Intake Diversion Dam Modification, Lower Yellowstone Project

Science Review Report

Final

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Prepared for:
Bureau of Reclamation
316 North 26th Street
Billings, MT 59101

Compiled by:
PBS&J
1120 Cedar Street
Missoula, MT 59802

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Summary

At the request of the Bureau of Reclamation (Reclamation) a Science Review Panel (Panel) was convened to provide a critical evaluation of the science surrounding the Lower Yellowstone Diversion Dam Project. The objective of the project is to provide both fish passage and a fish screen at the Lower Yellowstone Diversion in the Yellowstone River near Intake, Montana.

This review specifically considered whether the information provided in the Draft Environmental Assessment (DEA), Biological Assessment (BA), and responses to Missouri River Restoration Implementation Committee (MRRIC) Questions use the best available science and support a conclusion that the Intake Project is a viable alternative with benefits for recovery of pallid sturgeon in the Great Plains Management Unit. Questions of whether the project is the best choice from the range of possible management actions within the Management Unit are outside the scope of the review.

The science review process was facilitated by scientists from PBS&J and conducted by a panel of five scientists with specific, in-depth knowledge of pallid sturgeon life history, Upper Missouri sturgeon issues, lower Missouri and Mississippi river sturgeon issues, and life history of other sturgeon species. The review was organized by pallid sturgeon life stages (egg/embryo, larvae, juvenile, and adult). Given the importance of achieving adequate larval drift distance to the success of this project, the Panel also conducted a quantitative analysis of the range of expected drift distances associated with historical discharge on the Yellowstone River.

It is the consensus view of the Panel that the best science available was used in the development of the DEA, BA, MRRIC Question and Answers, and supporting documentation. This review concluded that the information effectively supports hypotheses that:

1. The project will provide passage and enhance upstream migration for adult pallid sturgeon.
2. Suitable spawning habitat exists upstream of the project.
3. Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs.
4. There is sufficient downstream drift distance for larval development for at least a portion of the larvae in some years for some level of natural recruitment might occur.
5. Proposed fish screens will effectively decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon and other fish species.
6. Conditions in the Yellowstone and connected sections of the Missouri River are suitable conditions to support completion of the pallid sturgeon life cycle.

The panel concluded that additional analysis or research might marginally reduce uncertainties regarding the probability of success but is not likely to lead to fundamentally different conclusions. The true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response. This action clearly represents a reasonably realistic alternative for restoration of natural recruitment for this distinct and evolutionarily significant population of pallid sturgeon. The project will also be an essential step in identifying the need to consider additional actions throughout RPMA 2 that might be required.

Introduction

At the request of the Bureau of Reclamation (Reclamation) a Science Review Panel (Panel) has been convened. The task before the Panel was to provide a critical evaluation of the science surrounding the Lower Yellowstone Diversion Dam Project (hereinafter referred to as the Intake Project). This report presents the results of this evaluation. The review reflects input from all Panel members. In general, consensus was reached on all items.

The objectives of the Intake Project are to provide: 1) fish passage in the mainstem Yellowstone River , and 2) a fish screen to prevent entrainment into a currently unscreened irrigation diversion canal at the Lower Yellowstone Diversion in the Yellowstone River near Intake, Montana. The primary purpose of the project is to benefit pallid sturgeon a federally endangered species that historically reproduced in this area. Both the ability for adults to move upstream of the dam to spawn and the survival of drifting larvae and juveniles are believed to be hindered at Intake. Several alternatives for meeting the project objective have been evaluated and presented by Reclamation in its Draft Environmental Assessment (DEA).

Panel Description and Review Process

Panel Selection

In order to ensure that the selection of panelists for this effort was not biased in any way, Reclamation contracted with a third-party consultant, PBS&J. It was PBS&J's responsibility to manage the process in which panelists were screened and selected, to facilitate the panel deliberations, and to assist with the compilation of their conclusions into this report. Through internet searches, and word-of-mouth networking, PBS&J identified a pool of 22 potential panelists. Prior to commencing the screening process, PBS&J had no working relationship, nor direct knowledge of the panelists' expertise or professional alliances.

Attempts were made to contact 9 of the 22 potential candidates. The nine were chosen by PBS&J with the general goal to provide a balanced panel with a mix of areas of expertise. The goal was to have a well-rounded panel with specific, in-depth knowledge of the following:

- Pallid sturgeon life history
- Upper Missouri sturgeon issues
- Lower basin (Missouri and Mississippi) sturgeon issues
- Life history of sturgeon species other than pallid sturgeon

Two additional criteria that were essential for any panelist to meet were:

- Ability to meet the tight timeframe for this review process
- Ability to provide a review that would be widely regarded as both credible and independent.

The effort to reach out to nine of the candidates yielded the following results:

- One (Sue Ireland with Kootenai Tribe of Idaho) was on vacation at the time of initial contact and was dropped from further consideration because of time constraints

- Two (Ken Lepla with Idaho Power and Boyd Kynard with University of Massachusetts) were not able to meet the schedule for this review and were dropped from further consideration
- One (Dennis Scarnecchia with University of Idaho) was determined to have a conflict of interest and was dropped from further consideration
- Five (Anders, Beamesderfer, Garvey, Parham, and Peters) were selected to be on the Panel

Brief biographies for each of these individuals are as follows (full resumes have been provided previously to Reclamation and are included in Appendix 1):

- Dr. Paul Anders is a Fishery Scientist with Cramer Fish Sciences Inc., and serves as Affiliate Faculty in the Department of Fish and Wildlife Resources at the University of Idaho in Moscow. Paul has 23 years experience in the fisheries profession, with 20 years in the Columbia River Basin, U.S. and Canada. Pertinent to the issues surrounding the Lower Yellowstone Project, Dr. Anders brings expertise to this project from over two decades of experience involving altered large river ecology and effects on biology, ecology, management, and recovery of sturgeon populations.
- Ray Beamesderfer, M.S., is a Fishery Scientist with Cramer Fish Sciences Inc. and previously worked for the Oregon Department of Fish and Wildlife. He has over 20 years of experience with status and biological assessment, research, management, conservation, and recovery planning for sturgeon throughout the western U.S. and Canada, and has published extensively in this arena.
- Dr. Jim Garvey is an Associate Professor in the Department of Zoology and Director of the Fisheries and Illinois Aquaculture Center at Southern Illinois University. He conducts research on the population dynamics of shovelnose and pallid sturgeon in the Mississippi River and has published extensively in this arena.
- Dr. James Parham is the President of Parham & Associates Environmental Consulting LLC in Tennessee, and serves as a research hydrologist and aquatic biologist for Bishop Museum, Hawaii. He has worked on a range of sturgeon life history issues with a primary research focus on the seasonal movement and habitat use of pallid and shovelnose sturgeon with respect to hydrogeomorphic conditions.
- Dr. Edward Peters is Professor-Emeritus of Natural Resources at the University of Nebraska-Lincoln where he conducted research in natural resources and fisheries. For over 20 years his research emphasis focused on the development of habitat suitability models for Platte River fishes, which included pallid and shovelnose sturgeon.

The opinions presented in this report reflect those of the Panelists and not the views of their respective employers, affiliations, or organizations.

Review Process

PBS&J was provided the Notice to Proceed from Reclamation on this review process on September 30, 2009. At that time, project staff began assembling a pool of potential candidates. The final Panel was selected and notified on October 9, 2009. The Panel members then reviewed relevant documents and convened for an in-person meeting in Missoula, Montana on October 19 and 20, 2009.

At this meeting, the Panel was provided a revised set of responses (dated October 6, 2009) to Missouri River Restoration Implementation Committee's (MRRIC) questions (Appendix 2). This revised set of responses was utilized by the Panel in their review. A revised Draft Environmental Assessment (DEA) (dated October 1, 2009) was provided to PBS&J on October 15, 2009, however, PBS&J was informed by Reclamation that the earlier version of the DEA had not be substantially modified. Therefore, the earlier version (dated September 11, 2009) was utilized by the Panel in their review (Appendix 2).

During the Missoula meeting, each panelist took responsibility for specific sections of this report and provided a draft of their text to the other Panel members. PBS&J staff facilitated the meeting but provided no substantive technical input. By the completion of the meeting, an initial draft of all sections of the Draft Scientific Review Report had been reviewed by each Panel member. Following the meeting the panelists continued drafting and refining various sections. The separate elements were sent to PBS&J where they were assembled into a draft report that was posted for final review by each panelist.

This report was edited by PBS&J staff and distributed for review to Panel members on October 22, 2009. Comments and edits were accepted by PBS&J and a final report completed and submitted to Reclamation on October 30, 2009. Comments were returned to PBS&J by Reclamation on November 13. These were provided to the Panel and a conference call held to discuss the comments and potential revisions to the report. The Panel split the responses to comments and report revisions amongst the Panel. Edited versions were returned to PBS&J for compilation and formatting before being submitted to Reclamation as this final report on November 30, 2009.

The review is grouped into two major levels of comments. Tier 1 comments are those made in response to the MRRIC questions and other major issues related to the DEA. Tier 2 comments are more minor comments related to the structure of the DEA or material presentation. Tier 2 comments do not relate specifically to the science supporting the responses to the MRRIC questions, DEA, or draft Biological Assessment (BA). However, the Panel felt that Tier 2 comments were useful in the broader context of pallid sturgeon recovery.

Directive and Limits of Review

The formal Scope of Work (dated September 16, 2009) from Reclamation states the following in its entirety:

> *"The Scope of Work for this Task Order includes convening a panel of pallid sturgeon and/or other riverine sturgeon species experts to review Reclamation's and the Corps' [Corps of Engineers] responses to questions submitted by the Missouri River Recovery Implementation Committee (MRRIC), to determine whether such responses are supported by the best available scientific information, and provide any uncertainties in that science."*

There were eight tasks in the Scope of Work. The first two related to project management and panel recruitment and do not directly apply to this review. The following tasks provided specific direction to the Panel on the scope of their review:

Task #3. Review relevant section of the DEA and draft BA [for Intake Project].
Task #4. Review the set of questions submitted by the MRRIC.
Task #5. Review Reclamation's and U.S. Army Corps of Engineers' (Corps) responses to those questions.
Task #6. Review relevant scientific literature and other information associated with, but not limited to, pallid sturgeon life history and reproductive strategies; pallid sturgeon swimming ability; availability and suitability of pallid sturgeon migration and spawning habitat in the Yellowstone River below Cartersville; and other structures that provide passage for sturgeon species.
Task #7. Determine whether any relevant scientific information was not considered and provide an assessment of any, or to what degree there may be, uncertainties in the science.
Task #8. Provide a draft report by October 30, 2009. This report should include the panel's conclusions whether Reclamation's and the Corps responses to MRRIC's questions are supported by the best available science; individual and collective comments of respective panel members; and appropriate citations.

This review specifically considered whether the information presented provides sufficient documentation to determine if the Intake Project is a viable project to enhance pallid sturgeon populations independent of other management actions in the region. If the DEA, BA, and Responses to MRRIC Questions use the best available science then the overall conclusion would be that the Intake Project would positively contribute to the recovery of pallid sturgeon in the Great Plains Management Unit (which contains RPMA 2).

It is outside the scope of this review to assess whether this project is the best choice from the range of possible management actions within the Great Plains Management Unit. The Panel did not delve into the regional (range-wide) issues related to pallid sturgeon recovery. For example, no attempt was made to weigh the relative merits of work in the Missouri River or modifications to Fort Peck Dam operations, versus the proposed work in the Yellowstone River.

Life History Model

The Intake Project is intended to aid in the recovery of the endangered pallid sturgeon in the Great Plains Management Unit. To assure that the project has adequately incorporated the best available science, a simplified model of the important life history parameters of pallid sturgeon is presented (Figure 1) in relation to the proposed project (see Wildhaber et al. 2007, for more comprehensive pallid sturgeon life history model). To consider the Intake Project a success, the system must enable pallid sturgeon to move upstream, find suitable spawning habitat, allow larvae to drift downstream, avoid entrainment in the diversion structure, and develop into juveniles and adults. The successful completion of each phase is critical for the ultimate completion of the whole life cycle and the creation of a self-sustaining population in the river. Understanding how the proposed project affects pallid sturgeon at all life stages is fundamental to understanding if the project will result in a positive change in pallid sturgeon populations.

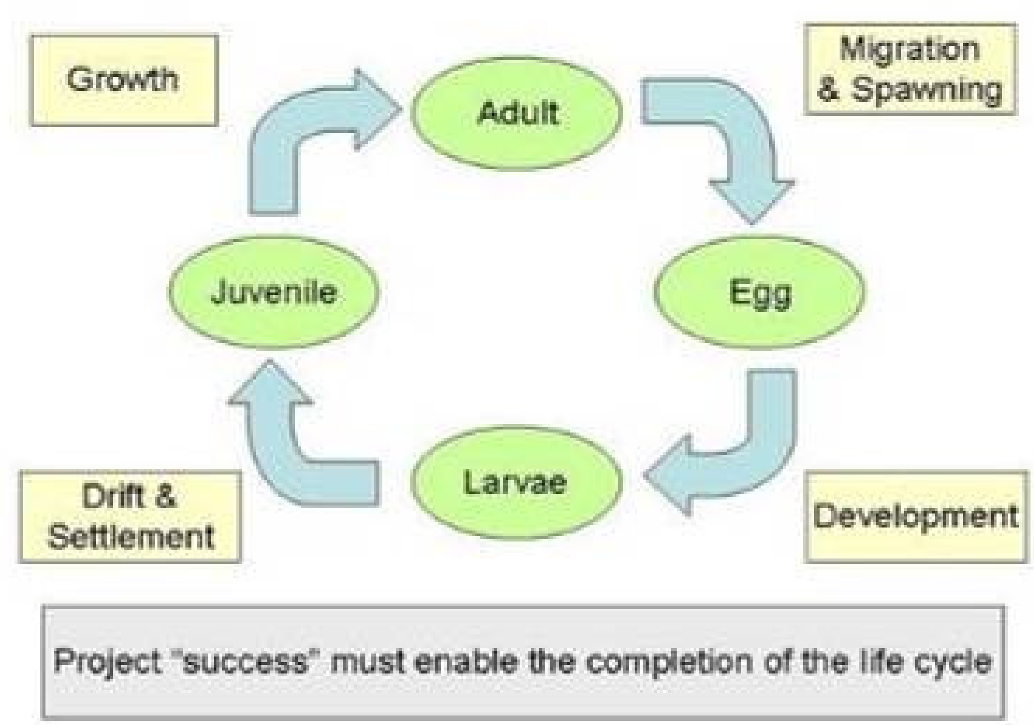

Figure 1. Simplified life history for pallid sturgeon

Pallid Sturgeon Adults (*passage and migration issues*):

Will the Lower Yellowstone Intake Diversion Dam Modification Project provide passage and enhance upstream migration for adult pallid sturgeon? Can and will adult pallid sturgeon pass the diversion structure during the purported spawning season (e.g., May through July) with the proposed modifications?

Pallid Sturgeon Adults (*spawning issues*):

Does suitable spawning habitat exist upstream of the Yellowstone Intake Diversion Dam, and if so, where and how far upstream is it located?

Pallid Sturgeon Eggs (*development and survival issues*): [1]

Are conditions at the potential upstream spawning sites suitable for the development and survival of pallid sturgeon eggs?

Pallid Sturgeon Embryos and Larvae (*downstream drift issues*):

[1] Although there is no specific discussion of pallid sturgeon eggs within the MRRIC questions or responses, DEA, or BA, the Panel felt that some discussion of this topic was appropriate in the life-cycle context of this review.

If pallid sturgeon can access and successfully spawn at upstream locations, is there sufficient downstream drift distance for larval development prior to entering Lake Sakakawea? Are embryo and larval drift distances adequate with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea? Does the proposed fish screen decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon?

Pallid Sturgeon Juvenile and Adult Life History (*habitat and growth issues*):

If the Intake Project functions as proposed, do conditions in the Yellowstone and connected sections of the Missouri River have suitable conditions to support completion of the pallid sturgeon life cycle? Are conditions suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon? Will the Intake Project have either neutral or positive effects on the juvenile through pre-reproductive adult stages?

Technical Review Topics

Many of the questions posed by MRRIC apply to multiple life-cycle stages of pallid sturgeon. To facilitate the review of the responses to these questions, the Panel created a table of the specific questions and the applicable life-cycle stage (Table 1). This allowed the Panel to divide the workload of addressing a particular topic while also ensuring that all life stages were evaluated. The following discussion presents the Tier 1 review topics that correspond to the major columns in Table 1.

Because some MRRIC questions contained multiple topics or applied to multiple life-cycle stages they were split into sub-questions (e.g., A1a and A1b). Each MRRIC question that applies to that topic is presented, followed by a summary of the material presented in the response to the MRRIC question, the DEA, and BA. This information is then evaluated to determine if the best available science was used in the analysis of project effects. A discussion of uncertainties and a conclusion complete the evaluation for each major topic.

Table 1. Questions posed by MRRIC and the life-cycle stages of pallid sturgeon to which those questions apply.

	Adult		Free Embryo/Larvae/Juvenile	
MRRIC Question	**Migration And Passage**	**Spawning**	**Drift and Entrainment**	**Rearing**
A1	X	X	X	
A2			X	
A3			X	
A4			X	
A5			X	
A6			X	
B1	X		X	
B2	X			
B3	X			
B4	X			
B5	X		X	X
B6	X	X	X	X

Table 1. Questions posed by MRRIC and the life-cycle stages of pallid sturgeon to which those questions apply.

MRRIC Question	Adult		Free Embryo/Larvae/Juvenile	
	Migration And Passage	Spawning	Drift and Entrainment	Rearing
B7	X		X	X
B8	X		X	X
B9			X	
B10		X	X	
C1	X	X	X	X
C2	X	X	X	X
C3	X	X	X	X
C4	X	X	X	X

Tier 1 Topics

PASSAGE AND ADULT MIGRATION

The Panel identified five MRRIC questions that are applicable to this topic area. These questions are:

B.1a Question: Will the project allow passage of pallid sturgeon for spawning?

B.2 Question: Will the rock ramp design allow passage of pallid sturgeon?

B.3 Question: What data are available to support the thesis the majority of the fish even would go up to Cartersville if there was a fish passage?

B.4 Question: Does the project design incorporate the best available technology for migration and protection of the pallid sturgeon population?

