroup believes are necessary in the upper basin and recovery implementation tasks described in the Recovery Plan. Recovery plans are guidance documents and as such, are meant to channel recovery in the needed direction, but may or may not be specific enough to direct individual recovery actions. Because pallid sturgeon are a wide-ranging species and because so much information on life history and habitat requirements is uncertain, it may be an unrealistic expectation for the Pallid Sturgeon Recovery Plan to contain sufficient detail to *describe* specific recovery efforts necessary in the upper basin. Rather, the Pallid Sturgeon Recovery Plan should *guide* those efforts by providing general direction. Also, the process of rewriting the Pallid Sturgeon Recovery Plan and having it approved would consume considerable staff energy and time while providing uncertain final results. For a species, such as the pallid sturgeon, where major advances in our knowledge of the species are gained each year, it would seem more appropriate to describe needed recovery actions in the form of reports or other documents produced at the sub-basin scale. We suggest sub-basin-specific strategies or a series of workgroup reports that are derived from the goals and objectives of the Pallid Sturgeon Recovery Plan and provide a template for recovery in the upper basin. Such strategies can be updated more efficiently at the sub-basin scale rather than range-wide scale. If the Pallid Sturgeon Recovery Plan is found to be inconsistent with what is necessary to recover the pallid sturgeon in the upper basin, a revision of the plan should be undertaken. In our opinion, revision of the Recovery Plan is not necessary simply because status and life history information in introductory sections (i.e., Part I) of the plan are outdated.

10. Improve relationship between Workgroup and Recovery Team.

**Concern/Opportunity:** At times, the relationship between the Workgroup and the Recovery Team (and Recovery Team Leader) has been divisive, causing unnecessary disagreement and dissension among the group. There also is confusion as to how actions of the Workgroup relate to fulfilling the objectives of the Recovery Plan.

**Recommendation:** The relationship between the Workgroup and the Recovery Team needs to be clearly defined, perhaps through a Memorandum of Understanding (MOU). The relationship between tasks and plans of the Workgroup and the range-wide recovery plan for the species should be clarified. Also, we encourage regular cross-communication between the Workgroup and Recovery Team through joint meetings and other forms of communication.

**Reason:** For successful recovery of the pallid sturgeon in the Upper Basin, it is essential to develop a strong working relationship between the Workgroup and Recovery Team, especially between leaders of these two groups. Based on our questionnaire and personal communications with Workgroup members, there is considerable distrust between the two

factions. This distrust appears to be caused by three factors: 1) the uncertainty of how restoration actions in the upper basin relate to the existing Pallid Sturgeon Recovery Plan, 2) the uncertain relationship between the Workgroup and Recovery Team/U.S. Fish and Wildlife Service, and 3) personality differences between leadership of the Workgroup and Recovery Team. Collaborative development of an MOU between the Workgroup and U.S. Fish and Wildlife Service would assist in defining, and we hope, improving these relationships. More frequent communication between the parties and an understanding of how actions in the upper basin fit into the broader recovery plan should provide a basis to improve relationships.

11. Encourage strong leadership and proactive support of recovery efforts from the U.S. Fish and Wildlife Service and Recovery Team.

**Concern/Opportunity:** Many Workgroup members expressed concern about the inactivity and lack of leadership from the range-wide Pallid Sturgeon Recovery Team. These concerns included a lack of leadership from the Team and Team Leader, a lack of coordination among the Recovery Team and the three Workgroups, and general inactivity by the Recovery Team.

**Recommendation:** The range-wide Pallid Sturgeon Recovery Team must become a stronger advocate for restoration of habitat and recovery of the species. The U.S. Fish and Wildlife Service must provide strong leadership and support for the Recovery Team in this effort. We further recommend that the new Team Leader meet with the Upper Basin Workgroup to discuss and address outstanding concerns.

**Reason:** Strong leadership from the Recovery Team and U.S. Fish and Wildlife Service are essential for recovery of the pallid sturgeon. To date, actions by the Recovery Team have been insufficient to meet this challenge.

12. Network with other sturgeon recovery efforts.

**Concern/Opportunity:** A vast amount of knowledge has been acquired by other sturgeon Recovery Teams (for example, the Kootenai River White Sturgeon Recovery Team, Upper Columbia River White Sturgeon Recovery Team, Gulf Sturgeon Recovery Team, and Shortnose Sturgeon Recovery Team).

**Recommendation:** Develop an information network with other sturgeon recovery teams throughout the United States and Canada.

**Reason:** The Upper Basin Pallid Sturgeon Recovery Program does not appear to be using the knowledge gained by other sturgeon Recovery Teams as effectively as needed. This information could be extremely useful for the recovery efforts of the pallid sturgeon throughout its range. Although the set of limiting factors, as well as some physiological responses, may differ among the threatened or endangered sturgeon species in North America, a substantial body of knowledge is available that may be directly applicable to the recovery efforts of pallid sturgeon.

13. Formalize data collection, storage and retrieval.

**Concern/Opportunity:** The long-term nature of the recovery program will result in the collection of large amounts of data from a wide variety of sources.

**Recommendation:** Three recommendations were developed to address this concern. 1) Develop standardized data collection protocols that will be used to build a master database for the entire upper basin recovery area. 2) Consider building a database that will allow inclusion of data from the middle and lower recovery areas. 3) Create a central repository for data and literature.

**Reason:** The data collected over the life of the recovery plan will be essential to demonstrate the effectiveness of the recovery programs, to identify problems or weaknesses of various recovery actions quickly, and provide a scientific basis on which to guide the recovery process. Having this information in a central repository will expedite the use, analysis, and decision making involved in the complex task of recovery of the pallid sturgeon. It is therefore imperative that the data be collected and maintained in the best possible manner. If not already developed, the data collection and recording protocols and the master database format should be designed by someone with expertise in large database design and management. The master database should be the responsibility of one individual that has the experience to conduct the required QA/QC to ensure the accuracy of the data and the skills to manipulate and query the database in response to requests from Workgroup members or researchers approved by the Workgroup.

14. Standardize review and cover of pallid sturgeon reports in upper basin.

**Concern/Opportunity:** Over the course of the recovery program, numerous publications (both primary and gray literature) will be produced.

**Recommendation:** Consider requiring that for all research funded by or conducted under the auspices of the Recovery Plan, that the resultant reports be submitted for peer review prior to finalization; depending on the type and importance of the document, the review could be conducted by the Workgroup, a subgroup thereof, or external experts,. To provide consistency in the identification of research produced by the Recovery Plan, consideration should be given to producing a standard cover plate for all reports.

**Reason:** The peer review of research elevates the standard of the report produced and helps ensure that any decisions that derive from the information are based on the best available science.

### ***Propagation and Genetics Recommendations***

15. Develop and implement new broodstock mating protocols.

**Concern/Opportunity:** Broodstock protocols should mimic natural sturgeon mating systems.

**Recommendation:** Develop and implement breeding protocols that maximize demographic and genetic benefits and minimize genetic risks. See the three potential scenarios below. Also, see Recommendation 22 as microsatellite analysis and identification of resulting alleles/allele frequencies should be used instead of simple randomization of matings.

**Reason :** Different levels of empirical data result in a different set of hatchery protocols. However, all recommendations for particular hatchery practices are aimed at minimizing inbreeding probabilities, and maximizing demographic enhancement and genetic variability and diversity. These recommendations are designed to mimic natural sturgeon mating systems, in healthy (and sufficiently large) populations, in which individuals from many cohorts, families, and generations interbreed within and across years.

Situation 1: Empirical demographic and genetic data are not available - Recommendations for breeding pallid sturgeon in captivity might include spawning matrices where every male and female is used; each female's eggs would be split into separate groups before being fertilized by every available male. The extent to which this could be accomplished would be dependent upon space constraints at production facilities (tank number and size).

Situation 2: Demographic data exist, but genetic data are not available - Recommended hatchery practices might include:

- ◆ Cross individuals collected during different years (useful with cryopreservation)
- ◆ Within years, cross individuals from different subpopulations or breeding areas (fish and wildlife management opinions differ considerably when it comes to these issues)
- ◆ Cross individuals from different reproductive areas in different years.

Situation 3: Empirical demographic and genetic data are available -

Hatchery recommendations include:

- ◆ Use of band-sharing comparisons to avoid breeding of closely related individuals (e.g. fish A shares 5 of 12 DNA bands (patterns) with fish B, and only 2 of 12 with fish C; all fish come from same spawning population. First pairing (A X C) would be preferred over A X B cross, which would result in higher inbreeding coefficient).
- ◆ Using microsatellite markers, you could perform parentage exclusion analysis to avoid sibling crosses (assuming enough variation still exists in remaining pallid sturgeon populations, and that markers provide enough resulting variability for such discrimination).
- ◆ Statistical or Bayesian approach to produce probability statements concern inbreeding levels among individual brood fish (matrix based on hierarchical genetic distance among individual brood stock).

16. Maximize each fish's genetic contribution to future generations.

**Concern/Opportunity:** Due to the acute demographic limitation facing pallid sturgeon, use all broodstock in order to maximize each fish's contribution to subsequent generations.

**Recommendation:** Collect and spawn as many fish as possible given the limitations of hatchery space, in a manner to create as many different crosses as possible.

**Reason:** Given the dire demographic condition of the pallid sturgeon populations, it appears impossible to spawn too many fish. The program must prioritize the capture and

spawning of as many fish as possible in as many combinations as possible. The demographic threat to survival may currently trump genetic threats to the species.

17. Determine most appropriate method for collection of gonadal tissue.

**Concern/Opportunity:** Assessing the impacts of gonadal biopsy through the abdominal wall versus catheterization through the urogenital pore is essential to the development of an optimal protocol for determination of sex and stage of maturity during broodstock collection and spawning readiness in broodstock. Other non-invasive or less-invasive methods to differentiate females and males and stages of maturity should be considered as well.

**Recommendation:** Determine whether gonadal biopsy or catheterization is the appropriate method for collection of gonadal tissue in 1) the field during broodstock collection to assess sex and maturity and 2) the hatchery to assess spawning readiness and the optimal time for spawning induction. Determine whether ultrasound may be a useful technique to determine sex and stage of maturity of pallid sturgeon during broodstock collection. Determine whether sex steroid concentrations in the plasma or urine may be used to discriminate between the sexes and stages of maturity of pallid sturgeon and assess egg quality. Maturing females in the captive broodstock at Gavins Point National Fish Hatchery should be utilized for assessment and comparison of the gonadal biopsy and catheterization procedures.

**Reason:** Assessment of the technique used for collection of gonadal tissue is essential to the long-term health, survival, and reproduction of the pallid sturgeon. Although catheterization is visibly less intrusive, the technique may result in long-term damage to the oviduct valve or Mullerian duct resulting in water or urine entering the body cavity or ovulated eggs not being able to exit the body cavity in future natural spawning events. Gonadal biopsies appear to be visibly more invasive though the healing process may be controlled through suturing of the incision thus reducing long-term damage. The use of ultrasound to determine sex and maturity in fish requires experience, however this is becoming a promising tool for sturgeon and should be assessed as a possible method for determining sex in pallid sturgeon. Ultrasound, however, will not currently replace the need to collect ovarian follicles to assess spawning readiness. Less-invasive techniques for determining sex and stage of maturity, such as the use of sex steroids in plasma and urine, are currently being used in white sturgeon, lake sturgeon, and Atlantic sturgeon populations. Plasma concentrations of sex steroids have also been found to decrease prior to visual signs of follicular atresia in white sturgeon. Hence, if females could be screened for early stages of follicular atresia through measurement of plasma steroids, hormonal induction of these females would not be necessary. Females undergoing ovarian regression may ovulate but produce poor quality eggs (early stages of follicular atresia) or may not be capable of ovulating at all (later stages of follicular atresia). This would reduce the stress females undergoing ovarian regression would experience in the hatchery as they may be released prior to hormonal induction of ovulation (for more information contact Dr. Molly Webb, Oregon State University, 541-737-2463, [Molly.Webb@oregonstate.edu](mailto:Molly.Webb@oregonstate.edu)). The comparison of gonadal biopsy and catheterization procedures will need to be conducted under the same hatchery conditions in several mature females (at least  $n = 4$  for each method, therefore a total of 8 females). This number is not available from the wild but is available in the captive broodstock held at Gavins Point National Fish Hatchery.

18. Cryopreserve excess sperm to maximize future options.

**Concern/Opportunity:** Due to the acute demographic situation of pallid sturgeon, use of cryopreserved sperm can maximize program productivity.

**Recommendation:** Motile sperm from all males should continue to be used for live-fertilization, and a suitable volume of collectable excess should be cryopreserved.

**Reason:** For individual pallid sturgeon, sufficient sperm volume (up to 450 ml per male) is often available from each fish, which is sufficient for both live-spawning and cryopreservation. Cryopreservation of excess milt is highly recommended in the interest of maximizing future genetic diversity and demographic vigor. All cryopreserved sperm samples do not have to be used/re-used in the future. However, if samples are not cryopreserved, they will never be available if subsequently needed.

19. Investigate methods to improve cryopreservation.

**Concern/Opportunity:** Collaboration with other scientists involved with cryopreserving sturgeon sperm may optimize cryopreservation techniques utilized in the pallid sturgeon propagation program.

**Recommendation:** Investigate methods to improve cryopreservation results through regular communication with other key researchers.

**Reason:** Although motility is a useful and valuable metric, fertility is the ultimate determinant of program success. Dr. Joe Cloud at the University of Idaho, Moscow, achieved near 50% fertility from thawed cryopreserved white sturgeon sperm with experimental trials at the Kootenai Hatchery. Nonetheless, fertility rates of this range could be used to pass important alleles and genetic material on to the next generation. Contacting these researchers could be beneficial: Dr. Joe Cloud, University of Idaho, (208)885-6388, jcloud@uidaho.edu; Sue Ireland, Kootenai Tribe of Idaho, (208)267-3620, Ireland@kootenai.org.

20. Do not jeopardize demographics by reducing released fish to lowest family production.

**Concern/Opportunity:** Recommendations in many fish breeding plans include releasing equal numbers of fish from each hatchery-produced family. However, this should not be done at the expense of demographic enhancement required to overcome or reduce probabilities of extinction risk. This is especially true if you believe or suspect that demographic risks currently trump genetic risks of future inbreeding.

**Recommendation:** Do not jeopardize demographic reconstruction by equalizing release groups (i.e., reducing the numbers released) to the lowest family production number.

**Reason:** While this recommendation may be more valid for semelparous salmon, it is not as applicable for communal spawning, iteroparous sturgeon. Equalization of individuals across family release groups at this point should not be done to the detriment of the population's need for demographic enhancement. However, equalized contribution across families is imperative when founding captive broodstock populations. These issues need to be developed in more detail in the plan to avoid any confusion during implementation. This

notion has recently been adopted into the Kootenai River White Sturgeon Hatchery Plan, which is now available, and could serve as an informative reference (contact Sue Ireland ([Ireland@kootenai.org](mailto:Ireland@kootenai.org)) for a copy). Dr. Paul Anders ([anders@spcramer.com](mailto:anders@spcramer.com)) is drafting a manuscript on this topic of equalization, and could provide additional arguments/discussions regarding its relevance to sturgeons.

21. Obtain information on adult fish movements through the use of internal transmitters, except for recently spawned individuals in hatcheries, which should not receive transmitters.

**Concern/Opportunity:** Lethal and sub-lethal effects of transmitter attachment or implantation should be reduced by using transmitter application techniques most suited for the species. Stress or injury related to external transmitter application procedures and application of internal transmitters in fish that have recently spawned in the hatchery have been determined to be a factor that significantly influences adult fitness or survival.

**Recommendation:** Fish that have just been spawned in the hatchery should not receive internal transmitters due to the need to avoid additional stress. External transmitters should not be used to monitor pallid sturgeon movements.

**Reason:** Although with external transmitter applications, invasive procedures are eliminated and transmitters can be attached with material designed to fall off after a predetermined time, there appears to be sufficient evidence to suggest external transmitters are not suited for use on pallid sturgeon. This assumes that potential problems related to internal transmitter attachment, such as infection of the incision and potential tag shed through ruptured sutures, are known and acceptable.