A.1b. What is the likelihood of pallid sturgeon using the newly opened area for spawning?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies stated in their responses to MRRIC questions and in the DEA and BA. The authors of the responses to MRRIC's questions and DEA and BA note that no passage of adult pallid sturgeon over the Intake Dam has been documented. Other fish passage projects of similar scope have been used successfully for improving pallid sturgeon migration in other systems; this helps justify the proposed project. If passage is improved at the Intake structure, then adult pallid sturgeon will have access to an additional 165 miles of river in which to forage and spawn. The efficacy of the rock ramp design has been initially tested (White and Mefford 2002) and will allow fish to pass. The slope of the proposed rock ramp (0.5%) may be steeper than that experienced by pallid sturgeon in natural reaches of the Yellowstone River. However, several studies are cited that suggest that this is the best available technology for passage. The BA and DEA support the view that this is the best viable alternative, weighed against the option of altering and moving the river channel as a bypass. The authors cannot say that the majority of pallid sturgeon in RPMA 2 will move upstream of the passage structure, once in place. However, the river upstream of the Intake Dam has at least 4,000 acres of potentially suitable spawning habitat, according to a personal communication by M. Jaeger. Historical information shows that pallid sturgeon adults were present in the reaches above the Intake Dam; thus it is likely that they will revisit this system again, once these areas are open. Fuller et al. (2008), working with telemetered reproductively viable pallid sturgeon, documented that these individuals were apparently staging below the dam as if they were attempting to pass. The authors assume that if these fish were able to pass, they would have done so.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

To the best of our knowledge, information pertaining to adult pallid sturgeon occurrence and movement in the Yellowstone River is fully documented in the responses to the MRRIC questions plus the associated BA and DEA. Conclusions are consistent with a large set of data on pallid sturgeon movement and spawning in other river reaches. This information provides further insight about passage issues associated with the Intake Dam area. These data support the idea that the proposed project will improve fish passage.

Adult pallid sturgeon passage is a pervasive issue throughout the impounded upper Missouri River (i.e., above Gavins Point Dam). Because these systems are typically fixed impoundments with no spill over (e.g., flow and passage are maintained by gates and locks), few opportunities for fish passage exist. An analog to the passage issue being considered at the Intake Dam in the Yellowstone River is the 17-mile Chain of Rocks area of the Middle Mississippi River, near the confluence of the Missouri River. This shallow, shoal area is largely un-navigable and has been bypassed by the construction of a canal plus lock and dam (Lock and Dam 27, Mississippi River). The river upstream of the canal is pooled by a 15 foot low head dam at RM 185.5 of the Middle Mississippi River (Ohio River confluence RM 0 and Lock and Dam 26, Alton, Illinois is RM 200). Catch rates of pallid and shovelnose sturgeon below this location are high relative to other portions of the Middle Mississippi River (Killgore et al. 2007). Also, the proportion of pallid sturgeon captured relative to all sturgeon is greater than other reaches of the Middle Mississippi River (Killgore et al. 2007). The low head may provide habitat conditions that attract pallid sturgeon (e.g., variable flow, scoured substrate) but may also be an impediment to movement. However, research with 87 acoustically tagged adult pallid sturgeon in the Middle Mississippi River and stationary, data-logging receivers demonstrated that pallid sturgeon occasionally did pass over the low head dam and move into the Missouri River (Garvey et al. 2009; http://fishdata.siu.edu/pallid). This movement typically occurred during elevated flow in spring and may have been related to reproduction. Whether passage can occur over this structure during low flow is unknown. Passage through the navigation canal and corresponding lock and dam structure adjacent to the lowhead is unlikely and has not been documented.

Telemetry research with adult pallid sturgeon has shown that those fish that are likely staging to spawn in the Middle Mississippi River are typically found < 500 meters (m) from known gravel or hard-rock (as opposed to sand or silt) beds (Garvey et al. 2009, http://fishdata.siu.edu/pallid). This research supports the idea in the DEA that hard substrates are necessary for spawning.

Research conducted on the habitat use of non-reproductive pallid sturgeon in the Mississippi River suggests that individuals are typically found at the "ecotone" between rapid and slow flow [average 0.9 meters per second (m/s)]. In this reach, these preferred areas are typically associated with wing dikes and adjacent deep scour holes (Garvey et al. 2009). The area below the Intake Dam seems to mimic these areas (see DEA). Similar areas upstream from Intake Dam may provide spawning and non-spawning (e.g., foraging, holding position) opportunities for passing pallid sturgeon.

Considerable information about the behavior and habitat use of spawning pallid sturgeon has been amassed in the lower Missouri River (e.g., DeLonay et al. 2009). These telemetry data not only provide information about the location of spawning but also the depth distribution of the fish. It appears that spawning may occur at a constant depth (given that a variety of depths are used just prior to and following spawning) of about 2 m in revetted outside bends (i.e., areas of clean, scoured substrate plus high flow velocity). Depth contours around the area of the Intake Dam as well as above the dam need to be considered to determine whether they provide depth and flow conditions conducive for spawning.

Pallid sturgeon peak spawning typically occurs at temperatures of 17 degrees centigrade (°C) and depends on complex conditions such as the presence of high spring or early summer discharge; see Delonay et al. 2009; Garvey et al. 2009). Thus, the upstream movements of pallid sturgeon and passage across the proposed structure should be most common prior to and during this time.

Uncertainties

The key uncertainty regarding passage of adult pallid sturgeon upstream from Intake Dam is not if they can pass following dam modification but whether significant numbers will in fact take advantage of the opportunity to seek potential spawning sites upstream.

Density dependent processes affecting adult dispersal throughout the Yellowstone River (and RPMA 2 in general) should be considered. Restoration of passage may not provide significant benefits in the near term when low numbers of adult spawners are available. However, future benefits could become significant as the population density of reproductively viable adults grows in response to the considerable stocking program (Numbers of hatchery-reared pallid sturgeon stocked in RPMA 2 are reported in Appendix D, page 20 of the DEA). This should increase the chance of some pallid sturgeon moving upstream into novel areas. A 1969 population abundance estimate for adult pallid sturgeon in RPMA 2 was 968 fish (Braaten et al. 2009). Recent densities of juvenile pallid sturgeon in the RPMA 2 appear to be growing (5 Year Pallid Sturgeon Recovery Review, Jordan 2007) and may be greater than this level. Thus, it is likely that the opportunities for passage by pallid sturgeon across the intake structure will increase in coming years.

Obviously, more comprehensive pallid sturgeon movement data, relative to hydrology conditions at the Intake Dam would be helpful. Often, upstream movements by pallid sturgeon are short in duration; individuals then drift back downstream (Garvey et al. 2009; Delonay et al. 2009). Upstream forays may be missed by manual crews tracking fish.

The area around the Intake Dam is within a reach that has some apparent attractive quality to it. As described by Jaeger et al. (2008), it is expected that the area having an attractive quality is a larger 139 kilometer (km) geomorphic reach (Reach 2), which extends from Fallon to Sidney, Montana. This reach is bisected by the Intake Diversion. Telemetered pallid sturgeon released within this reach below Intake Dam did not disperse long distances downstream but rather remained in this vicinity. Similarly, movement rates of fish released upstream of Intake Dam (e.g., Cartersville) decreased once they dispersed downstream into this reach, the upper extent of which is about 80 km upstream of Intake Diversion. Some of the fish released upstream passed over Intake Dam. Thus, it is expected that it is not Intake Diversion that has an attractive quality but rather the larger reach that it falls within (M. Jaeger, FWP, personal communication).

The attractive quality of the lowhead dam to all mobile life stages of pallid sturgeon at Intake may be enhanced by the proposed rock ramp. The ramp may produce both foraging and spawning opportunities that are desirable to pallid sturgeon (similar to conditions below the lowhead dam in the Middle Mississippi River). If these conditions encourage spawning at this location rather than cause fish to move upstream then desired outcomes for drifting larvae (i.e., enhancing drift distance) may not be achieved because pallid sturgeon would spawn at this location, as they may already do. Design elements of the rock ramp may help to minimize the attractiveness of the rock ramp to pallid sturgeon.

The current hydrology of the Intake Dam area and its implications for passage were not summarized in any of the comments responses nor in the DEA or BA that were available to the Panel at the time of their review. If water levels are sufficiently high above the current dam during high flow (> 1 m; this depth is uncertain), might this allow some pallid sturgeon movement? Could high flow conditions during occasional years be sufficient to facilitate fish passage without building a passage structure? Specific information about monitoring the "success" of passage is not provided. Preferably, a baseline for future comparisons would be helpful for adaptive management.

Conclusion/Summary

The best available information for the Yellowstone River was included. Information from other systems with parallel issues of passage supports the conclusion that some passage across the current Intake Dam may occur, albeit infrequently and only during the highest flow periods. The current level of monitoring is such that sampling power is low for detecting low levels of current passage. Future monitoring to quantify movements at the Intake Dam area could include telemetered fish and automated receivers (or crews continuously tracking fish).

Some concerns about the potential influence of the rock ramp design on pallid sturgeon spawning behavior (i.e., by discouraging upstream movement to other areas) have arisen. A similar issue could occur with the hard substrates associated with the bypass channel alternative. However, as adult population densities rise in the Yellowstone River following the successful stocking program, it is likely that some upstream movement will occur and may increase through time as spawning sites downstream become "saturated" with spawners and individuals look for novel spawning opportunities upstream.

Rock ramps similar to the one proposed for this project have been used successfully to enhance fish passage in many systems, suggesting a similar impact in the lower Yellowstone River.

SUITABILITY OF SPAWNING HABITAT

The Panel identified seven of the questions posed by the MRRIC as being relevant to the spawning adult life stage of pallid sturgeon. These include:

A.1a Question: Where above Intake on the Yellowstone River does spawning substrate exist?

B.6 Question: Is the bypass design the best for pallid sturgeon?

B.10 Question: If pallid sturgeon did go up to Cartersville what data is available regarding predation in that location, that would convince anyone the eggs or larvae would survive?

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.2 Question: How much will this project improve the pallid's survivability?

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at Intake?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. From the perspective of habitats for spawning adult pallid sturgeon the Panel summarized the responses to these questions posed by the MRRIC as follows. Without a long-term stocking program pallid sturgeon would be extirpated from this section of the Missouri River and the Yellowstone River. This does not meet the current or future down-listing requirements of the Endangered Species Act (ESA). Other management alternatives, including water release modifications at Ft. Peck Dam and manipulation of water levels in Lake Sakakawea are more expensive and may not be acceptable to the public at this time. Under current conditions on the Yellowstone River, adult pallid sturgeon can only access the area downstream from the diversion dam at Intake. While occurrences of spawning in this reach have been documented using telemetry, no naturally produced offspring have been recruited to the population for decades. This has led to an aging population of large individuals that are reaching senescence and will likely die out in the foreseeable future. Without access to appropriate spawning areas far enough upstream to allow larvae to develop adequately as they drift (before entering Lake Sakakawea), this population will require perpetual stocking to maintain a population.

Modifications in the diversion dam at Intake on the Yellowstone River has been considered an important component in the recovery of pallid sturgeon in this portion of its range, because it would allow adult fish to access extensive areas of spawning habitat potentially as far upstream as Forsythe, Montana. This would allow for longer drift distances, which would reduce the likelihood of the larvae drifting into Lake Sakakawea, where they may be subjected to high rates of predation by planktivorous fishes and other mortality factors. Among the potential modifications to the diversion dam at Intake that were considered, a suite of scoring criteria determined that a ramp structure was the best option. Protection from entrainment at Intake will significantly reduce the losses of pallid sturgeon and minnow species upon which larger juvenile and adult pallid sturgeon feed. Other management alternatives, including water release modifications at Ft. Peck Dam and manipulation of water levels in Lake Sakakawea are more expensive and may not be acceptable to the public at this time.

Pool habitats in general and bluff pool habitats in particular have been identified as important spawning habitats for several species of riverine fishes in the Yellowstone River. Several studies (Bramblett and White 2001; Fuller et al. 2008) have documented potential spawning sites for pallid sturgeon in the Yellowstone River downstream from Intake. The habitat survey by Jaeger et al. (2005) found pool habitats where sauger spawn between 100 and 300 km upstream from the confluence with the Missouri River. This spans the reach which encompasses the Intake diversion dam. DeLonay et al (2009) have found that pallid and shovelnose sturgeon used patches of deep water with relatively fast turbulent flow on the outside bank of revetted bends in the middle Missouri River. These conditions seem similar to the 4,000 acres of terrace pool and bluff pool habitats that M. Jaeger (FWP, personal communication) has estimated are present in the Yellowstone River between diversion dam at Intake and Cartersville, Montana.

Is This the Best Available Science and If Not What Needs to Be Added

As the DEA, BA, and responses to the questions from the MRRIC point out, there have been numerous conferences, long discussions, and excellent research which have documented the habitat alterations that are impacting the pallid sturgeon population in RPMA 2. It is only the longevity of pallid sturgeon, and effects of stocking that have allowed it to persist as long as it has without successful natural spawning and recruitment to the adult population. Under current habitat conditions within the Yellowstone River and the Missouri River reach between Ft. Peck Dam and Lake Sakakawea there seems little chance that pallid sturgeon populations can achieve recovery by natural reproduction. Therefore, the most significant measure of success for this project would be documentation of spawning upstream from the diversion at Intake and identification of naturally reproduced offspring from these events.

DeLonay et al. (2009) hypothesized that: "maturation and readiness to spawn in female sturgeon is cued many months before spawning." Specifically, day length and temperature respectively appear to define the "temporal spawning window" and the proximal cue for spawning. Several telemetry studies along with tag returns from intensive sampling throughout the range of pallid sturgeon have documented long distance movements. Whether the total length of riverine habitat associated with the Yellowstone River along with its tributaries and confluent reaches of the Missouri River meet the needs for pallid sturgeon to complete their life cycle is still a question that needs to be answered. However, it seems very likely that without the expansion of the length of the Yellowstone River facilitated by this project, recovery goals for pallid sturgeon in this area will not be met.

The Panel thinks that the authors of the documents have done a good job of reviewing the literature and data available on spawning and spawning habitat for pallid sturgeon in the Yellowstone River, but the Panel believes that the document could be strengthened by incorporating findings from additional, recently published research. Since DeLonay et al. (2009) have found that shovelnose sturgeon and pallid sturgeon use similar, overlapping areas for spawning, it seems that a survey of shovelnose sturgeon spawning locations in the Yellowstone River could provide useful guidance regarding how far upstream from the Intake Dam pallid sturgeon spawning might occur. In addition, several observations from studies in the Mississippi River (e.g., Hurley et al. 2004; Garvey et al. 2009) and the middle Missouri River (Steffensen and Hamel 2007, 2008) found concentrations of pallid sturgeon at the mouths of tributaries. Applying these observations to the Yellowstone River and its tributaries such as the Powder River and using information from Haddix and Estes (1976) and Penkal (1981) could prove fruitful in the identification of potential pallid sturgeon spawning localities. Confirmation of specific spawning areas would enable valuable empirical studies of drift distance for pallid sturgeon larvae, which would facilitate more accurate estimates of larval survival and recruitment potential.

The Panel agrees that the survey of bluff pool habitats done by Jaeger et al. (2005) provides a baseline of available habitat. Based on the habitat data presented, it would appear that most of the bluff pool habitats expected to provide suitable spawning conditions for pallid sturgeon are downstream of the confluence of Tongue and Yellowstone rivers (Jaeger 2005). This might reduce the benefit of the proposed gain of 165 miles of larval drift distance downstream from the Cartersville Diversion as many of the potential spawning locations were far down river from Cartersville and none were reported near Cartersville. The Panel thinks that a determination of shovelnose sturgeon spawning localities could narrow the focus for finding potential pallid sturgeon spawning sites. However, suitable spawning sites for pallid sturgeon upstream of Intake Dam will be most effectively identified by telemetry monitoring of distribution and movements after the Intake Project is completed.

Uncertainties

Because there have been no recent documented occurrences of wild pallid sturgeon upstream from the diversion dam at Intake in recent times, it is difficult to say whether this area will be used immediately. However, as pallid sturgeon stocked into RPMA 2 grow to maturity, it seems likely that they will "explore" and use the habitats made available by the proposed modifications because long distance upstream forays are common in pallid sturgeon juveniles and adults (Garvey et al. 2009).

Another concern for any species with populations as small as this pallid sturgeon population is whether sufficient numbers will be ready to spawn at the same time in one place (i.e., the Allee effect) (Delonay et al. 2009). Therefore, continued stocking may be needed to augment the population until a sufficient number of adults are present to carry on the species.

There is some question about whether the substrate composition in the ramp will act as an impediment to pallid sturgeon using the whole reach from Intake Dam to Cartersville. If the ramp provides habitat that is perceived by the pallid sturgeon as suitable for spawning, they may congregate at Intake Dam and not proceed to suitable upstream spawning sites. Therefore, the ultimate design criteria for the ramp or indeed any bypass at Intake Dam needs to consider how pallid sturgeon will respond to the microhabitat conditions within the modified area so that they will indeed pass the diversion dam at Intake.

Conclusion/Summary

Without the resumption of natural spawning there is no real possibility that the naturally produced (i.e., non-stocked) pallid sturgeon population in RPMA 2 will recover from its endangered status and therefore without stocking it will become extirpated. The Intake Project, as described in the materials the Panel reviewed, has the potential to open a path for pallid sturgeon spawning that has been blocked for nearly a century. In addition, modifications to prevent loss of fish into the canal will also reduce losses of sturgeon and other species as they move downstream.

Although there may be other issues outside of the Yellowstone River proper, this project seems, in the Panel's judgment, to have good potential to contribute to the re-development of a naturally reproducing population of pallid sturgeon in RPMA 2

LARVAL DRIFT

The Panel identified eleven of the questions posed by the MRRIC as being relevant to the larval drift of pallid sturgeon. Entrainment issues are also included in this set of questions. These questions are:

A.1c Question: [If upstream spawning habitat is used] And if they use it, is adequate drift distance/time provided for larvae survival?

A.2 Question: What is the current speed during the high water period on the Yellowstone May 15--to July 15, at Cartersville and below and what velocity rate (or range of rates) is appropriate to calculate larval drifts?

A.3 Question: What data is available to support the conclusion that any larvae would actually survive without ending up in the head waters of Lake Sakakawea where they would die?

A.4a Question: What are the anticipated drift rate and distance required for larval pallid sturgeon in the relevant reaches? A.4b What is the required water level in Lake Sakakawea to attain this distance? How often should these conditions exist? What is the level of uncertainty in the drift rate and distance calculations? How was this data considered when planning the Intake project?

A.5 Question: Is there a need to modify other upstream dams to allow enough drift distance for larvae? What progress/plans have been made on modifying upstream structures?

A.6 Question: Can/should a study be conducted on the Yellowstone River to provide drift information specific to this reach?

B.1b Question: Will it allow larval pallid sturgeon passage downstream and will it lead to their survival?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. A central hypothesis in the project justification is that restoration of adult passage will restore sufficient distance of free-flowing river such that larval sturgeon can complete the extended drift phase of their early life history before encountering unfavorable reservoir habitats. Pallid sturgeon in this area are at risk because natural recruitment has failed. Drift distance limitation is the leading hypothesis for this failure. This project may be able to restore some amount of natural recruitment in this management area if the distance between spawning areas upstream from Intake Dam and Lake Sakakawea is long enough to provide adequate in-river larval development before fish enter Lake Sakakawea.