22. Develop genetic markers to reduce inbreeding.

**Concern/Opportunity:** Hyper-variable microsatellite DNA loci have been developed and tested for sturgeons ( McQuown et al. 2000; Rodzen and May 2002; Rodzen et al. 2003). Use of these genetic markers could be beneficial to the pallid sturgeon program. Mating strategies are currently using microsatellite analysis and have been since 2000.

**Recommendation:** Microsatellite analysis and identification of resulting alleles/allele frequencies should be used instead of simple randomization of matings. Matrices of genetic distance measures (degree of genetic similarity or difference) among all potential broodstock should be developed to reduce inbreeding (mating of closely related individuals).

**Reason:** Due to the small and decreasing population size, and the resulting family and Allee effects, chance alone will not necessarily prohibit or reduce inbreeding. Generally, the smaller the population gets, the greater the degree of relatedness at the population level - fewer families, less diversity, more closely related (fewer parents). Matings should be systematic when sufficient genetic distance among broodstock is met. Alternatively, matings should be avoided among broodstock with insufficient genetic distance. This distance threshold could be implemented on a sliding scale, based on perceived or calculated magnitudes of other risks. Nonetheless, these ideas should be unambiguously presented so hatchery managers have a clear, justifiable set of methods and decision points to follow.

23. Consider using DNA as a marker for released fish.  
**Concern/Opportunity:** Consider use of DNA markers (microsatellites, parental exclusion analysis) to prevent too few fish from being reared due to facility limitation (holding/rearing capacity of hatchery).  
**Recommendation:** The use of DNA analysis such as microsatellite analysis could be considered in cases where physical marking of juvenile/fry releases is not possible, and when hatchery space limits rearing to larger sizes suitable for alternative tagging methods.  
**Reason:** Since all parents used in the hatchery should be genotyped for mate selections, microsatellite analysis could be used to identify post-release progeny to family in the event unmarked fish were captured in the future.
24. Consider covering holding and rearing tanks for fry and juveniles.  
**Concern/Opportunity:** Experience with endangered white sturgeon culture suggests use of totally or partially covered holding and rearing tanks for fry and juveniles may be warranted.  
**Recommendation:** To reduce stress and simulate natural photoperiod, consideration should be given to evaluating effects of reducing light in fry rearing areas by covering fry and juvenile rearing tanks, painting tanks with dark colors, etc.  
**Reason:** In the Kootenai white sturgeon hatchery, fry tanks are completely covered and tanks for rearing juveniles are partially covered; this program has very high early life survival rates. Although this practice is already in place in some pallid sturgeon culture facilities (e.g., the Garrison National Fish Hatchery), the relationship between light intensity and fry and/or juvenile survival could be determined experimentally by comparisons with other facilities that use differing light regimes to quantitatively assess light intensity effects on stress reduction.
25. Consider using feed formulated specifically for sturgeon.  
**Concern/Opportunity:** If not done already, evaluate the possibility of using feed formulated specifically for sturgeons.  
**Recommendation:** Continue efforts to develop a specifically formulated sturgeon feed.  
**Reason:** Lower survival rates of juvenile and younger sturgeons reared in captivity may be associated with health/condition/immune system problems that could be improved if fish were reared on improved diets. Discussions with sturgeon nutritionists or hatchery managers more familiar with this issue are recommended.
26. Determine appropriate guidelines for anesthetization of pallid sturgeon.  
**Concern/Opportunity:** The Propagation Plan states "Further research of the use of anesthetics to reduce stress and injury during handling, spawning, shipping and tagging is needed."  
**Recommendation:** Additional research should include development of specific anesthetic guidelines including anesthetic concentrations and induction times for pallid sturgeon at various life stages and water temperatures.  
**Reason:** Anesthetization is a critical part of any fish handling program. Improper procedures can result in both direct and delayed mortality, which is of great concern when

handling listed species. Although use of anesthetic may often not be necessary when handling adult sturgeon, some form of anesthetization will likely be used when marking juveniles. In addition, use of a "pre-anesthetic" prior to handling has been demonstrated to reduce stress levels and possibly increase overall survival in Columbia Basin juvenile salmonids. Similar consideration should be given to anesthetic practices for pallid sturgeon.

27. Conduct studies to determine optimal size/age for release of juveniles.

**Concern/Opportunity:** The Propagation Plan provides details regarding the marking, holding, transportation, and stocking of juvenile pallid sturgeon, but lacks recommendations for optimal size/age at release. Presumably this is because such research specific to pallid sturgeon has not been conducted or is inconclusive at this time due to the low recapture rate of pallid sturgeon juveniles.

**Recommendation:** Survival studies to determine optimal size/age at release for juvenile pallid sturgeon should be conducted.

**Reason:** Currently, similar studies are being conducted with juvenile white sturgeon in the Columbia River. Determination of optimal release size/age for pallid sturgeon will help shape future hatchery practices and monitoring programs. As differences in optimal size may exist among RPMAs, these studies should be completed for each RPA.

28. Provide broodstock security through use of multiple facilities and safety systems.

**Concern/Opportunity:** Only one captive broodstock population exists despite the recommendation in the recovery program that three populations should be established. Additionally within the propagation plan, there is no mention of what safety checks, such as emergency generators, pumps, or alarm systems, are currently available to protect the captive broodstock at Gavins Point National Fish Hatchery.

**Recommendation:** Identify possible additional facilities other than Gavins Point National Fish Hatchery that could rear and hold a captive broodstock population. The Gavins Point National Fish Hatchery and any other facility that houses broodstock should be equipped with up-to-date alarm systems, backup pumps, and generators.

**Reason:** Often with captive broodstocks for other endangered fishes, a "spread the risk" policy is adopted to prevent catastrophic losses. Without these precautions, the one and only broodstock population could be susceptible to catastrophic loss from power failure, water quality problems, or disease outbreaks. Progeny from families of acceptable genetic distance should be used to develop at least one and preferably two additional broodstock populations at hatcheries. If no suitable facilities are available, identify and consider using non-hatchery broodstock repositories.

29. Manage upper basin pallid sturgeon as a single population.

**Concern/Opportunity:** Managing each RPA as a distinct functional population may not be beneficial to the recovery of the pallid sturgeon as it may result in the loss of genetic variability. The separation of sturgeon populations in RPMAs are artificial and do not represent the historical life cycle of the species.

**Recommendation:** Depending on the availability of broodstock, crosses should be made among individuals of all RPMA in the upper basin.

**Reason:** The genetics focus of the Pallid Sturgeon Propagation Plan is the maintenance of maximum genetic diversity. The current design calls for selecting parents for crosses that maintain the maximum genetic variability (number of microsatellite alleles). Our knowledge of the historic distribution and movement patterns of sturgeon suggests that populations should not be managed as functionally distinct units defined by artificial barriers.

### ***Habitat and Population Ecology Recommendations***

30. Develop a strategy and implementation plan for restoring upper basin habitats.

**Concern/Opportunity:** There has been little progress made on restoring suitable habitat conditions to support natural reproduction of pallid sturgeon in the upper basin.

**Recommendation:** The Workgroup should develop a strategy and implementation plan that describes necessary habitat restoration actions in the upper basin. The strategy should be consistent with the Recovery Plan and be based on the knowledge of Workgroup members as well as information and recommendations contained in the 2002 National Research Council report *The Missouri River Ecosystem: Exploring the Prospects for Recovery*. Although there are critical short-term needs of the species related to hatchery propagation and genetics, it is also vital that the Workgroup immediately increase efforts to describe and implement habitat restoration on medium and long-term time scales.

**Reason:** The present focus of pallid sturgeon recovery consists mainly of short-term tasks related to rearing healthy progeny and establishing these fish into recovery management areas, as well as longer-term tasks of restoring suitable habitat for adult spawning and juvenile recruitment into the population. The Pallid Sturgeon Recovery Plan (Dryer and Sandvol 1993) provides sufficient general guidance from which specific strategies can be developed for the upper basin. For example, Recovery Plan Task 1.1.3. calls for actions to “Restore the natural temperature regime of the Missouri River” and Task 1.1.5. calls for actions to “Restore the dynamic equilibrium of sediment transport within the Missouri River.” Such guidance allows for more development of more specific tasks as to how, where, and when these recovery tasks are achieved. The Workgroup needs to focus on habitat related concerns – flow regimes, turbidity, temperature – as well as channel, large woody debris and other necessary habitat features. Workgroup plans should reinforce, where possible, the National Research Council (2002) findings and strategies for upper basin recovery.

31. Immediately work towards releasing a high seasonal pulse of water from Fort Peck Dam to stimulate pallid sturgeon recruitment.

**Concern/Opportunity:** The critically low number and old age of remaining adults coupled with disease problems associated with hatchery production dictate the need for immediate restoration of habitat conditions (flows, temperature, turbidity) in order to stimulate natural pallid sturgeon recruitment. RPMA 2 below Fort Peck Dam is the most prudent site for

increased releases because of natural riverine channels and the occasional presence of sturgeon larvae in this reach.

**Recommendation:** As soon as water storage in Fort Peck Reservoir is above spillway levels, conduct a seasonal release from Fort Peck Dam that mimics naturally higher flows and higher water temperature as a way to stimulate successful spawning of adults in the wild. This flow should be of a magnitude of 25,000 to 35,000 cfs for 3 to 7 days during May or June and then decrease somewhat but continue spilling for another 30 to 45 days at a level sufficient to maintain higher water temperatures. This effort should be closely monitored to assist with longer-term management recommendations. Because water levels in Fort Peck Reservoir are currently below spillway levels, work should begin immediately to aggressively fill the reservoir. This is likely to require reduced and/or fluctuating flows from Fort Peck Dam during fall and winter when natural river inflows are lower. Also, it may be necessary to begin work as soon as possible on the spillway at Fort Peck Dam to insure the integrity of this structure once water is available.

**Reason:** The critical status of remaining adults and the very limited success of the juvenile supplementation program dictates the need for immediate action to restore habitat conditions and stimulate successful natural reproduction. This could be a one season operational change to Fort Peck Dam and reservoir management to benefit the endangered species. If successful, one new age class of young, wild pallid sturgeon would buy significant time in the overall recovery effort of the species for experiments, research and implementation of long-term habitat restoration.

32. Determine essential elements of natural riverine function.

**Concern/Opportunity:** The Workgroup needs to better understand which aspects of natural riverine conditions (e.g., minimum flows, spring high flows, temperature, turbidity, substrates, channel complexity) are most critical to pallid sturgeon recruitment.

**Recommendation:** Research and experimentation are needed to determine which characteristics or suite of characters of natural riverine function are required for successful reproduction and recruitment of wild pallid sturgeon. This is a longer-term component that compliments the near-term experimental flow modifications addressed in Recommendation #31.

**Reason:** Construction of mainstem dams, tributary dams, and reservoir operation have altered flow regimes, minimum flows, spring high flows, temperature, turbidity and other factors in the Missouri River, all to the detriment of pallid sturgeon. It may be that not all of these characteristics are critical to long-term survival of pallid sturgeon. Although restoration of natural riverine conditions, including the historical hydrograph and turbidity regimes, would appear to be the ideal means to implement recovery of the sturgeon, it is uncertain what parameters of river conditions are the most critical for this species. If, for example, turbidity proves to be more important for stimulating reproduction and recruitment than flows or water temperature, a different set of management actions may be warranted than if a certain condition of flow or temperature were needed.

33. Develop and implement a step-down recovery plan for RPMA 2.

**Concern/Opportunity:** The Yellowstone River has significant potential to provide critical refuge for pallid sturgeon. Although efforts are proceeding to improve conditions for pallid sturgeon in the Yellowstone, this effort should be part of a comprehensive strategy to restore habitat in RPMA 2.

**Recommendation:** The Upper Basin Workgroup should develop and implement a plan to restore habitat conditions in RPMA 2. Such a plan should tier to the existing range-wide Recovery Plan and address conditions in the Yellowstone River as well as the Missouri River and upstream portions of Lake Sakakawea. This could be integrated as part of the plan developed for the above recommendation.

**Reason:** As noted above, the existing Recovery Plan provides sufficient information to guide general restoration efforts but a more specific strategy is needed that all parties represented in the Workgroup can collaboratively develop and implement. The Bureau of Reclamation work to modify fish barriers at the Intake on the Yellowstone River should proceed as the more holistic strategy is developed.

34. Restore natural riverine conditions in RPMA 1.

**Concern/Opportunity:** The Missouri River upstream of Fort Peck Reservoir provides much of the remaining habitat in the Missouri River that functions in a manner similar to natural conditions. Habitat restoration, particularly the restoration of natural riverine conditions (i.e., flow regimes, temperature, turbidity) in RPMA 1 should be a priority.

**Recommendation:** The National Research Council (2002) provided relevant findings and strategies for restoration of this river reach. The Workgroup should develop a plan for restoration of natural riverine conditions in this reach. This plan should include examination of opportunities to change management of reservoirs in the upper Missouri and Marias rivers. Adaptive management should be employed for actions that would restore more natural flow regimes, temperature, and turbidity. It may be that restoration of only one or two habitat parameters are necessary to encourage successful reproduction and recruitment of pallid sturgeon in RPMA 1.

**Reason:** Although much of the pallid sturgeon recovery effort in the Upper Basin to date has rightfully focused on propagation and introduction of hatchery-reared sturgeon in the upper basin, there is a strong need to begin a more strategic medium and long-term approach to restoration of natural habitat in the region. Of the entire range of the pallid sturgeon, the areas upstream of Fort Peck Reservoir and upstream of Lake Sakakawea appear to provide the best likelihood for restoration of natural conditions that are conducive to natural recruitment of this species. The Workgroup should develop strategy plans for recovery of these reaches.

35. Restore natural riverine conditions in RPMA 2.

**Concern/Opportunity:** The Missouri and Yellowstone rivers in RPMA 2 also provides important habitat that should be restored as a priority action in recovery of the pallid sturgeon.

**Recommendation:** The National Research Council (2002) provided relevant findings and strategies for restoration of this river reach. The Workgroup should develop a plan for restoration of natural riverine conditions in this reach. This plan should include examination of opportunities to change management of Fort Peck Reservoir and dams on the Milk River. Adaptive management should be employed for actions that would restore more natural flow regimes, temperature, and turbidity. It may be that restoration of only one or two habitat parameters are necessary to encourage successful reproduction and recruitment of pallid sturgeon in RPMA 2.

**Reason:** As noted above, there is a strong need to begin a more strategic medium and long-term approach to restoration of natural habitat in the region. Of the entire range of the pallid sturgeon, the areas upstream of Fort Peck Reservoir and upstream of Lake Sakakawea appear to provide the best likelihood for restoration of natural conditions that are conducive to natural recruitment of this species. Restoration of natural conditions in the Milk River may have substantial benefits not only for the Milk itself, but also for the Missouri River immediately downstream of its inflow. The Workgroup should develop strategy plans for recovery of these reaches.

36. Develop a reservoir research and management plan for Lake Sakakawea.

**Concern/Opportunity:** Heavy silt deposits in the upper segments of Lake Sakakawea may have substantially degraded conditions for native fishes including pallid sturgeon.

**Recommendation:** A Lake Sakakawea reservoir management plan should be developed by the Upper Basin Workgroup. The plan should analyze the values of Lake Sakakawea for pallid sturgeon and address issues such as sedimentation and fish movement at various reservoir levels.

**Reason:** Although highly altered, Lake Sakakawea provides important fishery resources, particularly in its upper reaches. The Workgroup should develop a plan for managing this resource to the benefit of native fishes, including pallid sturgeon. The Workgroup should develop a research proposal to test the hypothesis that the upper portions of Lake Sakakawea are a bottleneck for drifting larval pallid sturgeon. Silt loads at the upper end of the reservoir must be evaluated and restoration measures developed. Management actions to alleviate these problems should be developed.

37. Determine the impact of introduced fishes on survival and recovery of pallid sturgeon.

**Concern/Opportunity:** Numerous non-native fishes have been introduced into historic habitat of the pallid sturgeon. These introduced species may impact pallid sturgeon at various life history stages, but the extent of impact is uncertain.

**Recommendation:** Studies should be conducted to determine impacts from predation and competition by introduced fishes on pallid sturgeon larvae, juveniles, and adults. Sites where larval sturgeon would occur due to stocking, presence of spawning areas, or drift from upstream should be identified. Those areas should be given high priority for recovery. Probability of larval fishes encountering predaceous fishes should be examined, and problem areas targeted for predator fish control as needed.