Depending on Lake Sakakawea surface elevation, estimated 84-141 miles of drift distance is currently available in the Yellowstone and Missouri Rivers between Intake Dam and the upstream end of Lake Sakakawea (Table 2). The location of the headwaters of Lake Sakakawea varies and has been estimated to be between 13 and 70 miles from the mouth of the Yellowstone River based on the information provided (10/27/09 email from G. Davis, USBR to P. Callahan, PBS&J). Restoration of effective adult upstream passage at Intake Dam was estimated to provide access additional 165 miles of river for a total of 248-305 miles. If Cartersville Dam were subsequently modified, an additional 56 miles would be available for a total of 304-361 miles.

A distance of 217-497 miles was projected to be needed for completion of the larval drift phase of the life cycle. The range reflected seasonal differences in drift duration related to temperature and uncertainty in estimates of drift rate related to water velocity. The estimated 319 miles available with passage at Intake Dam exceeds the low end of the needed range. This led the Federal agencies to conclude that restoration of passage will provide adequate drift distance for a portion of any naturally-produced larvae spawned upstream of Intake during many or most years.

Estimates of drift distance requirements were based on a synthesis of the available information on the duration of the larval drift phase and the rate of drift (Table 3). Information was primarily derived from a series of articles published in peer-reviewed scientific journals and also included unpublished results of more recent studies. Descriptions of larval pallid sturgeon drift behavior and duration were based on a series of laboratory studies conducted at the USGS Conte Anadromous Fish Research Center in Massachusetts (Kynard et al. 2002, 2007). Drift behavior in a natural environment and drift rates relative to water velocity were estimated based on experimental field studies by Braaten et al. (2008) and Braaten et al. (in preparation). Braaten et al. (2008) used this information to simulate cumulative distance drifted in the upper Missouri River during ontogenic development. Simulation results were validated by subsequent capture of juveniles released as larvae which confirmed that significant survival could result when sufficient drift distance was available for larvae to complete development prior to reaching Lake Sakakawea. The simulation was subsequently adapted for evaluation of Intake Dam passage benefits on drift distance of larvae originating in the Yellowstone River by Horton (2009).

Table 2. River distances involved in the proposed project.

Location	River(a) miles	River(a) km	Above Intake miles	Above Intake km	Above Lk Sakakawea miles	Above Lk Sakakawea km
Lake Sakakawea headwaters (low pool) (b)	[1512]	[2434]	--	--	0	0
Lake Sakakawea headwaters (high pool) (b)	[1569]	[2526]	--	--	0	0
Yellowstone River	[1582]	[2547]	--	--	13-70	21-113
Intake Dam	71	114	0	0	84-141	135-227
Documented occurrence (historical)	183	295	112	180	196-253	315-407
Cartersville Dam	235	378	164	264	248-305	399-491
Yellowstone Dam (passage exists)	276	445	206	331	289-346	466-558
Rancher's Ditch Dam	291	468	220	354	304-361	489-581
Fort Peck Dam	[1709]	[2751]	--	--	140-197	225-317

Notes: (a) Missouri River distances are in brackets [ ]
(b) River mile locations and distances to headwaters are inconsistently reported in the DEA and related material.

Table 3. Re-creation of estimates and assumptions in projections of drift distance needed for completion of the larval drift phase of pallid sturgeon.

	Units	Min	Max	Comment
Larval development period	--	--	--	Mid June to Mid July
Temperature	°C	25	20	Average for period
Larval phase duration	Days	7	10	Fastest development at avg. temperate
Stream flow	ft^3/sec	25,000	25,000	20 year average @ Sidney
Water velocity	ft/sec	2.9	2.9	Assumed based on field measurements
Relative drift rate	--	0.62	1.00	Reflects 4 day lag in observed distribution
Drift velocity	ft/sec	1.8	2.9	Water velocity x relative drift rate
	mi/day	30.2	47.5	
Distance traveled	mi	211[a]	475[a]	Phase duration x drift velocity

Note:
a. The Panel's recreation of estimates differs slightly from the reported 217-497 miles (likely due to rounding errors).

Reservoir habitats are thought to be unfavorable to larvae because of unsuitable conditions or habitat in headwater depositional areas or predation by the reservoir fish community. This conclusion was consistent with the general timing of recruitment failure concurrent with the development of impoundments. Observations of significant numbers of mature adults, spawning migrations, spawning habitat, and spawning behavior indicate that recruitment failure is not due to the failure to spawn. Significant rates of survival of hatchery-origin juveniles released at post-larval sizes indicate that the recruitment bottleneck occurs in the early life history stage. Survival of hatchery-origin larvae that were provided the opportunity to complete development in a riverine habitat (as indicated by recapture months or years later) further narrows the bottleneck to the larval stage.

The drift distance limitation hypothesis and projected benefits of the modification of Intake Dam hypothesis is supported by information on the sympatric shovelnose sturgeon and pallid sturgeon populations in other areas. A large shovelnose sturgeon population occurs in the area which is consistent with the shorter duration of the larval drift phase for this species. Drift distance is adequate for completion of the shorter larval drift phase. Similarly, significant recruitment is observed for pallid sturgeon in other areas downstream where adequate drift distance is available.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

We note that a stronger case could be made for estimates of drift requirements and project benefits with a more structured, quantitative modeling analysis that might include:

- Daily flow and temperature profiles
- Representation of both Yellowstone & Missouri conditions
- Seasonal spawning and incubation patterns
- Annual variation in stream discharge and the location of Lake Sakakawea headwaters
- Annual variability in temperature patterns in relation to discharge
- Variable developmental periods based on temperature patterns
- Annual and daily variation in average stream velocity in relation to discharge
- Individual variance in larval drift rate reflecting the effects of channel complexity
- Explicit estimates of the benefit probabilities

While a more comprehensive modeling approach would facilitate consideration of the effects of alternative hypotheses and quantification of the effects of uncertainties, it is not likely to lead to fundamentally different conclusions. However, it would provide a more explicit and descriptive organization of the existing information. This work would involve development of a model from existing information but this model is not currently available. Hence, the analysis and descriptions provided in the existing documents continues to represent the best science currently available.

Given the importance of the larval drift distance to the ultimate success of the Intake Project, the Panel chose to conduct their own independent (coarse-level) analysis using river discharge data to evaluate the occurrence of larval drift distances in the Yellowstone River in relation to annual variability stream discharge based on some simplifying assumptions. The results of this analysis supported the possibility that adequate drift distances for pallid sturgeon larvae could exist in some years. This analysis illustrates how additional modeling of existing information can be instructive but represents just a portion of the more comprehensive physical and biological modeling approach outlined above. A complete analysis of the data is outside the scope of this review.

The methods for this example analysis were as follows:

1. The daily average discharge for the U.S. Geological Survey (USGS) gage at Sidney, MT was downloaded from the USGS website for the period of record (1910 – 2009). The years of 1910 and 1933 were dropped from the analysis because they had long periods of missing data.
2. Next, only data from the time period from May 15 to July 15 were considered because this was given as the likely range of pallid sturgeon spawning in the Yellowstone River. Pallid sturgeon peak spawning typically occurs at temperatures of 17°C and also depends on complex conditions (probably the presence of high spring or early summer discharge; see Delonay et al. 2009 and Garvey et al. 2009). This is cooler than the 20-25°C range suggested in the responses to the questions from the MRRIC, thus the longer time period selected.
3. The average daily discharge for each time period (May 15 – May 31, June 1 – June 30, July 1 – July 15) was calculated.
4. The minimum of the three time periods for each year was used as a potential window for successful larval drift.
5. To estimate average river velocity from discharge, the Panel used the standard relationship of $v = K * Q^a$, where v = mean velocity, K is a constant, Q = discharge, and a = 0.34 (see Jobson 1996). The average velocity was calculated for each year for the minimum time period discharge. K was determined from transect data on the lower Platte River, NE (Peters and Parham 2008) and compared with the estimate of 25,000 cubic feet per second (cfs) having a 3.23 feet per second (ft/sec) average velocity (Responses to the questions from the MRRIC, 2009).
6. The average velocity was also decreased by 40% to estimate the slowing of overall drift with the increased complexity of the Yellowstone River in comparison to the Missouri River as discussed by Jaeger et al. (2008).
7. The 1%, 10%, and 25% minimum drift lengths was calculated for the average velocity and slower 60% of average velocity using Braaten et al. (2008) equations for pallid sturgeon larval drift of the slowest drifters.
8. The number and percent of years that drift distance was less than the 253 miles (estimated minimum distance below Cartersville) and 312 mile (estimated minimum distance including Cartersville passage) were determined.
9. The average, maximum, and minimum drift distances were also reported.

The data tables for steps 3 through 7 are presented in Appendix 3 and Appendix 4 to this report. This analysis should be considered preliminary and a more detailed analysis of discharge to velocity measured on the Yellowstone River associated with the USGS gage sites and seasonal temperature variability would greatly improve the reliability of this estimate. Assessing the viability of this project was complicated by inconsistent mileage data for physical landmarks and associated distances to Lake Sakakawea. Distances from landmark locations to the headwaters of Lake Sakakawea are likely minimum estimates. The location of the headwaters of Lake Sakakawea varies and has been estimated to be between 15 and 55 miles downstream from the confluence of the Yellowstone River and the Missouri River (Scarnecchia et al., 1996). Results of the Panel's larval drift distance analysis for pallid sturgeon in the Yellowstone River suggest that improving passage will provide the possibility of adequate drift distances for pallid sturgeon larvae in some years (Table 4 and Figure 2). Given that pallid sturgeon larvae drift near the river bottom, and that the Yellowstone River has more complex channel structure than the Missouri River, drifting larvae could be expected to travel downstream at rates lower than average river velocity, and at rates lower than those recorded in the Missouri River. This is crucial because calculations using average velocity estimates based on discharge records indicate that few years would provide suitable drift distances (Table 4). If the Cartersville fish passage project is completed then the probability of suitable drift distances increases substantially (Table 5).

Table 4. Number and percent of years that suitable drift distances were available for the slowest 1, 10, and 25% of pallid sturgeon larvae during the 97 year period of record for the Sidney, MT USGS gage on the Yellowstone River. (Average velocity based on the velocity to discharge relationship and reduced velocity is 60% of average velocity. A successful year was considered to have an estimated drift distance less than 253 miles or the estimated distance from Cartersville Diversion to Lake Sakakawea.)

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Number of years out of 97	2	0	0	71	50	33
Percent of years	2%	0%	0%	73%	52%	34%

Table 5. Number and percent of years that suitable drift distances were available for the slowest 1, 10, and 25% of pallid sturgeon larvae during the 97 year period of record for the Sidney, MT USGS gage on the Yellowstone River with passage of Cartersville Diversion included. (Average velocity based on the velocity to discharge relationship and reduced velocity is 60% of average velocity. A successful year was considered to have an estimated drift distance less than 312 miles or the estimated distance with fish passage at Cartersville Diversion included and then downstream to Lake Sakakawea.)

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Number of years out of 97	13	8	2	95	85	73
Percent of years	13%	8%	2%	98%	88%	75%

These estimates (Tables 4 and 5) assume that pallid sturgeon will migrate upstream nearly to the base of the next upstream diversion and find suitable habitat in that area. The probability of this happening is unknown and is likely influenced by many factors, including the quality of spawning habitat in the area and the population size of the pallid sturgeon. It appears that the minimum successful drift distance for 1% of the drifting larvae in the Yellowstone River at the reduced velocity estimate is about 102 miles or 234 miles at the average velocity estimate (Table 6). This suggests that the current distance of 88 miles from the Intake to Lake Sakakawea is insufficient for even the most optimistic estimates. This minimum drift distance also suggests that in some years suitable spawning habitat far downstream of Cartersville Diversion may have the potential for a small fraction of the larvae to survive (Figure 4). These years would be very low discharge years and may not provide adequate passage upstream (see Peters and Parham 2008 for a discussion of the lack of connectivity of river habitats for migrating pallid sturgeon at low flows).

Table 6. Average, maximum, and minimum drift distances for pallid sturgeon larvae in the Yellowstone River.

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Avg drift distance (miles)	429	460	480	220	251	271
Max drift distance (miles)	611	642	662	329	360	380
Min drift distance (miles)	234	265	285	102	133	154

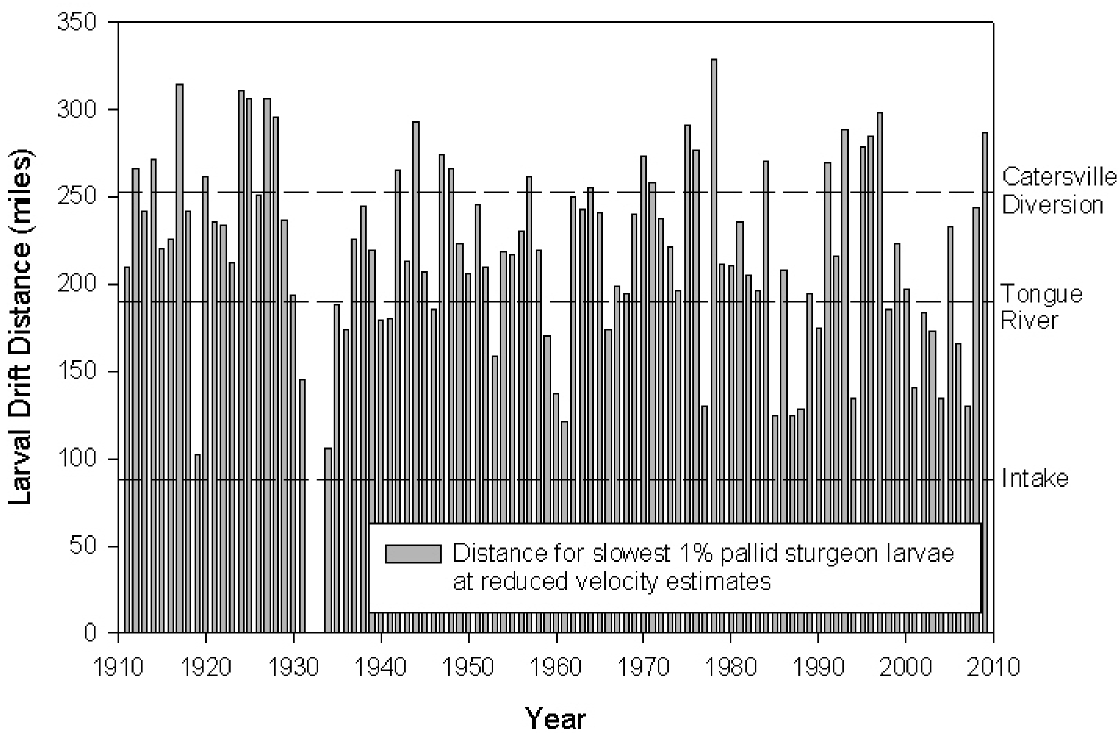

Figure 2. Annual variation of potential minimum larval drift distances for the slowest 1% of pallid sturgeon larvae based on the reduced velocity estimates. (Reference distances of interest are provided.)

This analysis only considers discharge in its prediction of larval drift distance. We used a wide time period of May 15 to July 15 in our model of minimum annual larval drift distances for the Yellowstone River to cover a range of possible spawning temperatures. While exact spawning temperatures and dates in the Yellowstone River are not known, some ranges for recent years have been determined. Estimated ranges for spawning in 2007 included May 24th to June 26th with a water temperature between 15 to 25°C. (Fuller et al. 2008) and in 2008 spawning may have occurred between June 19th and July 8th with water temperatures between 18 to 22°C. (M. Jaeger, FWP, personal communication). The inclusion of water temperature estimates would improve these predictions of the time of spawning and distance traveled by the larvae. Distance traveled is a function of discharge (controls water speed) and temperature (controls development time). The distance traveled curve will differ during spawning seasons and among years. In general, a warm year results in warmer water and therefore shorter development times than a cool year. A wet year will result in higher water flows and therefore faster transport rates than a dry year (Table 7). The combination of conditions will control the parameters of the distance traveled curve.

Table 7. The relationship between seasonal temperature and seasonal discharge. (The relationship is temperature/discharge. The plus (+) denotes shorter larval drift distances and the minus (-) denotes longer larval drift distances.)

	wet	dry
Warm	+/-	+/+
Cool	-/-	-/+

The estimates provided in the section above were inferred from the information provided in the answers to MRRIC, the BA, and the DEA. The Panel attempted to provide an explicit set of predictions of the effect of variable annual stream discharge on larval drift if the proposed project is implemented. This framework would be enhanced with a summary of historical discharge and temperature estimates for the period of record. This would provide an estimate of the proportion of years that may provide suitable drift distances for pallid sturgeon larvae. If this was coupled with a map of all the suitable spawning areas in the Yellowstone River and its tributaries and associated drift distances, then the number of years that suitable upstream spawning sites were available with suitable drift distances would be clearly shown. This would provide clear evidence of the potential for success of this project and provide an estimate of a portion of the uncertainty associated with this effort. The analysis could be further extended to explicitly evaluate the effect of other uncertainties related to seasonal and individual variation in temperature, developmental period, and drift rate in relation to water velocity.

Uncertainties

Estimates of the Intake Project benefits are subject to a number of significant uncertainties which were acknowledged by the authors. These include:

<u>Effect significance</u> – The available information suggests that drift distance may be adequate for some larvae originating upstream from Intake Dam. However, the significance of this effect, in terms of contribution to recruitment, is unknown. The portion of the larvae produced that might be expected to survive, the number of fish represented and the resulting viability of the wild population cannot be determined with the existing information.

<u>Drift distance requirements</u> – A range of estimates is presented based on uncertainty in water velocity of the Yellowstone and upper Missouri systems, larval drift rate in relation to water velocity, effects of larval age and condition on drift rate, and individual variance in drift rates, which determines the affected portion of the larval population.

<u>Annual flow and temperature effects</u> – Estimates of drift distance requirements generally represent average annual conditions but substantial annual and seasonal variability in benefits

will result from normal variability in flow and temperature patterns. The incidence of conditions under which drift distance is adequate remains unclear.

Benefits of upstream dam removal – It is unknown whether additional benefits will result from removal of additional dams upstream such as Cartersville. The additional drift distance could enhance the benefits of Intake modification, but benefits would obviously depend on whether adult pallid sturgeon take advantage of passage opportunities at each dam and find suitable upstream spawning locations (see previous sections).

Conclusion/Summary

This review concluded that the qualitative treatment of the available data supports the hypothesis that adequate drift distances would exist for natural recruitment to occur if adult pallid sturgeon passage at Intake Dam results in spawning at upstream locations. The best available science supports a conclusion that larval drift distance would likely be adequate for at least a portion of the larvae in some years.

While additional analysis or research could marginally reduce uncertainties regarding the probability of success, it is not likely to provide a more definitive conclusion. Additional analysis in a more comprehensive modeling framework (described above) is not likely to lead to fundamentally different conclusions. Nor is additional research on related questions such as larval drift rates relative to water velocity likely to result in fundamentally different assessments. The true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response.

ENTRAINMENT

The Panel identified several questions from MRRIC related to entrainment topics. These include:

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.8 Question: (if so what design [in reference to the answer to B.7])? Supporting information?