**Reason:** Introduced fishes are known to impact native fishes through predation and competition, as well as serving as a source of exotic parasites and diseases. Relevant reviews of this issue can be found in Minckley (1983), Taylor et al. (1984), and Moyle et al. (1986).

38. Develop a population dynamics model for pallid sturgeon in the upper basin.

**Concern/Opportunity:** Upper basin recovery efforts do not appear to be utilizing population dynamics models in recovery efforts.

**Recommendation:** The Workgroup should develop a population dynamics model to test different management strategies relating to the demographic consequences of propagation, habitat restoration, and fish health. Consideration should be given to the examination and possible refinement of existing modeling efforts (e.g., the PVA model developed by Yetta Jager for the Pallid sturgeon in the upper basin) to develop a model suitable for management applications.

**Reason:** Population dynamics models have proved helpful to recovery efforts of white sturgeon in the Columbia River Basin. Such a model could be of substantial benefit to pallid sturgeon recovery efforts by enabling the Workgroup to evaluate population trends over time and to test different management strategies.

39. Adopt and encourage adaptive management procedures.

**Concern/Opportunity:** The use of an adaptive management approach to resource management of the upper Missouri River would enhance our understanding of the ecosystem and encourage development of management alternatives that would benefit natural functions and native species. Adaptive management would stress evaluation of monitoring information and continuous use of new scientific data to achieve ecological and social objectives.

**Recommendation:** Agencies should implement the National Research Council's (2002) recommendations by adopting adaptive management policies as a way to benefit from the inherent variability and uncertainty of restoring and managing the Missouri River ecosystem. Adaptive management should be incorporated into recovery strategies developed by the Workgroup for the Upper Basin.

**Reason:** The National Research Council (2002) recommended that adaptive management be employed as a means to address the ecological and social uncertainty of Missouri River management. Agencies should take advantage of learning opportunities by working in a more adaptive management mode. The Council's report noted the following advantages of adaptive management when applied to restoration of this ecosystem:

- ◆ helps restore some degree of ecosystem resilience;
- ◆ explicitly recognizes and seeks to profit from uncertainty;
- ◆ promotes interdisciplinary collaboration and inquiry;
- ◆ uses models to support decisions and collaboration;
- ◆ seeks meaningful representation of a wide array of interest groups; and
- ◆ uses ecosystem monitoring to evaluate impacts of management actions.

Adaptive management requires that significant agency resources be allocated to long-term monitoring programs and that all parties share a commitment to 1) assist in gathering

monitoring data, 2) analyze monitoring results, and 3) implement improvements in management based on the analysis of monitoring data.

### ***Fish Health Recommendations***

40. Develop a reliable molecular test for pallid sturgeon iridovirus (PSIV).

**Concern/Opportunity:** Highest priority must be given to developing an accurate and reliable molecular test (polymerase chain reaction, PCR) for PSIV.

**Recommendation:** Find funding to support research for the development of an accurate and reliable molecular test for PSIV.

**Reason:** PSIV infections remain a constraint to hatchery production of pallid sturgeon and make stocking of juvenile pallid sturgeon problematic due to lack of knowledge of the fate of infected fish and concerns about increasing the prevalence of the disease and spreading it to areas where it may not occur. Answering a number of key questions regarding the impact of PSIV on stocked fish and in the wild may be essential to the success of the recovery program. A major limitation to finding answers to these questions is the lack of a rapid, reliable technique to detect infections, particularly those in carrier fish. Answers to the following questions are urgently needed:

- ◆ What is the route of infection of hatchery reared juveniles?
- ◆ Does vertical transmission occur?
- ◆ What is the natural host and geographical distributions of PSIV?
- ◆ Are adult sturgeon carriers of PSIV at levels that are presently undetectable using histopathology or do they eliminate the virus and become refractory to infection?
- ◆ Is the virus simply a hatchery problem? Or does it cause disease and mortality in wild fish, and if so, to what extent?

Resources should be devoted to developing an accurate and rapid molecular-based method of detection. This could involve increased contractual funding to university laboratories. However, as there appears to be a long-term need for this capability to deal with viral problems in pallid sturgeon and other fishes, strengthening the ability of the Bozeman Fish Health Center (BFHC) to better undertake this type of work should be considered.

41. Manage for elimination of PSIV from hatcheries and juveniles.

**Concern:** The Propagation Plan does not adequately address how the Workgroup intends to deal effectively with the virus problem.

**Recommendation:** Until more information is available on the effects of PSIV on released juveniles and wild stocks, a primary research and management focus should be on the elimination of the virus from the hatcheries and from juveniles (i.e., placing fish under more stringent "quarantine" conditions).

**Reason:** The Upper Basin Pallid Sturgeon Recovery Program intends to test fish prior to release for a maximum level of infection, and then release fish that are below this level. How and why the level was chosen and why they believe this will have any effect on improving survival of released fish is unclear. Until more information is available on the effects of PSIV on released juveniles and on wild stocks, a primary research and management focus

should be on the elimination of the virus from the hatcheries and from juveniles (i.e., placing fish under more stringent "quarantine" conditions).

42. Determine if mucus and sensory cells regenerate following a PSIV outbreak.

**Concern/Opportunity:** There is a need to determine if regeneration of mucus and/or sensory cells regenerate in pallid sturgeon following an iridovirus outbreak.

**Recommendation:** Determine if mucus and sensory cells in pallid sturgeon regenerate after surviving an iridovirus outbreak. A barbel clip should be collected from hatchery-released pallid sturgeon that are recaptured in the Missouri and Yellowstone Rivers to determine the number of mucus cells and sensory epithelia. Condition factor should be determined for all fish from which a barbel clip is collected.

**Reason:** Mucus cells and sensory cells are damaged by iridovirus, and short-term monitoring has revealed that these cells do not regenerate. Long-term monitoring of pallid sturgeon that have survived an iridovirus infection would allow researchers to determine if regeneration of the mucus and sensory cells occurs. Condition factor may be correlated to mucus and sensory cell scores as determined by BFHC. This may provide information regarding successful foraging, as measured by condition factor, and sensory cell health.

43. Determine differences in mucus and sensory cells between hatchery and wild fish.

**Concern/Opportunity:** A comparison of the BFHC's health assessment should be conducted with wild and hatchery-reared shovelnose sturgeon to identify differences in mucus and sensory cells in wild fish versus hatchery fish.

**Recommendation:** A barbel clip should be collected from a small sample size of wild and hatchery-reared shovelnose sturgeon of the same approximate age and/or size as the recaptured hatchery-released pallid sturgeon captured in the Missouri and Yellowstone rivers to determine the number of mucus cells and sensory epithelia. Condition factor should be determined on all fish from which a barbel clip is collected.

**Reason:** This analysis may be used as a comparison to determine how the BFHC's assessment evaluates wild versus hatchery fish.

44. Inventory pathogens and parasites of pallid sturgeon.

**Concern/Opportunity:** There is an almost complete absence of baseline data on the parasites and pathogens of pallid sturgeon.

**Recommendation:** Conduct a detailed inventory of pathogens and parasites of pallid sturgeon (see Appendix B).

**Reason:** Information regarding baseline data on the parasites and pathogens of pallid sturgeon is important from a biological perspective (for example, the extinction of the pallid sturgeon could entail the accompanying extinction of a number of species of parasites specific to this host). It also has importance in the identification of diseases and causes of mortality of adults and juveniles in both hatchery systems and in the wild, and in the prevention and treatment of diseases in cultured fish. The need for such information was recognized in the Pallid Sturgeon Recovery Plan (see Section 2.6.2); additionally, disease

problems associated with an unidentified gill amoebae and the presence of unidentified external parasites, of “*Costia*” (*Ichthyobodo*) and of fungi (*Saprolegnia*) and systemic external and internal bacterial infections (*Aeromonas*, *Pseudomonas*) in hatchery held fish have been recorded. No action has been taken to implement the recovery plan’s recommendation for more comprehensive examinations for pathogens and parasites. At present, full advantage is not being taken of the occasional mortalities of adult pallid sturgeon that occur during handling or under hatchery conditions to increase baseline knowledge of the diseases and parasites of this species.