B.9 Question: Given the location where pallid sturgeon larvae drift, will larvae either be trapped in the pool behind the Intake Dam or end up in the diversion?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies stated in their responses to MRRIC questions and in the DEA and BA. Fisheries biologists working on this project (including those from Montana Fish Wildlife and Parks, the U.S. Fish and Wildlife Service (Service), the Corps, and Reclamation) agreed that the screening system represented satisfactory design for pallid sturgeon and other native fishes at Intake. The screen design used the best available technology, including the smallest effective screen size and velocities recommended by the Service's Biological Review Team. The proposed screen size was the smallest that could be used effectively, in accordance with the National Oceanic and Atmospheric Administration (NOAA) juvenile salmonid criteria (maximum screen size of 1.75 millimeters (mm) profile bar (2.38 mm woven wire; Page 2-9 in DEA). The proposed screen design was deemed effective at avoiding entrainment of pallid sturgeon and other fishes over 1.6 inches total length (TL).

A supporting lab study evaluated the best technology available to meet the NOAA screening criteria for juvenile and larval pallid sturgeon < 3.9 inches [9.9 centimeters (cm)] long (Mefford and Sutphin 2008). This study was used to identify and design fish screens for the Intake Project, and evaluated four related topics: 1) swimming endurance, 2) impingement survival, 3) screening effectiveness, and 4) recovery of impinged fish from traveling fish screens. Fish larger than about 1.6 inches (~ 4 cm) were capable of swimming several minutes against a typical fish screen approach velocity of 0.4 ft/s (12.2. cm/s).

This study also indicated that NOAA criteria effectively protect pallid sturgeon >1.6 inches long. Screen impingement for periods up to 10 minutes (maximum impingement time evaluated) had no effect on fish mortality, when fish were recovered by back-flushing the screen.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

However, several studies have been published involving swimming speed and behaviors of juvenile pallid sturgeon that did not appear to be included in the DEA or the MRRIC question and answer document. These studies provided useful empirical information for characterizing entrainment risk for juvenile pallid sturgeon at the proposed Intake screens (Adams et al. 1999, 2003; ERDC 2005). Since the juvenile life stage of pallid sturgeon lasts for more than 8 or 10 years and fish can move great distances during this time, they may be exposed to risk of entrainment throughout this period. However, screen criteria in the proposed design are expected to protect all pallid sturgeon of post-larval and juvenile sizes.

Adams et al. (2003) reported juvenile pallid sturgeon swimming speeds > 15 cm/s, exceeding the 12 cm/s escape velocity needed to avoid entrainment at the proposed diversion intake screens. Adams et al. (1999) reported burst speed swimming of 55-70 cm/s and 40-70 cm/s for groups of large [17.0-20.5 cm fork length (FL)] and small (13.0-16.8 cm FL) juvenile pallid sturgeon. In all cases, escape velocities or swimming speeds demonstrated by juvenile pallid sturgeon (40-70 cm/s) greatly exceeding the 12 cm/s escape velocity required at the proposed diversion intake screens.

The Corps' Engineer Research and Development Center study (ERDC 2005) provided additional useful information to assess juvenile pallid sturgeon entrainment risk at the proposed diversion intake screens. Maximum swimming speeds were documented for groups of large (> 11.5 cm) and small (< 11.5 cm) pallid sturgeon, including 35 cm/s and 20 cm/s for these groups respectively. In both cases, documented escape velocities (20-25 cm/s) greatly exceeded required escape velocities at the proposed diversion intake screens of 12 cm/s.

Uncertainties

Estimates of project benefits are subject to uncertainties, including: the amount of time spent in area immediately in front of new screens at diversion works of both action alternatives by pallid sturgeon < 1.6 inches TL (deemed to be subject to entrainment), and entrainment efficiency of juvenile pallid sturgeon < 1.6 inch TL with proposed screens.

Conclusion/Summary

Completion of the juvenile life stage for pallid sturgeon is a critical prerequisite for mature, reproducing adults. The diversion currently entrains large numbers of fish produced upstream from Intake Dam but entrainment impacts on pallid sturgeon are limited because pallid sturgeon do not occur in significant numbers upstream from the dam. With the restoration of passage, larval and juvenile pallid sturgeon may then become vulnerable to entrainment at the diversion. However, screening of the diversion is likely to substantially reduce the impact of entrainment on vulnerable life stages. Proposed screening technology associated with both action alternatives appears to resolve any concerns about entrainment of larval or juvenile pallid sturgeon > 1.6 inches TL. However, entrainment might be an issue for larval pallid sturgeon between 1 and 1.5 inches TL should they spend considerable time in the immediate area of the diversion screens associated with either of the action alternatives. Current lack of behavioral and habitat use information for pallid sturgeon at this small size precludes any quantitative conclusions regarding their entrainment risk. Larger juvenile pallid sturgeon do not appear to be at risk of entraining based on several studies that tested and documented escape velocities that exceeded or greatly exceeded entrainment velocities (Adams et al. 1999, 2003; ERDC 2005). The Panel concluded that the net benefit of passage and spawning upstream from Intake Dam is likely to be significant even if a portion of the production is then subject to entrainment losses as long as associated diversion fractions are not excessive.

JUVENILE REARING

The Panel identified eight of the questions posed by the MRRIC as having relevance to the juvenile rearing life stage of pallid sturgeon. These questions are:

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.6 Question: Is the bypass design the best for pallid sturgeon?

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.8 Question: (if so what design [in reference to the answer to B.7])? Supporting information?

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.2 Question: How much will this project improve the pallid's survivability?

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at Intake?

Questions B.1-B.6 have been generally addressed in the previous discussion relating to entrainment and are not discussed in more detail in this area. In general, the screened diversion should protect juvenile sturgeon (see previous discussion). Project operations could alter available habitat, but the affects of project operations are to be addressed in a separate consultation process and were therefore not considered by the Panel.

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. The following questions were summarized from MRRIC Questions C.1 through C.4. Although none of these questions were specifically addressed by the MRRIC questions and responses document for juvenile pallid sturgeon, the Panel has provided the following relevant questions and responses for juveniles.

Will the proposal provide meaningful benefit to [juvenile] pallid sturgeon? What level of certainty would you attach to this proposal and its claimed positive effect on [juvenile] pallid sturgeon?

The proposed Intake Project would provide meaningful benefit to juvenile sturgeon, in terms of reduced loss (mortality) from currently unscreened irrigation diversion, and in the form of increased availability of suitable habitat. Telemetered juvenile pallid sturgeon have traveled upstream to the Intake Diversion Dam, did not pass, and turned to swim back downstream (Jaeger et al. 2008). Post-release growth and condition indicate that releases will provide benefits to the population (Jaeger et al. 2005, 2006, 2007). Of all juvenile pallid sturgeon tagged with transmitters and released at up to three sites in the fall, many moved downriver but not past the first downstream dam encountered (Cartersville and Intake; Jaeger 2005, 2006, 2007).

Therefore, based on pallid sturgeon studies over several years in the lower Yellowstone that provided relevant post-release movement and growth data, it is reasonable to expect that removal of the passage barrier for juveniles at Intake will help expand the geographic range and the amount of suitable juvenile habitat available. This could contribute positively to production of mature adults in the population as required for recovery.

What happens [to juvenile sturgeon] if nothing is done at Intake?

In terms of natural production of pallid sturgeon, unless adequate numbers of remnant adults migrate upstream past Intake following project implementation and produce adequate numbers of juveniles for a sustainable year class, this population will go extinct. Given this scenario, in the absence of hatchery input, the population is also expected to go extinct. However, this conclusion does not specifically depend on any current or predicted future limitation(s) of juvenile pallid sturgeon in the study area. Rather, it depends on production and life cycle completion, two things that are currently limited by the passage barrier at Intake Dam.

Is This the Best Available Science and If Not What Needs to Be Added

Information is provided in the preceding discussion supporting the conclusion that the MRRIC responses, DEA, and BA include best available science.

Uncertainties

For juvenile pallid sturgeon relevant uncertainties that might affect success of the proposed project include specific juvenile pallid sturgeon habitat use and requirements.

Conclusion/Summary

Summary and conclusion information can be found in the responses above.

Tier 2 Topics

Tier 2 comments are more minor comments related to the structure of the DEA or material presentation. Tier 2 comments do not relate to the science supporting the responses to the MRRIC questions, DEA, or BA).

Environmental Assessment Organization

The Panel would recommend considering the following clarifications to the DEA:

- Clarify river miles (and consistently use either English or metric units) between major features relevant to the project
- Include figure of river mile locations
- Are all MRRIC responses to be incorporated somewhere into the DEA/BA?

Conservation Genetics

The DEA and BA consider the project effects in terms of the extant population of aging pallid sturgeon. They seldom (if ever) note that a conservation stocking program is currently in place that has stocked a large number of juveniles into RPMA 2 that are assumed to mature in coming years. To what extent genetic diversity in the remnant population and maintained by stocking translates to phenotypic characteristics such as spawning habitat use, migration capability, and larval drift distance is unknown. This has important implications for the population to remain resilient to environmental changes and varying management decisions. The following elements may warrant consideration:

- Selection for slow drifting larvae?
- Revise based on flow/temperature analysis
- How well is the program representing allele frequencies from the remnant population?
- At what point does stocking stop?

Conclusions

In the life history model section, a series of questions were asked that if answered affirmatively would support the supposition that the proposed project would positively affect pallid sturgeon populations in the Great Plains Management Unit. The following section summarizes the results of the scientific review of question by life stage.

1. Pallid Sturgeon Adults (*passage and migration issues*):

Will the Lower Yellowstone Intake Diversion Dam Modification Project provide passage and enhance upstream migration for adult pallid sturgeon? Can and will adult pallid sturgeon pass the diversion structure during the purported spawning season (e.g., May through July) with the proposed modifications?

1a. The documentation of the proposed project provides evidence that the rock ramp alternative will improve passage for adult pallid sturgeon and with passage available adult pallid sturgeon may use habitats upstream of the Intake diversion.

1b. The documentation of the proposed project provides evidence that entrainment of adult pallid sturgeon will be minimized (and potentially eliminated) by the use of the fish screens on the headwater intakes.

1c. The proposed project does not substantially alter the habitat, hydrology, or sediment transport and thus is unlikely to adversely impact migratory or spawning cues for adult pallid sturgeon.

1d. Because the rock ramp will provide a break in the river gradient, a location with swift current (ramp face) near slower water (downstream scour hole) and extensive hard substrate (the ramp itself), the Panel carefully considered the potential attractiveness of this structure to spawning pallid sturgeon. However, the Panel feels that this is not a major concern for the following reasons:

- The small population size of adult pallid sturgeon in the lower Yellowstone River and connected Missouri River may need to expand to cause individuals to explore further upstream for additional suitable spawning habitats.
- The ability to pass the diversion structure will be improved so pallid sturgeon may not stop at the diversion structure on their upstream migration.
- The selection of the alternative that would relocate the main channel would also provide many of the same attracting characteristics (gradient changes, complex depth and

velocity patterns, and hard substrates from riprap and gradient control structures) as the rock ramp alternative.

1e. The current hydrology of the Intake Dam area and its implications for passage were not summarized in any of the answers nor in the DEA or BA. Including information from other systems with parallel issues of passage suggests that some passage across the current Intake Dam may currently occur, albeit infrequently and only during the highest flow periods.

Panel Conclusion: The proposed rock ramp alternative would provide passage and enhance upstream migration for adult pallid sturgeon. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information in the Yellowstone River basin and provided documentation of the assessment of alternatives, feasibility studies, and project design. Inclusion of comparisons of pallid sturgeon movement associated with the low head dam on other rivers would strengthen the report's conclusions.

2. Pallid Sturgeon Adults (*spawning issues*):

Does suitable spawning habitat exist upstream of the Yellowstone Intake Diversion Dam, and if so, where and how far upstream is it located?

2a. Suitable spawning habitat likely exists upstream of the Yellowstone Intake Diversion Dam.

2b. The definition of suitable pallid sturgeon spawning habitat as "terrace or bluff pools" is reasonably supported by recent scientific findings about pallid sturgeon spawning habitats.

2c. An estimated 4,000 acres of terrace pool and bluff pool habitats are present in the Yellowstone River between diversion dam at Intake and Cartersville, Montana (M. Jaeger, FWP, personal communication). The location (or distance upstream from Lake Sakakawea) is critical in determining if the potential habitat has suitable drift distances.

2d. Jaeger (2005) reports delineating all reaches and habitats on the Yellowstone River between the river km 74 and 537. This delineation included terrace and bluff pools. Given the importance of achieving adequate larval drift distance to the success of this project, a more detailed description to the amount and distribution of terrace and bluff pool habitats throughout the Yellowstone River would greatly improve the readers' understanding of potential increases in larval drift distances provided by the passage of the Yellowstone Diversion Intake Dam.

2e. The Panel thought it important to note that even if pallid sturgeon have suitable spawning habitat upstream near the Cartersville Diversion Dam, it may take some time before sturgeon utilize the spawning locations as sturgeon may stop at equally suitable downstream spawning locations. Increases in population size associated with the maturation of stocked pallid sturgeon would likely increase the probability of the use of more spawning locations.

Panel Conclusions: The consensus of the Panel was that suitable habitat exists upstream of the Yellowstone Diversion Intake Dam at suitable distances for pallid sturgeon larval drift in some years. Our analysis of larval drift distances related to discharge suggests that spawning locations far downstream of the Cartersville Diversion may have adequate larval drift distances for a small portion of larvae to develop prior to reaching Lake Sakakawea in some years. In most years there is some chance for pallid sturgeon larvae to complete the drift and settle in suitable habitats if the adults spawn near Cartersville. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions although the inclusion of maps with locations of terrace and bluff pool habitats would support the conclusions more strongly.

3. Pallid Sturgeon Eggs (*development and survival issues*):

Are conditions at the potential upstream spawning sites suitable for the development and survival of pallid sturgeon eggs?

3a. The Yellowstone River maintains a relatively natural flow with a snowmelt rise in discharge associated with the spawning of pallid sturgeon. The general habitat conditions are likely suitable for egg development and survival. Any abiotic factors such as toxins in the water or substrate that may limit egg and embryo development and survival have yet to be identified and the proposed modification to the Yellowstone Intake Diversion Dam is unlikely to decrease the development or survival of pallid sturgeon eggs, embryos, and free embryos.

3b. Increases in discharge result in an associated increase in turbidity. The highly turbid natural condition of the Yellowstone River during pallid sturgeon spawning likely provides some protection from sight feeding predators on pallid sturgeon eggs.

Panel Conclusion: Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs, embryos, and free embryos. The proposed modification to the Yellowstone Intake Diversion Dam is unlikely to decrease the development or survival of pallid sturgeon eggs. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions.

4. Pallid Sturgeon Larvae (*downstream drift issues*):

If pallid sturgeon access and successfully spawn at upstream locations, do sufficient downstream drift distances exist for larval development? Are embryo and larval drift distances adequate with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea? Does the proposed fish screen decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon?

4a. It appears that during some years, potential upstream spawning sites will provide adequate larval drift distances with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea.

4b. A decrease in entrainment of larval pallid sturgeon is likely given the design parameters of the screens and empirical swimming attributes of young pallid sturgeon. The Panel agrees that complete elimination of larval entrainment or impingement is not feasible. Positioning the intakes at least 1 m above the bottom would likely avoid entrainment of the bottom drifting larvae.

4c. Given the importance of achieving adequate larval drift distance to the success of this project, a clearer description to range of expected drift distances associated with historical discharge on the Yellowstone River would greatly improve the readers understanding of potential increases in larval drift distances provided by improving the passage facilities at the Yellowstone Diversion Intake Dam. Preliminary analysis conducted by the Panel indicates that:

- A basic model of drift distances related to historical discharge between May 15 and July 15 suggests that that improving passage will provide the possibility of adequate drift distances for small portions of pallid sturgeon larvae during most years.
- Including pallid sturgeon passage of the Cartersville Diversion, adequate drift distances for pallid sturgeon larvae increases substantially.

Panel Conclusions: It is the consensus of the Panel that potential upstream spawning sites will provide adequate larval drift distances with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea in some years. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions, although a more structured analysis of the information would greatly improve support for their conclusions. A clear description of larval drift distances would also highlight the importance completing fish passage at the Cartersville Diversion in the recovery of pallid sturgeon in the Yellowstone River.

5. Pallid Sturgeon Juvenile and Adult Life History (*Habitat and growth issues*):

If the Intake Project functions as proposed, do conditions in the Yellowstone and connected sections of the Missouri River have suitable conditions to support completion of the pallid sturgeon life cycle? Are conditions suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon? Will the Intake Project have either neutral or positive effects on the juvenile through pre-reproductive adult stages?

5a. Juvenile and adult pallid sturgeon already find suitable habitats for growth, survival, and maturation in the Yellowstone and connected sections of the Missouri Rivers.

5b. The proposed project does not substantially alter the habitat, hydrology, or sediment transport from current conditions and thus is unlikely to adversely impact pallid sturgeon growth, survival, or maturation.

5c. The decrease in entrainment of small fishes will likely provide increased food resources for pallid sturgeon and thus improve growth, survival, and maturation.

5d. The proposed project provides evidence that entrainment of juvenile and adult pallid sturgeon will be minimized (and potentially eliminated) by the use of the fish screens on the headwater intakes thus improving survival.

5e. It is unclear if the opening of habitats upstream of the diversion intake will result in large increases in juvenile pallid sturgeon habitat as many pallid sturgeon stocked at upstream sites moved downstream. This is not a problem with the design of the rock ramp or the overall proposed project. Given the small population size of pallid sturgeon in the lower Yellowstone River and connected Missouri River it is unlikely that juvenile or adult pallid sturgeon are currently habitat limited. Thus even if pallid sturgeon do not use the upstream habitats except during spawning seasons, the creation of adequate larval drift distances has the potential to increase population size within the area as a whole.

Panel Conclusions: Conditions in the Yellowstone and connected sections of the Missouri River appear suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon. The proposed project will not adversely affect and will likely enhance the growth, survival, and maturation of juvenile and adult pallid sturgeon. The DEA, BA, MRRIC Question and Answers, and supporting documentation used quality available information to support their conclusions. Additional information from published studies (Adams et al. 1999, 2003; ERDC 2005) supports the suitability of the screen design to lower entrainment risk for juvenile pallid sturgeon at the proposed intake screens.

Overall Conclusions

It is the consensus view of the Panel that the best available science was used in the development of the DEA, BA, MRRIC Question and Answers, and supporting documentation. Without the resumption of natural spawning there is no real possibility that the naturally produced (i.e., non-stocked) pallid sturgeon population in RPMA 2 will recover from its endangered status; without stocking it will likely be extirpated within a few years. The Intake Project, as described in the materials the Panel reviewed has the potential to provide access to pallid sturgeon spawning and early rearing habitats that have been blocked for nearly a century by the Intake Dam. In addition, modifications to prevent loss of fish into the irrigation canal will reduce losses of sturgeon and other species.