45. Analyze fish die-offs and deformities for chemical contaminants.

**Concern/Opportunity:** There may be certain chemical ions in the water that are not conducive to the growth and development of pallid sturgeon. It is feasible to analyze suspect fish for these chemical elements using x-ray microprobes in conjunction with electron optics, a non-destructive method of analysis.

**Recommendation:** Suitable methods of chemical analysis, such as x-ray microanalysis, for suspect fish should be available whereby a conclusion can be made about the possible cause of a fish die-off.

**Reason:** The reasons for fish die-offs and deformities may include water quality and the uptake of harmful chemical ions. Tissue samples from the fish can be analyzed in many ways including x-ray microanalysis. The later technique is a non-destructive method for the sample and can be accomplished at a minimum cost with values in the part per million range. For more information, please contact Dr. Richard Heckmann, Brigham Young University, (801) 422-2495, [Richard\\_Heckmann@byu.edu](mailto:Richard_Heckmann@byu.edu).

46. Collect information on sturgeon parasites and diseases.

**Concern/Opportunity:** Little information has been published in this country concerning parasites and bacterial diseases of the pallid sturgeon or other sturgeon species.

**Recommendation:** Data and information from other countries pertaining to parasites and diseases should be collected and made available. Through email, literature searches, correspondence or direct contact, the published data and reports about diseases and parasites of sturgeon from other countries, especially species closely related to pallid sturgeon, should be obtained. There should be one central location for these articles (see Recommendation 12).

**Reason:** There may be valuable information published in other countries (Russia, Iran, Moldova, etc.) that would give insight into the biology of the pallid sturgeon and the diseases associated with sturgeon. This would be very helpful for recovery programs and eliminate some duplication of research projects.

47. Determine baseline blood chemistry of pallid sturgeon to aid in assessment of fish health and survival of broodstock.

**Concern/Opportunity:** Opportunity exists to determine normal blood chemistry values for pallid sturgeon. This information may be very useful in assessing the overall health of

juvenile and adult pallid sturgeon and in determining the cause(s) of decline/death of wild pallid sturgeon spawned in hatcheries.

**Recommendations:** Determine normal baseline blood chemistry values for comparison with those of diseased and stressed pallid sturgeon. Determine if a correlation exists with a specific parameter(s) and disseminated intravascular coagulation commonly seen in livers of juvenile fish showing severe fatty vacuolation. Determine cortisol, glucose, lactate, ions, and enzyme concentrations that may be used as indicators of stress in broodstock pallid sturgeon. Determine which factors, such as lectin and lysozymes, may be used to assess immunosuppression in pallid sturgeon.

**Reason:** Determining normal blood chemistry values of fish will establish normal baseline parameters that can be used to compare blood chemistry values between healthy and sick fish and/or non-stressed and stressed fish. Understanding normal blood chemistry values in broodstock is essential for evaluation of factors that may decrease egg quality and survival of fish while in the hatchery.

48. Develop non-toxic therapeutic approaches for treating fungal and/or bacterial infections in adult pallid sturgeon.

**Concern/Opportunity:** Several adult pallid sturgeon that have died after spawning in the hatchery have been found to have fungal and/or bacterial infections. It is important to distinguish between primary pathogens or opportunistic invaders in these cases. There is a need to develop an appropriate therapeutic protocol for treating infections.

**Recommendation:** Determine whether fungal or bacterial infections are primary pathogens or opportunistic invaders and develop appropriate protocols for treating infections.

**Reasons:** Formalin appears to be ineffective for treating fungus infections in adult pallid sturgeon. Less toxic therapeutic agents used for treating fungal and bacterial infections must be identified and their efficacy in pallid sturgeon established.

49. Involve fish health specialists in assessment of sick and dead adult pallid sturgeon.

**Concern/Opportunity:** Fish health specialists should be directly involved in the assessment of and collection of tissues from sick or dead adult pallid sturgeon.

**Recommendation:** A fish health specialist should always be called when an adult pallid sturgeon becomes sick or dies. Every possible effort should be made to prevent mortality. If an adult dies, the fish health specialist should be the one to examine the carcass, conduct the preliminary mortality screening, and assure that tissue samples and the carcass are handled and preserved properly for further examinations. Full necropsies should be undertaken on all mortalities of adult pallid sturgeon.

**Reason:** Depending on location of mortalities of adult sturgeon and of the examining laboratory, necropsies can be conducted on freshly dead sturgeon, on frozen carcasses, or on selected, preserved material. Prior contractual arrangements should be made with a laboratory having expertise in fish parasitology, bacteriology and disease diagnostics to provide specific protocols for handling, preservation and shipping of samples, to conduct necropsies, and to provide the necessary expertise to identify all parasites encountered to species level. An outline of how samples could be handled to obtain maximum information

during mortality screening can be found in Appendix C. Full methods for bacteriology and parasitology will need to be worked out in consultation with the examining laboratory. In the case where hatcheries are distant from a specialized fish health laboratory, designated staff should be trained in the proper methods to perform preliminary examinations, collect tissue samples, and prepare and ship carcasses to the examining laboratory(ies). Proper collection of tissue samples and assessment of health and/or cause of death is essential to understanding the factors that may lead to mortality of wild pallid sturgeon in the hatchery environment.

50. Involve fish health specialists in assessment of sick and dead juvenile pallid sturgeon.

**Concern/Opportunity:** Fish health specialists should be directly involved in the assessment of and collection of tissues from sick or dead juvenile pallid sturgeon.

**Recommendation:** For hatchery-reared juveniles that die or appear sick, full necropsies of moribund fish by a specialized laboratory are encouraged (live specimens can be shipped by overnight courier for examination). At minimum, samples of any tissues and organs showing gross pathology and a full complement of tissue samples for histopathological study should be collected and sent to the BFHC for disease diagnosis.

**Reason:** See Reason/Purpose 49.

51. Assess juvenile fish health and rearing conditions at each hatchery.

**Concern/Opportunity:** The Sturgeon Pre-Release Health Assessment as outlined in BFHC, Pallid Sturgeon Fish Health Summary is an important document for providing the Pallid Sturgeon Recovery Team and others working on the recovery of the pallid sturgeon with consistent fish health information from each hatchery raising pallid sturgeon.

**Recommendation:** Four recommendations were developed to address this concern. 1) Sturgeon Pre-Release Health Assessment as outlined in BFHC 2003 Pallid Sturgeon Fish Health Summary should be consistent among hatcheries raising pallid sturgeon. Protocols must be followed and information provided to the BFHC for inclusion in their Fish Health Summary. 2) Exact cause of mortality at all hatcheries should be identified whenever possible and reported to the BFHC for inclusion in the Pallid Sturgeon Fish Health Summary Report. 3) Provide hatchery rearing conditions, e.g. average water temperature, feeding rate (% body weight), diet fed, mortality and any treatment of fish, on a quarterly basis to be included in the BFHC Pallid Sturgeon Fish Health Summary Report. 4) In addition to length and weight measurements that are taken during the Fish Health Assessment, condition factor can easily be determined and should also be reported in the BFHC Pallid Sturgeon Fish Health Summary Report.

**Reason:** Information provided to the BFHC varies from hatchery to hatchery. For example, the hatchery rearing conditions 30 days prior to sample collection may or may not always be reported for each hatchery. Range is given for some hatchery parameters, but not others. Mean, range and standard deviation should be reported for all hatcheries. All hatcheries need to provide consistent information to the BFHC to enable them to produce a meaningful summary report. Consistent information should help fish health biologists identify the reason(s) for disease outbreaks. Specific diseases may be associated with rearing conditions, handling, season, water temperature, etc. It is valuable to be able to make correlations

between disease and rearing conditions. Since records are taken monthly or more frequently, it would be of value for the fish health biologist to know hatchery conditions throughout the rearing period, as well as 30 days prior to release of the fish. Condition factor is a general indicator of fish health. Reporting condition factor will allow a general comparison of condition, and therefore health, of fish among hatcheries and with wild fish.

52. Create central file to track pallid sturgeon health in each hatchery.

**Concern/Opportunity:** Information pertaining to outbreaks of disease (viral, bacterial, parasites) and treatment of hatchery-reared and -released pallid sturgeon does not appear to be readily available in one central file. This file may be used to relate the overall health of these fish upon recapture with their health history pre-release.

**Recommendation:** Create one central file or matrix that will document the disease, treatment, and survival of pallid sturgeon at each hatchery. This file can be updated with information regarding the health (condition factor, fin condition, barbel clip analysis, etc.) of fish following recapture.

**Reason:** It is essential to keep track of disease outbreaks and treatment at each hatchery for comparison of this information to the health of hatchery released pallid sturgeon upon recapture.

## SUMMARY

The Upper Basin Pallid Sturgeon Workgroup faces a most difficult challenge, that of recovering a critically endangered species and restoring a degraded and fragmented habitat system in the face of inadequate funding, scientific uncertainty, and limited political and public support. The first and most vital task of the Workgroup is to prevent extirpation of the pallid sturgeon in the Upper Basin and to ensure its survival. The WDAFS Pallid Sturgeon Recovery Review Committee believes that the following tasks are highest priority to prevent extinction of the pallid sturgeon in the Upper Missouri Basin:

- Encourage strong leadership and proactive support of recovery efforts from the U.S. Fish and Wildlife Service and Recovery Team (Recommendation #11);
- Develop and implement new broodstock mating protocols (Recommendation #15);
- Maximize each fish's contribution to future generations (Recommendation #16);
- Provide broodstock security through use of multiple facilities and safety systems (Recommendation #28);
- Immediately work towards releasing a high seasonal pulse of water from Fort Peck Dam to stimulate pallid sturgeon recruitment (Recommendation #31);
- Develop and implement a step-down recovery plan for RPMA 2 (Recommendation #33);
- Develop a reliable molecular test for pallid sturgeon iridovirus (PSIV) (Recommendation #40);
- Manage for elimination of PSIV from hatcheries and juveniles (Recommendation #41); and
- Determine baseline blood chemistry of pallid sturgeon to aid in assessment of fish health and survival of broodstock (Recommendation #47).

In addition, we provide numerous additional recommendations for further consideration. The complexity of recovering pallid sturgeon in the upper basin and the large number of Workgroup members have encouraged us to suggest several modifications to the Workgroup structure and function. Some of these changes were discussed at the December 2003 annual meeting of the Workgroup in Miles City, Montana. In general, we concur with the direction and progress that the Workgroup made during that meeting in terms of their restructuring, but offer some additional suggestions that we believe will increase their efficiency. In particular, we recommend changes in decision-making of the Workgroup, which according to the results of our questionnaire was troubling many members. Also, we recommend formalization of a number of subcommittees or advisory groups that will facilitate completion of the many and varied tasks. We further recommend the addition of several critical skills that appear to be lacking in Workgroup membership. Also included in this section are recommendations to improve the relationship between the Workgroup and the Pallid Sturgeon Recovery Team, including the Recovery Team Leader. A better relationship between the Recovery Team Leader and the Workgroup, and improved effectiveness of the Recovery Team are critical to the recovery process, and we urge all parties to work actively to enhance their joint activities through openness and more frequent communication. Provincialism can be minimized by remembering that all parties share the same primary goal of recovery of the pallid sturgeon and its natural habitat. Development of a clear Workgroup goal that all members have a stake in and adhere to may also minimize conflicts.

We offer a number of recommendations under the heading of Propagation and Genetics to assist the Workgroup in recovery of pallid sturgeon in the Upper Basin, including development of breeding protocols that maximize demographic and genetic benefits while minimizing risks. These recommendations address the use of broodstock, methods to minimize their stress, cryopreservation of excess sperm, and use of covered holding facilities for juveniles. We recommend development of feed specially formulated for sturgeon. Finally, we believe the need to maximize genetic diversity dictates the value of making crosses between individuals from RMPAs 1, 2 and 3. It is probable that prior to dam construction and fragmentation of habitats, pallid sturgeon moved throughout the available upper basin habitats. Managing RMPA areas as separate populations seems counterproductive and contrary to the natural behavior patterns of the species.

As the species survival is maintained through propagation efforts and management of genetic diversity, the work of restoring natural riverine function must occur. It is vital that the Workgroup increase efforts to plan and implement habitat restoration on medium and long-term time scales. In addition, a near-term restoration of natural flow conditions is urgently needed to create successful recruitment and buy time for further research and experiments in habitat restoration. Recommendations are provided that should assist the Workgroup in the restoration of natural riverine conditions, including minimum flows, spring peak flows, higher turbidity, and appropriate temperature regimes. We urge all agencies to expedite experiments and adaptive management programs aimed at modifying dam releases to restore more normative river conditions. Federal and state agencies should examine opportunities to modify operations of existing reservoirs on the Missouri River, as well as those on the Milk and Marias rivers that

may be valuable in restoring more natural conditions in the upper basin (National Research Council 2002).

To date, progress towards recovery has been hampered by fish health issues, especially iridovirus. There is a clear need for additional research into many fish health concerns, including work on parasites and pathogens, blood chemistry, as well as iridovirus. There is an immediate need to develop accurate tests for iridovirus and to manage hatcheries in such a way as to eliminate this disease from holding and propagation facilities. We also include recommendations for assessing and understanding factors that may contribute to mortality by involving fish health specialists, as well as development of a single repository for information and data related to pallid sturgeon health.

## **ACKNOWLEDGEMENTS**

We would like to thank Ken McDonald for his foresight to request an independent peer review of the upper basin pallid sturgeon recovery effort, our American Fisheries Society subcommittee members (Table 1) for their valuable assistance, the Western Division American Fisheries Society for their support of the review, and the Upper Basin Pallid Sturgeon Workgroup members for their hard work toward recovery of this living fossil and their candor in the review process. This report was improved by reviews from the WDAFS Executive and Environmental Concerns Committees, WDAFS subcommittee members, and Upper Basin Pallid Sturgeon Workgroup members. Funding for this review was provided Western Area Power Administration and the North Dakota Fish and Game Department. We hope the amazing pallid sturgeon will live long and prosper for another 200+ million years.

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## Appendix A

### Summary of Upper Basin Recovery Questionnaire Responses

Q2. In your opinion, what is the purpose of the Upper Basin Workgroup?

Recover pallid sturgeon	n=9
Coordinate recovery efforts and activities	n=8
Prioritize needs for pallid sturgeon	n=4
Facilitate information exchange for management and recovery decisions	n=4
Act as an implementation team	n=3
Act as a advocate	n=2
Identify and address limiting factors	n=2
Evaluate findings	n=1
Operate an effective hatchery program	n=1
Set guidelines for handling fish	n=1
Decide on stocking numbers and locations	n=1
Establish genetically fit populations	n=1
Prevent extinction	n=1

Q3. Do you feel the upper Basin Workgroup is functioning effectively: If not, why?

Very Effective	n=0
Somewhat Effective	n=9
Not Effective	n=11

Why?

Workgroup too large	n=8
Recovery Team leader overrides Workgroup decisions	n=5
Circular arguments without resolution	n=4
Leadership conflict between Feds and States	n=3
Issues have become personal not remained professional	n=3
Recovery plan not updated	n=2
Too much emphasis on fish health	n=2
Decisions made against majority opinion	n=1
Need neutral facilitator	n=1
Group dominated by Montana	n=1

Q4. What do you think are the top 5 priorities of the Upper Basin Workgroup?

Implement culture and stocking program	n=17
Share information about pallid sturgeon and recovery efforts	n=8
Restore habitat	n=7
Acquire and allocate funding	n=6
Prioritize habitat needs and restoration efforts	n=4

Retain genetic diversity/preserve wild genome	n=4
Develop and implement a Fish Health Plan	n=4
Establish natural hydrograph	n=4
Gather information about pallid sturgeon and recovery efforts	n=4
Recover pallid sturgeon	n=3
Set priorities for recovery	n=3
Identify and correct limiting factors	n=2
Develop goals, objectives, and strategies for pallid sturgeon recovery	n=2
Ensure viability of pallid sturgeon	n=1
Coordinate recovery activities	n=1
Monitor recovery activities	n=1
Reduce duplication effort in research and monitoring	n=1
Act as advocates for pallid sturgeon	n=1
Gather groups involved in recovery efforts	n=1
Improve data quality	n=1
Seek accountability for agencies involved in recovery and management	n=1
Investigate population dynamics, life history, and general biology	n=1
Prevent extinction	n=1
Develop outreach activities	n=1

Q5. What is your understanding of how Workgroup decisions are made?