The Panel recognized that the probability of success cannot be determined with complete assurance because of significant uncertainties that inevitably constrain our ability to predict the behavior of complex biological systems. It remains plausible that the action will not achieve the desired effect. However, this action clearly represents a reasonably realistic alternative for restoration of natural recruitment for this distinct and evolutionarily-significant population of pallid sturgeon. Although there may be other issues outside of the Yellowstone River proper, this project seems, in our judgment, to have good potential to contribute to the re-development of a naturally reproducing population of pallid sturgeon in RPMA 2. It will also be an essential step in identifying the need to consider additional actions required throughout RPMA 2 to meet recovery objectives.

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Appendix 1: Panelist CVs

PAUL J. ANDERS, Ph.D.

ASSOCIATE CONSULTANT, FISHERIES SCIENTIST

Cramer Fish Sciences
121 Sweet Ave., Suite 118
Moscow, ID. 83843
208-883-9730
anders@fishsciences.net
www.fishsciences.net

AFFILIATE FACULTY

University of Idaho
College of Natural Resources
Department of Fish and Wildlife
Moscow, ID. 83844
208-883-9730

PROFESSIONAL HISTORY

Dr. Anders is an Associate Consultant and a Fishery Scientist with Cramer Fish Sciences Inc., and serves as Affiliate Faculty in the Department of Fish and Wildlife Resources at the University of Idaho in Moscow. Paul has 23 years experience in the fisheries profession, with 20 years in the Columbia River Basin, US and Canada. Paul is a prolific writer, having published over 100 scientific papers, reports, articles, and abstracts addressing a wide range of fisheries and aquatic ecology topics since 1991. Dr. Anders has contributed to the acquisition of over $25 million in fisheries and aquatic science project funding through authorship and co-authorship of numerous grant proposals since 1988.

EDUCATION

Ph.D. Natural Resources (Conservation Biology of White Sturgeon), University of Idaho, 2002
M.S. Biology (Fisheries), Eastern Washington University, 1991
B.S. Natural Science, Saint Norbert College, 1983

VITAL INFORMATION

EMPLOYMENT HISTORY

1. Associate Consultant, Fishery Scientist, Cramer Fish Sciences (Formerly S. P. Cramer and Associates) Moscow, ID. (10/05-Present)
2. Affiliate Faculty, University of Idaho, College of Natural Resources, Fish and Wildlife Department (9/03-present)
3. Senior Fisheries Consultant, S. P. Cramer and Associates, Moscow, ID. (10/02-10/05)
4. Fisheries Scientist (0.5FTE) Columbia River Inter-Tribal Fish Commission, Steelhead kelt reconditioning project (Fall 01 – Fall 02)
5. Research Support Scientist II, University of Idaho, Center for Salmonid and Freshwater Species at Risk Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (1/00-10/02)
6. Research Associate, University of Idaho, Center for Salmonid and Freshwater Species at Risk Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (1/99-1/00)
7. Independent Fisheries Consultant (1/99-10/02)
8. Doctoral Research Assistant, University of Idaho, Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (7/96-12/98)
9. Fisheries Biologist/Administrator, Kootenai Tribe of Idaho, PO. Box 1269, Bonners Ferry, ID. (5/94-7/96)
10. Fisheries Biologist, Kootenai Tribe of Idaho, PO. Box 1269, Bonners Ferry, ID. (2/93-5/94)
11. Fisheries Biologist (GS-9-482), U.S. Fish and Wildlife Service, Columbia River Field Station, Cook WA. (8/90 - 2/93)
12. Graduate Research Assistant, Eastern Washington University, Cheney, WA. (1/89-5/91)
13. Fisheries Technician, white sturgeon research Idaho Department of Fish and Game, Bonners Ferry, ID. (1/89-8/90)
14. Fisheries Technician, anadromous research, Idaho Department of Fish and Game, Lewiston, ID. (12/87-12/89)
15. Research Assistant, altered reservoir ecology, Fish and Wildlife Cooperative Research Unit, South Dakota State University, Brookings (9/84-12/87)
16. Research Assistant, stream fish ecology, University of North Dakota, Grand Forks, and University of Minnesota Biological Research Station, Itasca, MN. (5-9/84)

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107. Anders, P. J., A. I. Miller, and L. G. Beckman. 1995. Feasibility of radio telemetry to document fish movements in the Columbia River. In: Status and Habitat Requirements of the White Sturgeon Populations in the Columbia River Downstream from McNary Dam. Project No. 86-50. Final Report of Research to the Bonneville Power Administration, U.S. Dept. of Energy, Portland, Oregon. Volume 2.

108. Parsley, M. J., P. J. Anders, A. I. Miller, L.G. Beckman, and G .T. McCabe. 1995. Factors affecting spawning and recruitment of white sturgeon in the Columbia River downstream from McNary Dam. In: Status and Habitat Requirements of the White Sturgeon Populations in the Columbia River Downstream from McNary Dam. Project No. 86-50. Final Report of Research to the Bonneville Power Administration, U.S. Dept.

of Energy, Portland, Oregon. Volume 2.

109. Siple, J. T., and P. J. Anders. 1995. Annual Kootenai Hatchery Report. In: Kootenai River White Sturgeon Studies. Annual Report of Research. Report B. Bonneville Power Administration Project No. 88-64.

110. Anders, P. J. 1994a. Kootenai River fisheries studies. Annual Progress Report FY93. Report A: Natural spawning of white sturgeon in the Kootenai River. Kootenai Tribe of Idaho. Prepared for U.S. Department of Energy, Bonneville Power Administration. Project No. 88-64. Portland, OR.

111. Anders, P. J. 1994b. Kootenai River fisheries studies. Annual Progress Report FY94. Report A. Natural spawning of white sturgeon (*Acipenser transmontanus*) in the Kootenai River, 1994. Kootenai Tribe of Idaho. Prepared for U.S. Department of Energy, Bonneville Power Administration. Project No. 88-64. Portland, OR.

112. Anders, P. J. 1993. Kootenai River Fisheries Studies. Annual Progress Report FY93 Report C: Kootenai River tributary kokanee spawning ground survey. Kootenai Tribe of Idaho. Prepared for U.S. Department of Energy, Bonneville Power Administration. Project No. 88-64. Portland, OR.

113. Anders, P. J., and L. G. Beckman. 1993. Location and Timing of White Sturgeon Spawning in Three Columbia River Impoundments. Report B. Pages 47-59 *in* R. C. Beamesderfer and A. A. Nigro editors. Status and Habitat Requirements of the White Sturgeon Populations in the Columbia River Downstream From McNary Dam. Vol. 1. Final Report to Bonneville Power Administration, Project No. 86-50. Portland, OR.

114. Anders, P. J. 1991. White sturgeon (*Acipenser transmontanus*) movement patterns and habitat utilization in the Kootenai River system, Idaho, Montana and British Columbia. Master's Thesis, Eastern Washington University. 153 pp.

115. Apperson, K. A. and P. J. Anders. 1991. Kootenai River white sturgeon investigations and experimental culture. Annual Progress Report FY1990. Idaho Department of Fish and Game. Report prepared for Bonneville Power Administration, Contract No. DE-A179-88BP3497; Project No. 198806500. Portland, Oregon.

Research grant acquisition history from grant proposals authored or coauthored by Paul Anders, including submitted proposals for work through 2009. See the following page for project titles and funding sources.

Project:	1	2	3	4	5	6	7	8 to 16
Year								
1988	$117,653							
1989	$156,104							
1990	$236,430							
1991	$150,000							
1992	$179,723							
1993	$649,573							
1994	$378,553							
1995	$952,387	$175,000						
1996	$67,356	$175,000						
1997	$566,650	$226,600						
1998	$715,000	$250,000		$40,000				
1999	$1,263,692	$245,598		$60,000				
2000	$880,193	$300,000		$146,938				
2001	$1,147,674	$272,410		$136,043				
2002	$1,330,389	$380,539						
2003	$989,751	$710,268						
2004	$1,390,068	$953,377					$70,000	
2005	$1,413,817	$1,643,840	$20,100					
2006	$1,413,817	$1,643,840	$130,500					
2007	$1,970,800	In negotiation	In negotiation	In negotiation				$68, 367
Totals	**$13,998,830**	**$6,976,472**	**$146,300**	**$382,981**			**$70,000**	**$68,367**

Total grant money secured through to date in 2007: $ 21,642,950

Project	Project funding source(s) and Project Titles
1	BPA/KTOI Project 198806400 - Kootenai River Native Fish Restoration and Conservation Aquaculture
2	BPA/KTOI Project 199404900 - Kootenai River Ecosystem Improvements Project
3	BPA/KTOI Project 200201100 - Kootenai River Floodplain Operational Loss Assessment
4	BPA/UI Projects 19860500/19990220 - Assessing Genetic Variation Among Columbia Basin White Sturgeon Populations
5	BPA/KTOI Project 200200200 - Restore Natural Recruitment of Kootenai River White Sturgeon
6	BPA Project 200701330Systemwide distribution of genetic variation within and among populations of the white sturgeon
7	US Army Corps of Engineers - Fisheries Advisor
8	British Columbia Ministry of Water, Land, & Air Protection - Conservation aquaculture program design and review
9	British Columbia Ministry of Water, Land, & Air Protection - White Sturgeon Recovery
10	BPA-Kootenai River and Kootenai/y Lake Burbot demographic and genetic review
11	Mobrand Inc. - Hatchery Review
12	Parametrix: Lake Roosevelt - Whole Lake Assessment
13	NPPC - Artificial Production Review
14	Tetra Tech Inc. Critical Habitat Restoration Project
15	Canadian Columbia River Intertribal Fish Commission - White Sturgeon Stocking review
16	Canadian Columbia River Intertribal Fish Commission - Experimental non-essential population development and review
17	Yakama Indian Nation – Habitat and nutrient restoration research in anadromous salmonid habitats

PROFESSIONAL SOCIETY AND ORGANIZATION INVOLVEMENT

- Member of American Fisheries Society (1985-Present)
- Upper Columbia River White Sturgeon Recovery Team, Genetics Subcommittee, British Columbia (2001-Present)
- Chair of the Coeur d'Alene Tribal Interdisciplinary Hatchery Team (2002-2003)
- Member of Kootenai Tribe of Idaho's Research Review and Design Team (2002-present)
- Member of International Kootenay Ecosystem Restoration Team (IKERT, 1999-Present)
- Co-Chair of Columbia Basin White Sturgeon Genetics Workgroup (1999- Present)
- Member of the Snake River White Sturgeon Technical Advisory Committee (Idaho Power Company, 1999-Present)
- Member of Coeur d'Alene Tribal Interdisciplinary Hatchery Team, and Project Review Team (2001-2003)
- Member of the Society for Conservation Biology (1997-Present)
- Member of American Fisheries Society, Idaho Chapter (1988-1991, 1995-Present), Graduate Student Representative, Palouse Unit of the Idaho Chapter (1997-1998)
- Federally appointed member of U.S. Fish and Wildlife Service Kootenai River White Sturgeon Recovery Team (1994-Present)
- Member of Pacific Fishery Biologists (1992-1996)
- Member of American Fisheries Society, Pacific International Chapter (1991-1994)
- Member Kootenai River Network (1990-Present)
- Associate Member of Sigma Xi Scientific Research Honor Society (1989-Present)
- Member of Gamma Sigma Delta, Academic Honor Society of Agriculture, (1986, 1987)
- President of Lakota Chapter of the National Audubon Society, Brookings, SD. (1/87-12/87)
- Member of Lakota Chapter of the Audubon Society (3/86-3/88)
- Member of South Dakota Chapter of The Nature Conservancy (1986-1987)
- Member of South Dakota Wildlife Federation (1986)
- Chairman of Fisheries Committee, Brookings Wildlife Conservationists (1986)
- Member of American Fisheries Society, Dakota Chapter (1985-1987)

PROFESSIONAL REFERENCES

The following people are available for comment concerning my professional performance and accomplishments:

- Steve Cramer, President and Principal Consultant, Cramer Fish Sciences Inc. 600 NW Fariss Rd. Gresham OR. 97030 (503) 491-9577. SteveC@spcramer.com
- Ray Beamesderfer, Associate Consultant, Fishery Scientist, Cramer Fish Sciences Inc. Inc. 600 NW Fariss Rd. Gresham OR. 97030 (503) 491-9577. beamesderfer@spcramer.com
- Dr. Ken Cain, Associate Professor, Department of Fish and Wildlife resources, University of Idaho, Moscow, ID. 83843. kcain@uidaho.edu
- Susan Ireland, Fishery Biologist/ Program Director, Kootenai Tribe of Idaho, Bonners Ferry, ID. 83805 (208) 267-3620; ireland@kootenai.org.
- Dr. Ken Ashley, British Columbia Ministry of Land Water and Air Protection, University of British Columbia. Ken.Ashley@gvrd.bc.ca (604) 432-6438.
- Harvey Andrusak, President, Redfish Consulting Ltd. Nelson, British Columbia. handrusak@shaw.ca, (250) 825-9365.
- Colin Spence, Rare and Endangered Species Biologist, British Columbia Ministry of Environment, Lands, and Parks, 333 Victoria St., Nelson, BC. (250) 354-6777

CLIENT AND COLLABORATOR TESTIMONIALS

- "Paul is an outstanding scientist that understands practical application of research results. He is a pleasure to work with and has impeccable integrity."

  - Jason Scott, Senior Fisheries Scientist, GeoEngineers, Inc., Spokane Washington.

- "Dear Dr. Anders: Thank you very much for your expert input and assistance on the Kootenai River fertilization experiment. The Kootenai River project is the largest and one of the most complex nutrient enrichment restoration experiments to have ever occurred. It is a perfect complement to the multi-year Kootenay Lake fertilization experiment downstream in British Columbia. It would not have been possible to obtain regulatory approval for this experiment without the sound science and management experience you brought to the process".

  - Ken Ashley, Ph.D., Limnologist and Senior Engineer, Greater Vancouver Regional District, BC.

- "In collaboration with Paul Anders at Cramer Fish Sciences, we were able to develop a truly innovative approach to Subbasin Planning in the Kootenai. Aspects of our plan became a model for other Subbasin Plans across the Columbia River Basin. Paul's contribution, along with his professionalism and hard work, was a big reason for that."

  - David Rockwell, Natural Resource Author and Consultant, Dixon, Montana

CRAMER FISH SCIENCES
Oregon • California • Washington • Idaho • Alaska

600 NW Fariss Road
Gresham, OR 97030
V: 503.491.9577
F: 503.465.1940
beamesderfer@fishsciences.net

Raymond C. P. Beamesderfer

Senior Fish Scientist

Education and Training

B.S. in Wildlife & Fisheries Biology 1979, University of California, Davis.

M.S. in Fishery Resources 1983, University of Idaho.

Employment History

Cramer Fish Sciences, Senior Fish Scientist, 2000-Present.

Oregon Department of Fish and Wildlife, Fishery Management Biologist, 1997-2000.

ODFW, Staff Biologist/ Analyst, 1994-1997.

ODFW, Fish Research, 1983-1993.

Professional Activities

Certified Fisheries Scientist, American Fisheries Society, 1989.

Associate Editor, North American Journal of Fisheries Management, 1992-1993.

Speaker at numerous regional, national, and international symposiums of fisheries scientists.

Ray has analyzed applied problems of fish biology and management for over 25 years:

- extensive experience with salmon, steelhead, trout, sturgeon, warmwater gamefish, and nongame species;
- work in Oregon, Washington, Alaska, Idaho, California, and British Columbia;
- numerous reports, biological assessments, management plans, and scientific articles on fish population dynamics, fish conservation, fishery management, sampling, and species interactions;
- special expertise in the use of quantitative analysis, statistics, and computer modeling to solve difficult fish questions and in synthesizing and translating scientific analyses for a variety of audiences;
- widely-recognized expertise in sturgeon population dynamics, biological assessment, conservation, and management.

With *Fish Sciences*, Ray has completed a wide variety of fishery management, biological assessment, and conservation or recovery planning projects for State and Federal Agencies, Indian Tribes, Private Industry, and Non-Governmental Organizations. Significant sturgeon-related projects have included conservation and recovery plans for upper Columbia River white sturgeon and Sacramento green sturgeon, status assessments and hatchery evaluations of Kootenai sturgeon, biological assessments of the effects of water project operations, and design of monitoring and evaluation programs. Ray has also provided extensive technical review and input on pallid sturgeon issues.

Previously, he worked for the Oregon Department of Fish and Wildlife as a management biologist for Columbia River salmon and sturgeon fisheries; staff analyst and agency representative for inter-jurisdictional Columbia River salmon, resident fish, and hydropower issues; and program and project leader for research on sturgeon stock assessments, predator control evaluation, warmwater fish management alternatives, adult and juvenile salmon passage at dams and diversions, and design and implementation of a system to facilitate exchange of salmon and steelhead data for the Columbia River basin (*StreamNet*).

Projects

Biological Assessment

Comments on green sturgeon portions of the Oroville Dam Draft Biological Opinion by the National Marine Fisheries Service. 2009. *California State Water Contractors.*

Comments on green sturgeon portions of the Biological Opinion on the Long-term Central Valley Project and State Water Project Operations Criteria and Plan. 2009. *California State Water Contractors.*

Kenai River Habitat Assessment. 2008. *Alaska Department of Fish and Game and the Kenai River Sportfishing Association.*

Status and limiting factors of ESA-listed lower Columbia and Willamette River chum, Chinook, coho, and steelhead in supplemental comprehensive analysis of the federal Columbia River power system and mainstem effects of the upper Snake and other tributary actions. 2007. *National Oceanic and Atmospheric Administration and the Bonneville Power Administration*.

Independent technical review of predation scenarios on juveniles salmonids in the Columbia River. 2007. *Battelle Pacific Northwest Laboratory*.

Independent technical review of evaluation of ladder use at John Day Dam by chinook salmon and steelhead trout. 2006. *Battelle Pacific Northwest Laboratory*.

Oregon Native Salmon and Steelhead Conservation Assessment. 2005. *Oregon Department of Fish and Wildlife*.

Population dynamics and extinction risks of Kootenai River burbot. 2004. *Kootenai Tribe of Idaho and Idaho Department of Fish and Game*.

Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. 2004. *California State Water Contractors*.

Stranding of juvenile fall chinook salmon in the Hanford Reach of the Columbia River as a result of hydropower operations. 2003. *Columbia River Intertribal Fish Commission for Alaska Department of Fish and Game*.

Green sturgeon status review. 2002. *Metropolitan Water District of Southern California*.

Indirect effects of water export on juvenile salmon in the Sacramento-San Joaquin Delta: a conceptual Foundation. 2002. *Metropolitan Water District of Southern California*.

Analysis of cutthroat trout population viability in Timothy Lake, Oregon. 2002. *Portland General Electric*.

Evaluation and modeling of steelhead capacity, population dynamics, and reintroduction potential above impoundments in the upper Deschutes River, Oregon. 2001. *Portland General Electric*.

Analysis of salmon rearing, migration, survival, and passage based on PIT tag detections for the Clackamas River. 2001. *Portland General Electric*.

Biological assessment of effects of Sherman Island Levee repairs on listed Delta smelt and Sacramento splittail. 2001. *James C. Hanson Engineers*.

Review of conservation assessment of steelhead populations in Oregon. 2001. *American Forest Resources Council*.

Documentation of existing and historic habitat, and native and introduced fish in the Clackamas basin, Oregon. 2001. *Portland General Electric*.

Relicensing studies of fish populations in the upper Stanislaus River, California. 2001. *Pacific Gas and Electric Company and Tri-dam Project*.

Assessments of biological and habitat effects of Otter Creek and South Fork to Black Bear Creek projects. 2001. *Alaska Power and Telephone*.

Conservation & Recovery Planning

Assessment of adult population objectives and monitoring needs for Pallid Sturgeon. March 23-24, 2009. Pallid Sturgeon Conference and Workshop. Billings MT.

Peer review of critical habitat designation for white sturgeon populations in British Columbia, Canada under the Species At Risk Act. 2009. *Department of Fisheries and Oceans Canada.*

Preparation of background materials for the development of the recovery plan for the southern distinct population segment of North American green sturgeon. 2009. *National Marine Fisheries Service Southwest Region.*

Lower Columbia salmon and steelhead recovery plan. 2009. *Washington Lower Columbia River Fish Recovery Board*.

Research, monitoring and evaluation program for Lower Columbia Salmon and Steelhead. 2008. *Washington Lower Columbia River Fish Recovery Board.*

Estimation of salmon recovery targets for ESA-listed lower Columbia and Willamette river coho, Chinook, Chum, and steelhead using population viability analysis. 2007. *Oregon Department of Fish and Wildlife and Washington Lower Columbia River Fish Recovery Board.*

Lower Columbia salmon and steelhead recovery plan (interim). 2002-2004. *Washington Lower Columbia River Fish Recovery Board*.

Kootenai River Burbot conservation plan. 2004. *Kootenai Tribe of Idaho*.

Upper Columbia River white sturgeon recovery plan. 2002. *Spokane Tribe of Indians, British Columbia Ministry of Water, Land and Air Protection, and BC Hydro Corporation*.

Fishery Management

Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 2009. *Pacific Fishery Management Council.*

Biometrics and fishery analysis support for the Pacific Fishery Management Council Scientific and Statistical Committee. 2009. *Oregon Department of Fish and Wildlife.*

Risk Analysis of All-H Recovery Strategies for Tule Fall Chinook. 2009. *Washington Lower Columbia River Fish Recovery Board.*

Peer review of Marine Stewardship Council assessment of the sustainability of British Columbia commercial salmon fishery. 2009. *TAVEL Certification.*

Problems and solutions in escapement goal management of upper Cook Inlet salmon fisheries. 2008. *American Fisheries Society Alaska Chapter Meeting.*

Marine Stewardship Council assessment of the sustainability of Russia's JSC Gidrostroy commercial salmon fishery on Iturup Island in the south Kuriles. 2008. *Scientific Certification Systems*.

Upper Cook Inlet salmon fishery model for analyzing harvest, allocation, and escapement effects of alternative management strategies. 2008. *Kenai River Sportfishing Association*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2008. *Kenai River Sportfishing Association*.

Fishery risk assessment for Columbia River coho based on population viability analysis. 2007. *Washington Department of Fish and Wildlife and the Lower Columbia Fish Recovery Board*.

Biological analysis of population and fishery effects of *de minimis* fisheries for Klamath Fall Chinook. 2007. *Pacific Fishery Management Council*.

Marine Stewardship Council assessment of the sustainability of Alaska commercial salmon fisheries. 2007. *Scientific Certification Systems and the Alaska Department of Fish and Game*.

Kasilof sockeye escapement goal analysis. 2007. Kenai River Sportfishing Association.

Analysis of size-selective Kenai King salmon fisheries and regulations. 2007. *Alaska Department of Fish and Game*.

ESA fisheries management and evaluation plan for lower Columbia River coho in Oregon freshwater fisheries of the lower Columbia River. 2005. *Oregon Department of Fish and Wildlife*.

Analysis of the potential effects and alternatives for selective fishing in the lower Columbia River commercial and recreational fisheries. 2005. *Bonneville Power Administration*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2005. *Kenai River Sportfishing Association*.

Review of the Coded Wire Marking Program for Columbia Basin Hatchery Salmon and Steelhead, Phase I. 2004. *Bonneville Power Administration*.

Review of live capture selective harvest methods study for Columbia River spring chinook. 2003. *Salmon for All*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2002. *Kenai River Sportfishing Association*.

Effects of large-mesh gillnet use on steelhead and salmon catch in Columbia River Zone 6 gillnet fisheries. 2001. *Yakama Nation and the Bonneville Power Administration*.

ESA fisheries management and evaluation plan for lower Columbia River chinook in Oregon freshwater fisheries of the lower Columbia River. 2001. *Oregon Department of Fish and Wildlife*.

ESA fisheries management and evaluation plan for upper Willamette Spring chinook in freshwater fisheries of the Willamette basin and lower Columbia River. 2000. *Oregon Department of Fish and Wildlife*.

Conservation risks of mixed stock fisheries for wild spring chinook salmon from Oregon's McKenzie River based on a population viability analysis. 2000. *Oregon Department of Fish and Wildlife.*

Peer review of certification report on sustainability of Alaska salmon fisheries. 2000. *Marine Stewardship Council*.

Hatchery Evaluation

Strategic and Hatchery Master Plans for impounded white sturgeon populations of the lower Columbia and Snake rivers. 2008-2009. Columbia River Inter-tribal Fish Commission.

Sturgeon hatchery planning and evaluation technical assistance. 2009. *Yakama Nation Fisheries.*

Upper Columbia sturgeon hatchery release strategy. 2008. *British Columbia Ministry of Environment and BC Hydropower*.

Kootenai River White Sturgeon Conservation Aquaculture Program Overview, 1990-2007. 2008. *Kootenai Tribe of Idaho*.

Kootenai River sturgeon hatchery and endangered species evaluations. 2001-2009. *Kootenai Tribe of Idaho*.

Hatchery genetic management plans for the Sandy and Clackamas River Hatcheries. 2005. *Oregon Department of Fish and Wildlife*.

Coeur d'Alene Tribe Trout Production Master Plan. 2002. *Coeur d'Alene Tribe*.

Scientific Publications

2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences 66:802-815. *(Justice, Pyper, Beamesderfer, Paragamian, Rust, Neufeld & Ireland).*

2008 Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234. *(Paragamian, Pyper, Daigneault, Beamesderfer & Ireland).*

2007 Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337. *(Beamesderfer, Simpson, & Kopp).*

2005 Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532. *(Paragamian, Beamesderfer & Ireland).*

2004 Dilemma on the Kootenai River - The risk of extinction or when does the hatchery become the best option? American Fisheries Society Symposium 44:377-385. *(Paragamian & Beamesderfer).*

2003 Growth estimates from tagged white sturgeon suggest that ages from fin rays underestimate true age in the Kootenai River, USA and Canada. Transactions of the American Fisheries Society 132:895-903. *(Paragamian & Beamesderfer).*

2002 Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650. *(Ireland, Beamesderfer, Paragamian, Wakkinen & Siple)*.

2000 Managing fish predators and competitors: Deciding when interspecific intervention is effective and appropriate. Fisheries 25(6):18-23. *(Beamesderfer).*

1997 Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417. *(Beamesderfer & Farr).*

1996 Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908. *(Beamesderfer, Ward & Nigro).*

1995 Growth, natural mortality, and predicted response to fishing for largemouth and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688-704. *(Beamesderfer & North).*

1995 Differences in the dynamics and production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society 126:857-872. *(Beamesderfer, Rien & Nigro).*

1994 Accuracy and precision in age estimates of white sturgeon using pectoral fin rays. Transactions of the American Fisheries Society 123:255-265. *(Rien & Beamesderfer).*

1994 Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80:161-170. *(Rien, Beamesderfer & Foster).*

1993 Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67:105-111. *(North, Beamesderfer & Rien).*

1993 A standard weight equation for white sturgeon. California Fish and Game 79:63-69. *(Beamesderfer).*

1992 Book review of "Pacific Salmon Life Histories." Fisheries 17:56-58. *(Beamesderfer).*

1992 Reproduction and early life history of northern squawfish (*Ptychocheilus oregonensis*) in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241. *(Beamesderfer).*

1991 Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447. *(Beamesderfer & Rieman).*

1991 Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458. *(Rieman, Beamesderfer & Poe).*

1990 Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304. *(Beamesderfer, Rieman, & Vigg).*

1990 Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76:174-180. *(Elliott & Beamesderfer).*

1990 Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241. *(Rieman & Beamesderfer).*

1990 White sturgeon in the lower Columbia River: Is the stock overexploited? North American Journal of Fisheries Management 10:388-396. *(Rieman & Beamesderfer).*

1988 Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510. *(Beamesderfer & Rieman).*

Name James E. Garvey

Title Associate Professor, Zoology, College of Science
Director, Fisheries and Illinois Aquaculture Center, Graduate School

Date of Birth 11 July 1968

Address 173 Life Sciences II
Fisheries and Illinois Aquaculture Center (FIAC)
Department of Zoology
1125 Lincoln Drive
Southern Illinois University–Carbondale
jgarvey@siu.edu
http://www.science.siu.edu/zoology/garvey/index.html
http://fisheries.siu.edu
http://fishdata.siu.edu (curator)

Education
- 1998 Post-Doctoral Fellow, Queens University, Ontario
- 1997 Ph.D., Zoology, The Ohio State University, Ohio
- 1992 M.S., Zoology, The Ohio State University, Ohio
- 1990 B.A., *cum laude*, Zoology, Miami University, Ohio

Professional Experience

2009	Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2008-2009	Interim Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2005-2008	Associate Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2005-	Associate Professor, Department of Zoology, Southern Illinois University
2000-2005	Assistant Professor, Department of Zoology, Southern Illinois University
1998-2000	Assistant Professor, Division of Biology, Kansas State University
1997-1998	Postdoctoral Fellow, Department of Biology, Queens University, Ontario
1997	Research Associate, Department of Zoology, The Ohio State University
1996-1997	Presidential Fellow, Graduate School, The Ohio State University
1990-1996	Graduate Research Associate, Department of Zoology, The Ohio State University
1990-1996	Graduate Teaching Associate, Department of Zoology, The Ohio State University
1988-1990	Research Technician, Department of Zoology, Miami University
1988	Student Researcher, School for Field Studies, St. John, U.S. Virgin Islands

Fields of Research Competence

Aquatic ecology, fish ecology, basic and applied fish biology, limnology, food web dynamics, life history modeling. My current research follows three basic themes:

1. Understanding how bioenergetics and various life history characteristics of fishes and other ectotherms vary along environmental gradients to affect population dynamics

and community interactions in lakes and rivers.

Key citations:

Garvey, J.E. et al. 2003. Energetic adaptations along a broad latitudinal gradient: implications for widely distributed communities. BioScience 53(2):141-150.

Garvey, J.E. et al. 2009. Searching for threshold shifts in spawner recruit relationships. Canadian Journal of Fisheries and Aquatic Sciences 66:312-320.

2. Determining the relative impact of abiotic and biotic characteristics of aquatic systems on the movement and spatial distribution of fishes through effects on physiology and biotic interactions.

Key citations:

Garvey, J.E. et al. 2004. Interactions among allometric scaling, predation and ration affect size-dependent growth and mortality of fish during winter. Ecology 85(10):2860-2871.

Garvey, J.E. et al. 2007. A hierarchical model for oxygen dynamics in streams. Canadian Journal of Fisheries and Aquatic Sciences 64:1816-1827.

3. Exploring the impact of spatial scale on species interactions, with particular relevance to the invasion potential of exotic species.

Key citations:

DeGrandchamp, K.L., **J.E. Garvey**, and L.A. Csoboth. 2007. Linking reproduction of adult Asian carps to their larvae in a large river. Transactions of the American Fisheries Society 136:1327-1334.

Lohmeyer, A.M., and **J.E. Garvey**. 2009. Placing the North American invasion of Asian carp in a spatially explicit context. Biological Invasions 11:905-916.

Administrative Duties at Fisheries and Illinois Aquaculture Center (FIAC)

Plan and implement actions that fulfill the research and graduate training mission of the FIAC–an interdisciplinary research laboratory and training facility with considerable laboratory and office infrastructure and over fifty personnel, including faculty members, graduate assistants, post-doctoral associates, researchers, administrative assistants, and undergraduate technicians.

Courses at Southern Illinois University

Conservation Biology, Zoology 410–(3 hours, Fall 2009)
Limnology, Zoology 415–(3 hours, Fall 2007, 2008; web site: http://fisheries.siuc.edu/water/)
Aquatic Ecosystem Management, Zoology 585C–(3 hours, Summer 2007)
Principles of Ecology, Biology 307- (3 hours, Spring 2006)
Fish Ecology, Zoology 485-2–(3 hours, Spring 2004)

Fisheries Conservation and Management, Zoology 466 - (3 hours; Fall 2000-2007; course web site: http://www.science.siu.edu/zoology/materials/zool466/index.html)
Advanced Fisheries Management, Zoology 569 - (3 hours; Spring 2001)
Fisheries Seminar, Zoology 586 - (1 hour; Fall 2001 [fisheries science sociology], Fall 2005 [review of "A Primer of Ecological Statistics"])
Fish Stock Assessment, Zoology 568 - (2 hours; Spring 2002)
Fish Biology, Zoology 306–(Occasionally lectured, Spring 2003)
Dynamics of Exploited Fish Populations, Zoology 585Z–(3 hours, Spring 2005)

Courses at Kansas State University

Fish Ecology, Biology 697 - (3 hours; 1 year)
Ichthyology, Biology 542 - (3 hours; 1 year)

Courses at Ohio State University

Honors General Biology - Prepared and conducted laboratory sessions (1 year)
Introduction to Ecology - Developed course and occasionally lectured (5 years)

Completed Graduate Students at Southern Illinois University = 18

Post-Doctoral Fellows

Dr. Timothy Spier, 2001-2004. Demographics of Pallid Sturgeon. Assistant Professor, Western Illinois University, Fall 2004.

Current Graduate Students

Quinton Phelps, Ph.D., Recruitment of sturgeons in the Mississippi River corridor. (anticipated graduation: fall 2010)

Dawn Sechler, M.Sc., Feeding ecology of young sturgeon in the Mississippi River. (anticipated graduation: fall 2009)

Heather Calkins, M.Sc., Trophic basis of habitat selection of Asian carps. (anticipated graduation: fall 2009)

Jenny Johnson, M.Sc., Habitat selection of young sturgeon (start: fall 2009)

Bill Hintz, Ph.D., Sturgeon recruitment in the Mississippi River system (start: fall 2009)

Funded Grants (> $2.5 M lifetime); Since 2005

Monitoring Population Status and Movement of Native and Non-native Fishes in the Upper Mississippi River. **Garvey** and Brooks. May 2009–September 2009. U.S. Army Corps of Engineers (includes projects for sturgeon, fish passage, New Madrid Floodway, and Asian carps; Federal)

Status of Aquatic Resources on Sparta National Guard Property. Garvey. Illinois Department of Military Affairs. 2008-2009 (State)

Pallid sturgeon reproduction in the Mississippi River. Garvey, Brooks, Herzog, Hrabik. Spring 2008. U.S. Army Corps of Engineers, Navigation and Ecosystem Sustainability Program (Federal–Cooperative Ecosystem Study Unit Program)

Maintenance of a fish passage monitoring network in the Upper Mississippi River. Garvey and Brooks. Spring 2008. U.S. Army Corps of Engineers, Navigation and Ecosystem Sustainability Program (Federal–Cooperative Ecosystem Study Unit Program)

Development of a hydrological monitoring network at the Mississippi River Wetland Field Station. Whiles, Baer, Battaglia, Hellgren, **Garvey**, Whitledge, Williard. Spring 2007. ORDA Interdisciplinary Grant Program. (University)

Development of a Geographic Information System for Asian carps. September 2006-September 2007. **Garvey**. U.S. Fish and Wildlife Service. (Federal)

Monitoring Population Status and Movement of Native and Non-native Fishes in the Upper Mississippi River. **Garvey** and Brooks. May 2006–September 2007. U.S. Army Corps of Engineers (includes projects for sturgeon, fish passage, and Asian carps; Federal)

Age-Related Demographics of Asian Carp in the Illinois River. ORDA Undergraduate Research Award with Matt Wegener. July 1, 2005 - June 30, 2006. (University)

Larval fish assemblages in the Illinois River. ORDA Undergraduate Research Award with Shea Cox. July 1, 2005 - June 30, 2006. (University; declined by Cox)

Honors and Awards

2008 Illinois Award, Illinois Association of Wastewater Agencies, Evanston, Illinois

2001 Best Oral Presentation, Annual Meeting of the Illinois Chapter of the American Fisheries Society, February 2001

2000 Best Oral Presentation, 2000 Annual Meeting of the Kansas Chapter of the American Fisheries Society, Manhattan, Kansas

1999 Article titled "Competition between larval fishes in reservoirs: the role of relative timing of appearance" (co-author, R.A. Stein) was among 5 nominated by a selection committee for Best Paper in Transactions of the American Fisheries Society (out of –100 articles)

1999 American Society of Limnology and Oceanography's DIALOG III Symposium, Bermuda, October 1999

1998 Graduate Faculty Status, Kansas State University, November 1998

1996 Best Poster, Annual Meeting of the American Fisheries Society, Dearborn, Michigan, August 1996

1996 University Presidential Fellowship, July 1996

1995 Honorable Mention, Best Oral Presentation, Annual Meeting of the American Fisheries Society, Tampa, Florida, August 1995

Student Awards

2009 Quinton Phelps, Student Mentee Award, American Fisheries Society Annual Meeting, Nashville, TN (national)

2009 Quinton Phelps, Richard E. Blackwelder Student Achievement Award, Department of Zoology (department, one of Zoology's highest honors)

2009 Dawn Sechler, Student Research Grant, Illinois Chapter of the American Fisheries Society, $500 (state)

2009 Quinton Phelps, Student Research Grant, Illinois Chapter of the American Fisheries Society, $480 (state)

2008 Dawn Sechler, Semi-finalist, Janice Lee Fenske Memorial Award, North Central Division, American Fisheries Society (regional)

2008 Quinton Phelps, College of Science, Todd Fink Memorial Conservation Award (college)

2008 Dawn Sechler, Best Poster Award, Illinois Chapter of the American Fisheries Society, Rockford, IL (state)

2006 Rob Colombo, Department of Zoology, Foote and Foote Graduate Teaching Award (department)

2006 Rob Colombo, Best Paper, Mississippi River Research Conference, LaCrosse, Wisconsin (regional)

2005 Rob Colombo, Skinner Travel Award, American Fisheries Society Meeting, Anchorage, Alaska, September 2005 (national)

2005 Laura Csoboth, Student Travel Award, Early Life History Section, American Fisheries Society, Barcelona, Spain, July 2005 (international)