Recovery Team leader overrides Workgroup decisions	n=12
Majority	n=9
Consensus	n=6
Debate	n=1
Recovery plan dictates Workgroup actions	n=1
WAPA and/or COE controls decisions making process	n=1
Decisions tabled if one group disagrees	n=1
Outside of the meetings, decisions are dictatorial	n=1

Q6. What is the relationship between the Upper Basin Workgroup and the Recovery Team:  
What recommendations do you have to improve the relationship?

Unknown/Relationship not defined	n=9
Poor relationship	n=6
Good relationship	n=1
Recovery team not active in Workgroup activities/decisions	n=1
Workgroup part of the Recovery Team	n=1
Workgroup acts as defacto Recovery Team	n=1

Recommendations:

Joint meeting between the Workgroup and the Recovery Team	n=8
Update the Recovery Plan	n=2
Direct communication between the Workgroup and the Recovery Team	n=2

Share more joint staff between the Workgroup and the Recovery Team	n=1
Range-wide symposium	n=1
Structure within the group (not just a chair)	n=1

Q7. What is the existing decision-making process for implementing the Recovery Plan: What recommendations do you have to improve the process?

Unknown	n=8
USFWS/Recovery Team leader makes decisions	n=5
Workgroup is responsible for implementing decisions	n=1
Recovery priorities ranked by the Workgroup	n=1
Decisions dictated by Recovery Plan	n=1

Recommendations:

Review and update Recovery Plan	n=6
Core/smaller voting body	n=3
Decisions should lie with the Workgroup	n=2
Workgroup should be implementation body	n=1
Workgroup should have decision-making process	n=1
Include a moderator at the meetings	n=1
Review Recovery Team membership	n=1
Better define the roles of the Workgroup and the Recovery Team	n=1
Use subcommittees	n=1
Need structure for general representation of the Workgroup	n=1
Recovery Team leader should not vote	n=1
Recovery Team leader should not have veto power	n=1
Recovery Team leader should be liaison between Upper Basin and other workgroups	n=1

Q8. Are recommendations of the workgroup being followed by the agencies that are tasked to implement them? If no, please give examples.

Generally yes	n=8
No	n=5
Yes	n=3
Don't know	n=1

Examples:

COE has not managed flows from Ft. Peck for sturgeon needs	n=3
Federal hatchery inventories exceed recommended densities	n=3
Fish health protocols are not followed	n=2
USFWS has not followed stocking recommendations	n=2
Recommendations contradict authority of agency	n=2
Funding not available	n=1
Approved research swayed by current decision making process	n=1

Fish transferred between federal hatcheries	n=1
USFWS takes actions not authorized/recommended by Workgroup	n=1
Delays in implementing heating system at Garrison Dam NFH	n=1
COE controls information release	n=1
Montana fish health policy has prevented stocking in Montana	n=1

Q9. How effective do you think the workgroup is toward recovering pallid sturgeon in the Upper Basin?

Effective	n=2
Somewhat Effective	n=12
Not Effective	n=7

Q10. Please identify any issues you feel that are keeping the Upper Basin Workgroup from functioning as effectively as they can or should.

No formal structure of Workgroup	n=6
Fish health issues	n=4
Size of the Workgroup	n=4
Recovery Team leader	n=4
Workgroup recommendations ignored or vetoed	n=4
Turf battles	n=3
Feds vs States	n=2
Lack of strong leadership	n=2
Need expertise in genetics and reproductive physiology	n=2
Workgroup vs Recovery Team leader	n=1
Inappropriate funding allocation	n=1
Limited funding	n=1
Decisions made without authority	n=1
Stocking numbers	n=1
Spawning protocols	n=1
Hatchery production goals	n=1
To tag or not to tag	n=1
Lack of communication with lower basin	n=1
Better understanding between biologists and hatchery personnel	n=1

Q11. What is (are) the major ecological, social, and political impediment(s) to recovery of the pallid sturgeon in the upper Missouri Basin?

Ecological:

Alterations in temperature, non-native species, flow, channelization	n=7
Loss of suitable habitat	n=7
Dams	n=2
Disease impacts unknown	n=2
Lack of population data	n=2

Fish health practices at Garrison NFH	n=1
Research limited to mainstem Missouri River	n=1
Large range and complexity of recovery program	n=1
River management	n=1
Lack of ecosystem restoration	n=1
Need better monitoring of stocked fish	n=1
Need larval drift studies	n=1
Small population size restricts research	n=1
Absence of knowledge regarding limiting factors	n=1
Hatchery operation problems	n=1

Social:

Lack of public support and knowledge	n=6
Public intolerance of necessary peak flows	n=1
Pallid sturgeon have no economic value	n=1
Landowner and tribal issues not addressed	n=1
Continues acceptance of by-catch	n=1

Political:

COE refuses to modify flow releases	n=7
Politics preclude good biological decisions	n=3
Turf battles between state and feds	n=3
USFWS coordination of recovery efforts	n=2
Water management policies of states and feds	n=2
Unresolved conflicts with barge industry and power generation	n=2
Lack of support from current administration	n=2
Lack of cooperation from BOR	n=1
Lack of adequate funds	n=1
Montana's strict fish health policy	n=1
Montana DNR controls water issues for state but doesn't attend meetings	n=1
Missouri River water management is political quagmire	n=1
Conflict with lower basin states that possess more electoral votes	n=1

Q12. What have been the key successes of the recovery program to date?

Propagation/stocking programs (despite fish health issues)	n=15
Information gained/shared to guide recovery	n=5
Public outreach	n=2
Establishment of captive broodstock	n=2
Formation of the Workgroup	n=2
Survival and growth of stocked progeny	n=2
Knowledge of how and where to capture broodstock from the wild	n=2
Documenting population size	n=1
Adult pallids still found in the wild	n=1
Identification of adult staging areas	n=1

BOR screening Yellowstone River diversion	n=1
Committed field staff in agencies	n=1
Working relationship between USGS-BRD and MTFWP	n=1
WAPA's continued support and funding	n=1
Planned spring pulse at Ft. Peck (pending drought)	n=1
Establishment of standardized sampling protocol	n=1
Realization that peer review was needed and proactively addressed	n=1

## **Appendix B**

### **Possible Handling Protocol for Adult Pallid Sturgeon Mortalities**

Immediately following mortality:

1. Initial examination of external surfaces for clinical signs of disease and parasites.
2. Collection of fin tissues for viral assessment.
3. Collection of coelomic fluid to determine if urine is present in body cavity.
4. Collection of material for bacterial culture (kidney, spleen, gill, etc. - aseptic technique required).
5. Collection of thin blood smears from heart (trypanosomes, etc.).
6. In females, check for damage to Mullerian and kidney ducts and oviduct valve due to method of ovarian follicle collection.
7. Collection of tissue for liver condition analysis.
8. Collection of tissue samples for histopathology, including gill, spleen, kidney, liver, gonad, intestine, brain/spinal cord, and samples of any external or internal tissues showing gross lesions.
9. Collection of blood sample for chemistry.

## Appendix C

### **Parasitological Examination**

Option 1 - fresh (preferred) – examination of fresh carcass (fish may be bagged and held in a refrigerator or on ice for up to 24 hrs and still prove useful for necropsy). Full parasitological examination for helminths and protozoans will require approximately 1 full day per adult fish.

Option 2 – frozen – fish should be frozen as quickly as possible. They can then be shipped frozen to the laboratory for examination. Note that freezing destroys most external protozoans (e.g., ciliates, flagellates, amoebae) and small monogeneans (eg., *Dactylogyrus*, *Gyrodactylus*); internal helminths may be damaged and/or distorted, making taxonomic determinations difficult or occasionally impossible.

Option 3 – preservation of selected tissues – allows good fixation and preservation of most parasites. Examples:

gills – remove gill basket and place in a jar in 1:4000 formalin for 20 min to relax parasites, then top up jar to 10% buffered formalin.

gall bladder, urinary bladder, samples of posterior kidney, brain/spinal cord, muscle, intestine, liver, spleen, gonad – place in 10% buffered formalin. Suitable for preparing smears for identification of myxozoa, coccidians, some other protozoans. (Note that these samples comprise a series separate from those collected for histopathology.)

digestive tract – several possibilities (e.g., inject with hot fixative (formalin or AFA) to relax and fix helminths, or flash freeze).