2005 Rob Colombo, Lewis Osborne Best Student Platform Presentation Award, Illinois American Fisheries Society Meeting, Moline, Illinois, March 2005 (Provides travel support to national AFS meeting) (regional)

2005 Rob Colombo, Kelly DeGrandchamp, and Doug Schultz. Student Travel Awards, Illinois American Fisheries Society Meeting, Moline, Illinois, March 2005 (state)

2004 Brian Koch, National Society of Environmental Toxicology and Chemistry, Jeff Black Student Award (national)

2004 Dean Sherman, Honorable Mention, Best Poster Award, Undergraduate Research Forum, Southern Illinois University, Carbondale, March 2004 (university)

2004 Laura Csoboth, Student Travel Award, Illinois American Fisheries Society Meeting, Champaign, Illinois, March 2004 (state)

Professional Service (Since 2005)

2009	Reviewer, Great Lake Fishery Commission proposal
2009	Reviewer, USGS Columbia Environmental Research Center, draft research product (report)
2009	Program Co-Chair, 2009 Midwest Fish and Wildlife Conference Planning Committee, Springfield, IL
2009	Panelist, NSF Graduate Research Fellowship Program, Ecology, February 2009, Arlington, VA
2009	Reviewer, Hudson River Foundation proposal
2008	Past-president, Illinois Chapter of the American Fisheries Society
2008	SIUC Representative, Cooperative Ecosystems Study Unit
2006-present	Webmaster, Illinois Chapter of the American Fisheries Society
2007	President, Illinois Chapter of the American Fisheries Society
2007	Site Reviewer, USGS Upper Mississippi Environmental Research Center, LaCrosse, WI, Sept. 10 -14, 2007
2007	Reviewer, USGS Long-term Monitoring Program 10- Year Report, 189 pages
2007	Reviewer, National Science Foundation, Ecology Panel, October 2007
2006	President-elect, Illinois Chapter of the American Fisheries Society
2006-2007	Chair, Farm Bill Advisory Committee, American Fisheries Society
2006	Reviewer, National Science Foundation, Ecology Panel & Biological Oceanography Program (N=2)
2006	Reviewer, National Fish and Wildlife Foundation proposal
2005	Participant, Pallid Sturgeon Recovery Team meeting to decide stocking strategies in the Missouri and Mississippi River basins, Denver, Colorado

2005	Member, Committee to Draft Pallid Sturgeon Conservation Plan for the Middle Mississippi River
2005-2006	Member, Systems Evaluation Team for Environmental Management Program in the Upper Mississippi River, US Fish and Wildlife Service, US Army Corps of Engineers, and US Geological Survey
2005	Secretary-Treasurer, Illinois Chapter of the American Fisheries Society
2005	Reviewer, US Army Corps of Engineers Scope of Work, Barge Entrainment by Larval and Adult Fish
2005	Reviewer, Great Lake Fisheries Commission grant proposal
2005	Reviewer, National Science Foundation proposals, Ecology Panel (2 proposals)
1994-present	Peer Reviewer of journals including *Behaviour*, *Biological Invasions*, *Canadian Journal of Zoology*, *Canadian Journal of Fisheries and Aquatic Sciences*, *Transactions of the American Fisheries Society*, *North American Journal of Fisheries Management*, *Ecology*, *Ecological Applications*, *Fisheries*, *Fisheries Management and Ecology*, *Great Basin Naturalist*, *American Midland Naturalist*, *Prairie Naturalist*, *Journal of Plankton Research*, *Animal Behaviour*, *Journal of the North American Benthological Society*, *Journal of Fish Biology*, *Environmental Biology of Fishes*, *Northwest Science*, *North American Journal of Aquaculture*, *Proceedings of the Royal Academy of Science –Great Britain*, *Journal of Applied Ichthyology*, *Journal of Animal Ecology*, *Hydrobiologia*, *Limnology and Oceanography* (average 8 reviews per year)

<u>Society Memberships</u>

2003-present	Member, American Institute of Biological Sciences
1990-present	Ecological Society of America
1990-present	American Fisheries Society
1990-present	North American Benthological Society
2001-present	Illinois Chapter of the American Fisheries Society
1999-present	Full Member, Sigma Xi
1999-2000	Kansas Chapter of the American Fisheries Society

<u>University Service (Since 2005)</u>

2009-	Senator, Faculty Senate Representative for College of Science, 3-year term (elected)

2009	Member, Governance Committee, Faculty Senate
2009-	Member, Middle Mississippi River Wetland Field Station Advisory Committee
2009	Chair, Aquaculture Faculty Search Committee, Department of Zoology, SIUC
2009	Member, Todd Fink Memorial Award Selection Committee
2008	SIUC Representative, North Central Regional Aquaculture Center Science Committee
2007	Member, SIUC Department of Zoology, Aquaculture/Fish Physiology Faculty Search Committee, Fall 2007
2007-2009	Touch of Nature Advisory Board, SIUC
2007-2009	Member, Doctoral Fellowship panel, SIUC
2005	Member, SIUC Department of Zoology, Fisheries Faculty Search Committee, Spring 2005
2005-2006	Member, Faculty Seed Grant Committee, Biological Science Panel, ORDA

Invited Presentations (Since 2005)

2009	College of Agricultural Sciences, SIUC, Brazil Agricultural Minister Visit, May 2009
2008	Department of Biology, Saint Louis University, November 2008
2008	Department of Biology, Kent State University, Kent, Ohio, October 2008
2008	Participant, Round-table discussion on Mississippi River research and management; Mississippi River Research Consortium, Davenport, Iowa, April 2008.
2007	Presenter, Bridging the Gap: addressing critical uncertainties in North American sturgeon conservation and recovery. Symposium, American Fisheries Society Meeting, San Francisco, CA, September 2007
2007	Department of Forestry and Natural Resources, Purdue University, March 2007
2006	Ecology, Evolution, and Organismal Biology Seminar Series, The Ohio State University, January 2006
2005	Chicago Sanitary Shipping Canal, Invasive Species Barrier stakeholder meeting, June 2005

2005 Water Resources Program, Utah State University, March 2005

Technical Reports (Selected reports available at http://fishdata.siu.edu)

R.C. Brooks, S.J. Tripp, and **Garvey, J.E.** 2008. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Year 3. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 90 pages

R.C. Brooks, S.J. Tripp, and **Garvey, J.E.** 2007. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Year 2. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 56 pages.

Garvey, J.E. 2007. Spatial assessment of Asian carp population dynamics: development of a spatial query tool for predicting relative success of life stages. US Fish and Wildlife Service. 45 pages. Spatial tool at http://fishdata.siu.edu/carptools

Garvey, J.E., and multiple co-authors. 2007. Swan Lake Habitat Rehabilitation and Enhancement Project: Post-Project Monitoring of Water Quality, Sedimentation, Vegetation, Invertebrates, Fish Communities, Fish Movement, and Waterbirds. US Army Corps of Engineers. 608 pages.

Garvey, J.E., E.J. Heist, R.C. Brooks, D.P. Herzog, R.A Hrabik, and K.J. Killgore. 2006. Current status of the Pallid Sturgeon (*Scaphirhynchus albus*) in the Middle Mississippi River: Habitat, Movement, and Demographics. Final Report–St. Louis District, US Army Corps of Engineers. 475 pages. (http://fishdata.siu.edu/pallid)

Garvey, J.E., R.C. Brooks, and S.J. Tripp. 2006. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 32 pages.

Garvey, J.E., K.L. DeGrandchamp, C.J. Williamson. 2006. Growth, fecundity, and diets of Asian carps in the Upper Mississippi River system. U.S. Army Corps of Engineers Technical Note, ERDC, Waterways Experimental Station. ERDC/TN ANSRP-06.

Colombo, R., **J.E. Garvey**, and R.C. Heidinger. 2005. Population Demographics of Catfish in Fished and Unfished Reaches of the Wabash River. Final Report to Indiana Department of Natural Resources, Federal Aid in Sport Fish Restoration Program, 128 pages.

Garvey, J.E., R. Brooks, M. Eichholz, J. Chick. 2005. Swan Lake Habitat Rehabilitation and Enhancement Project: Post-Project Monitoring of Fish Movement, Fish Community, Waterfowl, Water Quality, Vegetation, and Invertebrates. Year 1 Summary to US Army Corps of Engineers, St. Louis District. 135 pages.

Garvey, **J.E.**, M.L. Lydy, M.R. Whiles, and R.C. Heidinger. 2004. Aquatic environmental assessment of the Sparta Illinois National Guard Training Facility. Final Report. 137 pages.

Garvey, J.E., and M.R Whiles. 2004. An assessment of national and Illinois dissolved oxygen water quality criteria. Illinois Association of Wastewater Agencies. 56 pages.

Garvey, **J.E.**, M.L. Lydy, M.R. Whiles, and R.C. Heidinger. 2004. Aquatic environmental assessment of the Sparta Illinois National Guard Training Facility. Annual Progress Report. 62 pages.

Hrabick, R.A., K. J. Killgore, T. Spier, and **J.E. Garvey**. 2004. Pallid sturgeon recovery update. Issue 14. Edited by R. Wilson. Publication of the Pallid Sturgeon Recovery Team. p. 15.

Garvey, J.E., S.Welsh, and K.J. Hartman. 2003. Winter habitat used by fishes in Smithland Pool and Belleville Pool, Ohio River. Final Report. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers. 295 pages.

Spier, T. and **J.E. Garvey**. 2003. Demographics of pallid sturgeon project. Annual Report. U.S. Army Corps of Engineers. 3 pages.

Garvey, J.E., B.D. Dugger, M.R. Whiles, S.R. Adams, M.B. Flinn, B.M. Burr, and R.J. Sheehan. 2003. Responses of fish, waterbirds, invertebrates, vegetation, and water quality to environmental pool management: Mississippi River Pool 25. U.S. Army Corps of Engineers. 181 pages.

Garvey, J.E. 2002. Winter habitat used by fishes in Smithland Pool, Ohio River. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, 90 pages.

Garvey, J.E., and R.J. Sheehan. 2001. Winter habitat associations of riverine fishes: predictions for the Ohio River, U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, 39 pages.

Garvey, J.E., R.A. Wright, R.A. Stein, E.M. Lewis, K.H. Ferry, and S.M. Micucci. 1998. Assessing the influence of size on overwinter survival of largemouth bass in Ohio on-stream impoundments. Ohio Division of Wildlife Final Report. Federal Aid in Sport Fish Restoration Program 29, 288 pages.

Stein, R.A., and **J.E. Garvey**. 1996. A review of a technical report prepared for the Cuyahoga River (Ohio) Community Planning Organization by EnvironScience Inc.

Theses and Dissertations

Garvey, J.E. 1997. Strong interactors and community structure: testing predictions for reservoir food webs, Ph.D. dissertation, 235 pages.

Garvey, J.E. 1992. Selective predation as a mechanism of crayfish species replacement in northern Wisconsin lakes. M.S. thesis, The Ohio State University, 88 pages.

Policy Statements/Editorials

Garvey, J.E. (Written as Chair of Farm Bill Advisory Committee). 2007. Farm Bill 2007: placing fisheries upstream of conservation provisions. Fisheries 32(8):399-404.

<u>Popular Press</u>

Garvey, J.E. 2005. A tale of two sturgeons. Outdoor Illinois. April, pp. 11-13.

<u>Book Chapters</u>

4. Phelps, Q.E, S.J. Tripp, **J.E. Garvey**, D.P. Herzog, D.E. Ostendorf, J.W. Ridings, J.W. Crites, and R.A. Hrabik. In press. Ecology and habitat use of larval and age-0 paddlefish in the unimpounded Middle Mississippi River. Paddlefish Management, Propagation, and Conservation in the 21st Century: Building From 20 Years of Research and Management. American Fisheries Society, Bethesda, Maryland. (Peer reviewed)

3. Chipps, S.R., and **J.E. Garvey.** 2007. Chapter 11: Assessment of food habits and feeding patterns. Pages 473-514 in M.L. Brown and C.S. Guy, editors. Analysis and Interpretation of Freshwater Fisheries Data. American Fisheries Society, Bethesda, Maryland. (Peer reviewed)

2. DeVries, D.R., **J.E. Garvey**, and R.A. Wright. 2009. Chapter 5: Early life history and recruitment. Pages105-133 *in* S. Cooke and D. Philipp, editors. Centrarchid fishes: diversity, biology, and conservation. Wiley-Blackwell Scientific.

1. **Garvey, J.E.,** and S.R. Chipps. Accepted pending revision. Quantifying diets and energy flow. Third edition of Fisheries Techniques, American Fisheries Society. 97 MS pages, 1 table, 4 figures, 8 boxes. (Peer reviewed)

<u>Book Reviews</u>

2. **Garvey, J.E.** 2005. Sustaining hope for fisheries in the 21st century. Review of "Sustainable Management of North American Fisheries" Edited by E.E. Knudsen, D.D. MacDonald, and Y. K Muirhead. American Fisheries Society, Bethesda. 2004. 281 pp. Appeared in BioScience 55(10):3-5. (Invited)

1. **Garvey, J.E.** 2003. Searching for scales in fisheries. Review of "Hierarchical Perspectives on Marine Complexities: Searching for Systems in the Gulf of Maine" by Spencer Apollonio. Columbia University Press, New York. 2002. 229 pp. Appeared in BioScience 53(10):1004-1006. (Invited)

<u>Peer-Reviewed Publications</u>

49. Wahl, N.C., Q.E. Phelps, **J.E. Garvey**, S.T. Lynott, and W.E. Adams. 2009. Comparisons of scales and sagittal otoliths to back-calculated lengths-at-age of crappies collected from Midwestern waters. Journal of Freshwater Ecology 24(3):469-475.

48. Phelps, Q.E., D.P. Herzog, R.C. Brooks, V.A. Barko, D.E Ostendorf, J.W. Ridings, S.J. Tripp, R.E. Colombo, **J.E. Garvey**, and R.A. Hrabik. In press. Seasonal comparison of catch rates and size structure using three gear types to sample sturgeon in the Middle Mississippi River. North American Journal of Fisheries Management.

47. Colombo, R., Q. Phelps., **J.E. Garvey**, R.C. Heidinger, and N. Richards. Accepted pending revision. Comparison of channel catfish age estimates and resulting population demographics using two common structures. North American Journal of Fisheries

Management.

46. Schrey, A., R. Colombo, **J. Garvey**, and E. Heist. In press. Stock structure of shovelnose sturgeon analyzed with microsatellite DNA and morphological characters. Journal of Applied Ichthyology.

45. **Garvey, J.E.**, R.A. Wright, and E.A. Marschall. 2009. Searching for threshold shifts in spawner recruit relationships. Canadian Journal of Fisheries and Aquatic Sciences 66:312-320.

44. Tripp, S., Q. Phelps, R. Colombo, **J. Garvey**, B. Burr, D. Herzog, and R. Hrabik. 2009. Maturation and reproduction of shovelnose sturgeon in the Middle Mississippi River. North American Journal of Fisheries Management 29(3):730-738.

43. Tripp, S.J, R.E. Colombo, and **J.E. Garvey**. 2009. Declining recruitment and growth of shovelnose sturgeon in the Middle Mississippi River: implications for conservation. Transactions of the American Fisheries Society 138:416-422.

42. Lohmeyer, A.M., and **J.E. Garvey**. 2009. Placing the North American invasion of Asian carp in a spatially explicit context. Biological Invasions 11:905-916.

41. DeGrandchamp, K.L., **J.E. Garvey**, and R.E. Colombo. 2008. Habitat selection and dispersal of invasive Asian carps in a large river. Transactions of the American Fisheries Society 137:33-44.

40. Csoboth, L.A., and **J.E. Garvey**. 2008. Lateral exchange of larval fish between a restored backwater and a large river in the east-central U.S. Transactions of the American Fisheries Society 137:45-56.

39. Flinn, M.R. Whiles, S.R. Adams, and **J.E. Garvey**. 2008. Biological responses to contrasting hydrology in backwaters of Upper Mississippi River Navigation Pool 25. Environmental Management 41:468-486.

38. **Garvey, J.E.**, M.R. Whiles, and D. Streicher. 2007. A hierarchical model for oxygen dynamics in streams. Canadian Journal of Fisheries and Aquatic Sciences 64:1816-1827.

37. Colombo, R.E., **J.E. Garvey**, N.D. Jackson, R. Brooks, D.P. Herzog, R.A. Hrabik, and T.W. Spier. 2007. Harvest of Mississippi River sturgeon drives abundance and reproductive success: a harbinger of collapse? Journal of Applied Ichthyology 23:441-451.

36. DeGrandchamp, K.L., **J.E. Garvey**, and L.A. Csoboth. 2007. Linking reproduction of adult Asian carps to their larvae in a large river. Transactions of the American Fisheries Society 136:1327-1334.

35. Jackson, N.J., **J.E. Garvey**, and R.E. Colombo. 2007. Comparing aging precision of calcified structures in shovelnose sturgeon. Journal of Applied Ichthyology 23:444-451.

34. Colombo, R.E., Q.E. Phelps, **J.E. Garvey**, and R.C. Heidinger. 2008. Gear-specific population demographics of channel catfish in a large unimpounded midwestern river. North American Journal of Fisheries Management 28:241-246.

33. Colombo, R.E., **J.E. Garvey**, and P.S. Wills. 2007. A guide to the embryonic development of the shovelnose sturgeon (*Scaphirhynchus platorynchus*), reared at a constant temperature. Journal of Applied Ichthyology 23:402-410.

32. Schultz, D., **J.E. Garvey**, and R. Brooks. 2007. Backwater immigration by fishes through a water control structure: implications for connectivity and restoration. North American Journal of Fisheries Management 27:172-180.

31. Colombo, R.E., **J.E. Garvey**, and P.S. Wills. 2007. Gonadal development and sex-specific demographics of the shovelnose sturgeon in the Middle Mississippi River. Journal of Applied Ichthyology 23:420-427.

30. Adams, S.R., M.B. Flinn, B.M. Burr, M.R. Whiles, and **J.E. Garvey**. 2006. Ecology of larval blue sucker (*Cycleptus elongatus*) in the Mississippi River. Ecology of Freshwater Fish 15:291-300.

29. Koch, B.T, **J.E. Garvey**, M.J. Lydy. 2006. Elevated organochlorines in the brain-hypothalamic-pituitary complex of intersexual shovelnose sturgeon. Environmental Toxicology and Chemistry 25:1689-1697.

28. Heatherly, T., II, M.R. Whiles, D. Knuth, and **J.E. Garvey**. 2005. Diversity and community structure of littoral zone macroinvertebrates in southern Illinois reclaimed surface mine lakes. American Midland Naturalist 154(1):67-77.

27. Vanni, M.J., K.K. Arend, M.T. Bremigan, D.B. Bunnell, **J.E. Garvey**, M.J. González, W. H. Renwick, P.A. Soranno, and R.A. Stein. 2005. Linking landscapes and food webs: effects of omnivorous fish and watersheds on reservoir ecosystems. BioScience 55:155-167.

26. Williamson, C.J., and **J.E. Garvey**. 2005. Growth, mortality, fecundity, and diets of newly established silver carp in the Middle Mississippi River. Transactions of the American Fisheries Society 134:1423-1430.

25. Flinn, M.B., M.R. Whiles, S.R. Adams, and **J.E. Garvey**. 2005. Macroinvertebrate and zooplankton responses to emergent plant production in upper Mississippi River floodplain wetlands. Archiv für Hydrobiologie 162:187-210.

24. Ostrand, K.G., S.J. Cooke, **J.E. Garvey**, and D.H. Wahl. 2005. The energetic impact of overwinter prey assemblages on age-0 largemouth bass. Environmental Biology of Fishes 72(3):305-311.

23. **Garvey, J.E.**, K.G. Ostrand, and D.H. Wahl. 2004. Interactions among allometric scaling, predation and ration affect size-dependent growth and mortality of fish during winter. Ecology 85(10):2860-2871.

22. Whiles, M.J., and **J.E. Garvey**. 2004. Aquatic resources of the Shawnee and Hoosier National Forests, USDA Forest Service. Aquatic resources of the Shawnee-Hoosier National Forest. Pages 81-108 in Frank R. Thompson, III editor. The Hoosier-Shawnee Ecological Assessment. General Technical Report, NC-244. USDA, Forest Service, North Central Research Station. (peer-reviewed)

21. Colombo, R.E., P.S. Wills, and **J.E. Garvey**. 2004. Use of ultrasound imaging to determine sex of shovelnose sturgeon *Scaphirhynchus platorynchus* from the Middle Mississippi River. North American Journal of Fisheries Management 24:322-326.

20. Roberts, M.R., JE. Wetzel, III, R.C. Brooks, and **J.E. Garvey**. 2004. Daily incrementation in the otoliths of the red spotted sunfish, *Lepomis miniatus*. North American Journal of Fisheries Management 24:270-274.

19. **Garvey, J.E**., and E.A. Marschall. 2003. Understanding latitudinal trends in fish body size through models of optimal seasonal energy allocation. Canadian Journal of Fisheries and Aquatic Sciences 60(8):938-948.

18. Micucci, S.M., **J.E. Garvey**, R.A. Wright, and R.A. Stein. 2003. Individual growth and foraging responses of age-0 largemouth bass to mixed prey assemblages during winter. Environmental Biology of Fishes 67(2):157-168.

17. **Garvey, J.E**., J.E. Rettig, R.A. Stein, D.M. Lodge, and S.P. Klosiewski. 2003. Scale-dependent associations among fish predation, littoral habitat, and distributions of native and exotic crayfishes. Ecology 84(12): 3339-3348.

16. **Garvey, J.E**., R.A. Stein, R.A. Wright, and M.T Bremigan. 2003. Largemouth bass recruitment in North America: quantifying underlying ecological mechanisms along environmental gradients Black bass: ecology, conservation and management. Edited by D. Philipp and M. Ridgway. American Fisheries Society Symposium 31:7-23. (peer-reviewed)

15. **Garvey, J.E.**, D.R. DeVries, R.A. Wright, and J.G. Miner. 2003. Energetic adaptations along a broad latitudinal gradient: implications for widely distributed communities. BioScience 53(2):141-150.

14. **Garvey, J.E.**, T.P. Herra, and W.C. Leggett. 2002. Protracted reproduction in sunfish: the temporal dimension in fish recruitment revisited. Ecological Applications 12:194-205.

13. **Garvey, J.E.**, R.A. Wright, K.H. Ferry, and R.A. Stein. 2000. Evaluating how local- and regional- scale processes interact to regulate growth of age-0 largemouth bass. Transactions of the American Fisheries Society 129:1044-1059.

12. Fullerton, A.H., **J.E. Garvey**, R.A. Wright, and R.A. Stein. 2000. Overwinter growth and survival of largemouth bass: interactions among size, food, origin, and winter duration. Transactions of the American Fisheries Society 129:1-12.

11. Wright, R.A., **J.E. Garvey**, A.H. Fullerton, and R.A. Stein. 1999. Using bioenergetics to explore how winter conditions affect growth and consumption of age-0 largemouth bass. Transactions of the American Fisheries Society 128:603-612.

10. **Garvey, J.E.**, and R.A. Stein. 1998. Competition between larval fishes in reservoirs: the role of relative timing of appearance. Transactions of the American Fisheries Society 127:1023-1041.

9. **Garvey, J.E.**, R.A. Wright, and R.A. Stein. 1998. Overwinter growth and survival of age-0 largemouth bass: revisiting the role of body size. Canadian Journal of Fisheries and

Aquatic Sciences 55:2414-2424.

8. **Garvey, J.E.**, N.A. Dingledine, N.S. Donovan, and R.A. Stein. 1998. Exploring spatial and temporal variation within reservoir food webs: predictions for fish assemblages. Ecological Applications 8:104-120.

7. **Garvey, J.E.**, and R.A. Stein. 1998. Linking bluegill and gizzard shad assemblages to growth of age-0 largemouth bass in reservoirs. Transactions of the American Fisheries Society 127:70-83.

6. Lodge, D.M., R.A. Stein, K.M. Brown, A.P. Covich, C. Brönmark, **J.E. Garvey**, and S.P. Klosiewski. 1998. Predicting impact of freshwater exotic species on native biodiversity: challenges in spatial and temporal scaling. Australian Journal of Ecology 23:53-67.

5. **Garvey, J.E**., E.A. Marschall, and R.A. Wright. 1998. From star charts to stoneflies: detecting relationships in continuous bivariate data. Ecology 79(2):442 447.

4. Schaus, M.H., M.J. Vanni, T.E. Wissing, M. Bremigan, **J.E. Garvey**, and R.A. Stein. 1997. Nitrogen and phosphorus excretion by the detritivorous gizzard shad (*Dorosoma cepedianum*) in a reservoir ecosystem. Limnology and Oceanography 42(6):1386-1397.

3. **Garvey, J.E**., R.A. Stein, and H.M. Thomas. 1994. Assessing how fish predation and interspecific prey competition influence a crayfish assemblage. Ecology 75:532-547.

2. **Garvey, J.E.**, and R.A. Stein. 1993. Evaluating how chela size influences the invasion potential of an introduced crayfish, *Orconectes rusticus*. American Midland Naturalist 129:172-181.

1. **Garvey, J.E.**, H.A. Owen, and R.W. Winner. 1991. Toxicity of copper to the green alga, *Chlamydomonas reinhardtii* (Chlorophycea), as affected by humic substances of terrestrial and freshwater origin. Aquatic Toxicology 19:89-96.

<u>Oral Presentations and Posters (Since 2005)</u>

97. Calkins, H., and **J.E. Garvey**. Linking habitat use and phytoplankton consumption of silver carp in the upper and middle Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Calkins)

96. Brooks, R., S. Tripp, **J. Garvey**, and 5 co-authors. Fish passage throughout pools 20-26 of the Upper Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Tripp)

95. Boley, R., A. Schrey, D. Sechler, **J.E. Garvey**, and E. Heist. Genetic identification of larval pallid sturgeon, shovelnose sturgeon, and their hybrids in the middle Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Poster presentation)

94. Heist, E., **J.E. Garvey**, and 8 co-authors. Status of pallid sturgeon. Invited presentation. Acipenseriformes Symposium, National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Heist)

93. Whitledge, G., Q. Phelps, and **J.E. Garvey**. Identifying river of origin for age-0 sturgeon in the middle Mississippi River using fin ray microchemistry. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Whitledge)

92. Colombo, R., **J.E. Garvey**, and 11 co-authors. Distribution, life history, and population status of shovelnose sturgeon. Invited presentation. Acipenseriformes Symposium, National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Colombo)

91. Brooks, R., **J. Garvey**, M. Hill, S.J. Tripp, H.A. Calkins, T. Spier, N. Bloomfield, T. Moore, D. Herzog, and R. Hrabik. Fish Passage Throughout Pools 20-26 of the Upper Mississippi River. 41st annual Mississippi River Research Consortium, LaCrosse WI, 30 April 2009. (Oral presentation by Tripp)

90. Sechler, D., Q. Phelps, and **J.E. Garvey**. Diet composition of young-of-year *Scaphirhynchus* sturgeon in the middle Mississippi River: Does foraging behavior change with season, macrohabitat and total length of fish? Meeting of the IL Chapter of the American Fisheries Society, Quad Cities, IL. March 2009. (Oral presentation by Sechler)

89. Calkins, H.A., and **J.E. Garvey**. Linking habitat use of silver carp to phytoplankton consumption in the Mississippi River. Meeting of the IL Chapter of the American Fisheries Society, Quad Cities, IL. March 2009. (Poster presentation)

88. Calkins, H.A., and **J.E. Garvey**. Movement, Habitat Use and Phytoplankton Consumption of Silver Carp in the Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation).

87. Tripp, S.J., Q.E. Phelps, D. Herzog, and **J.E. Garvey**. Habitat Use of Young-of-Year Pallid Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation).

86. Ratterman, N., N. Wahl, Q.E. Phelps, and **J.E. Garvey**. Comparing Scale and Sagittal Otolith Back-Calculated Lengths at Age in Crappies. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

85. Seibert, J.R., Q.E. Phelps, S.J.Tripp, and **J.E. Garvey**. Seasonal Diet Composition of Adult Shovelnose Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

84. Sechler, D.R., Q.E. Phelps, N.C. Wahl, and **J.E. Garvey**. Diet Composition of Young-of-Year Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

83. Phelps, Q.E., S.J. Tripp, D. Herzog, and **J.E. Garvey**. Early life history of pallid sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Oral presentation by Phelps)

82. Wagner, C., M. Nannini, **J.Garvey**, and D. Wahl. Influence of fall condition and prey

abundance on overwinter success of age 0 largemouth bass. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

81. Phelps, Q., R. Colombo, **J.E. Garvey**, and R.C. Heidinger. Comparison of channel catfish age estimates and resulting population demographics using two common structures. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Poster presentation)

80. Sechler, D., Q. Phelps, and **J.E. Garvey**. Diet composition of juvenile shovelnose sturgeon in the Middle Mississippi River. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Poster presentation)

79. **Garvey, J.E.**, S.M. Bartell, and T. Keevin. Predicting local extinction of pallid sturgeon in the Mississippi River. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Oral presentation)

78. **Garvey J.E.** Asian carp in cyberspace. Illinois River Barrier Panel Meeting, Chicago, IL, June 2008. (Oral presentation)

77. **Garvey, J.E.** Searching for thresholds in spawner-recruit data. Annual Meeting of the Illinois Chapter of the American Fisheries Society, Rockford, Illinois, March 2008. (Oral presentation)

76. Phelps, Q.P., A.M. Lohmeyer, G.W. Whitledge, and **J.E. Garvey**. 2007. Black crappie nest site selection: habitat characteristics and anthropogenic influences in a small reservoir. Midwest Fish and Wildlife Conference, Madison, Wisconsin. December 2007. (Poster presentation).

75. **Brooks, R.**, J.E. Garvey, S.J. Tripp, M. Hill, T. Spier, D. Herzog, and R. Hrabik. Fish movement in the middle and upper Mississippi River. Midwest Fish and Wildlife Conference, Madison, Wisconsin. December 2007. (Oral presentation by Brooks).

74. Lohmeyer, A.M., and **J.E. Garvey**. Larval Asian Carp in the Upper and Middle Mississippi River: an index of establishment and dispersal potential. National meeting of the American Fisheries Society, San Francisco, CA. September 2007. (Poster presentation).

73. Phelps, Q.P., T.C. Allen, R.D. Davinroy, and **J.E. Garvey**. A laboratory examination of substrate, water depth, and light use at two water velocity levels by juvenile pallid and shovelnose sturgeon. National meeting of the American Fisheries Society, San Francisco, CA. September 2007. (Oral presentation by Phelps).

72. Lohmeyer, A.M., and **J.E. Garvey**. Larval Asian Carp in the Upper and Middle Mississippi River: an index of establishment and dispersal potential. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Lohmeyer).

71. Tripp, S.J., R.C. Brooks, M. Hill, M. Mangan, T. Spier, D. Herzog, R. Hrabik, and **J.E. Garvey**. Fish movement in the Mississippi River. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Tripp).

70. **Garvey, J.E.** and R.E. Colombo. Comparative stock assessment between the Wabash and Mississippi Rivers. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Garvey).

69. DeVries, D.R., **J.E. Garvey**, and R.A. Wright. Searching for generality in centrarchid recruitment: a prescription for research. National Meeting of the American Fisheries Society, Lake Placid, New York. September 2006. (Oral presentation by DeVries).

68. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. National Meeting of the American Fisheries Society, Lake Placid, New York. September 2006. (Oral presentation by Colombo).

67. **Garvey, J.E.** Spatial reproductive patterns of Asian carp in the Illinois River and Upper Mississippi River. Habitat use of Asian carps in the Illinois River. Asian Carp Symposium, Peoria, Illinois. August 2006. (Oral presentation by Garvey).

66. DeGrandchamp, K.L., and **J.E. Garvey.** Habitat use of Asian carps in the Illinois River. Asian Carp Symposium, Peoria, Illinois. August 2006. (Oral presentation by DeGrandchamp).

65. **Garvey, J.E.** Spatial reproductive patterns of Asian carp in the Illinois River and Upper Mississippi River. Meeting of the Chicago Barrier Advisory Committee. (Oral presentation by Garvey).

64. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. Annual Meeting of the Mississippi River Research Committee, LaCrosse, Wisconsin. April 2006. (Oral presentation by Colombo; won best student paper).

63. DeGrandchamp, K.L., and **J.E. Garvey.** Habitat use of Asian carps in the Illinois River. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by DeGrandchamp).

62. Tripp, S.J., **J.E. Garvey**, and R.C. Brooks. Reproductive status of shovelnose sturgeon in the Middle Mississippi River. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by Tripp).

61. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by Colombo).

60. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Habitat use and movement patterns of Asian carp in the lower Illinois River. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by DeGrandchamp).

59. Knuth, D. and **J.E. Garvey**. Effect of adult size and littoral habitat on larval sunfish production in unexploited lakes. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by Knuth).

58. Colombo, R., **J.E. Garvey**, and R. Heidinger. Comparing the demographics of channel catfish populations from fished and un-fished regions of the Wabash River. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by

Colombo).

57. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by Csoboth).

56. Schultz, D., **J.E. Garvey**, K. DeGrandchamp, and L. Csoboth . Seasonal Fish Movement between the Illinois River and a Restored Backwater. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Poster presentation by Schultz).

55. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. 29th Annual Larval Fish Conference, Early Life History Section, American Fisheries Society, Barcelona, Spain. July 2005. (Oral presentation by Csoboth).

54. **Garvey, J.E.** Dynamics of shovelnose and pallid sturgeon in the Middle Mississippi River. River Resources Action Team Annual Meeting, June 2005. (Oral presentation by Garvey).

53. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Habitat use and movement patterns of Asian carp in the lower Illinois River. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by DeGrandchamp).

52. Colombo, R., **J.E. Garvey**, and R. Heidinger. Comparing the demographics of channel catfish populations from fished and un-fished regions of the Wabash River. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by Colombo).

51. Knuth, D. and **J.E. Garvey**. Effect of adult size and littoral habitat on larval sunfish production in unexploited lakes. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by Knuth).

50. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Csoboth).

49. Colombo, R., **J.E. Garvey**, and R. Heidinger. Population dynamics of catfish in fished and unfished reaches of the Wabash River. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Colombo; won Best Paper Award).

48. Schultz, D., **J.E. Garvey**, K. DeGrandchamp, and L. Csoboth. Fish movement between the Illinois River and lower Swan Lake, an associated backwater. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Schultz).

47. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Movement Patterns and Habitat Use of Bighead and Silver Carp in the Lower Illinois River. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by DeGrandchamp).

Workshops and Miscellaneous Activities (Since 2005)

2009-	List moderator, sturgeon inter-basin communication mailing list (> 150 participants), STURGEON-L@siu.edu
2009	Invited judge, Illinois Junior Science and Humanities Symposium oral presentations, March 2009 at SIUC
2009	Interviewed, Heartland News (local television), fisheries interaction with SIUC Child Development Laboratory, February 2009
2008-	Adviser, SIUC Student Subunit of the American Fisheries Society
2008	Interviewed by Southeastern Missourian newspaper on pallid sturgeon telemetry
2007-	Webmaster & LAN Administrator, SIUC Fisheries and Illinois Aquaculture Center
2007	Interviewed on WSIU Radio for piece on conservation genetics and sturgeon, November 2007
2007	Invited participant, Research Needs and Management Strategies for Pallid Sturgeon Recovery, St. Louis, MO. Hosted by Ruckelshaus Institute; July 31-August 2
2007	Participant, BioSonics hydroacoustics workshop, Seattle, WA, January 22-27
2006	Interviewed on Marketplace, nationally syndicated radio show
2006	Research featured on the SIUC Media Communications and Southern Spotlights outlets
2005	Participant, multi-state shovelnose sturgeon regulation meeting (invited), Cape Girardeau, Missouri, April 2005
2004-2006	Technical consultant, four hearings before the Illinois Pollution Control Board, produced numerous reports and exhibits

CRAMER FISH SCIENCES
Oregon • California • Washington • Idaho • Alaska

600 NW Fariss Road
Gresham, OR 97030
V: 503.491.9577
F: 503.465.1940
beamesderfer@fishsciences.net

Raymond C. P. Beamesderfer

Senior Fish Scientist

Education and Training

B.S. in Wildlife & Fisheries Biology 1979, University of California, Davis.

M.S. in Fishery Resources 1983, University of Idaho.

Employment History

Cramer Fish Sciences, Senior Fish Scientist, 2000-Present.

Oregon Department of Fish and Wildlife, Fishery Management Biologist, 1997-2000.

ODFW, Staff Biologist/ Analyst, 1994-1997.

ODFW, Fish Research, 1983-1993.

Professional Activities

Certified Fisheries Scientist, American Fisheries Society, 1989.

Associate Editor, North American Journal of Fisheries Management, 1992-1993.

Speaker at numerous regional, national, and international symposiums of fisheries scientists.

Ray has analyzed applied problems of fish biology and management for over 25 years:

- extensive experience with salmon, steelhead, trout, sturgeon, warmwater gamefish, and nongame species;
- work in Oregon, Washington, Alaska, Idaho, California, and British Columbia;
- numerous reports, biological assessments, management plans, and scientific articles on fish population dynamics, fish conservation, fishery management, sampling, and species interactions;
- special expertise in the use of quantitative analysis, statistics, and computer modeling to solve difficult fish questions and in synthesizing and translating scientific analyses for a variety of audiences;
- widely-recognized expertise in sturgeon population dynamics, biological assessment, conservation, and management.

With *Fish Sciences*, Ray has completed a wide variety of fishery management, biological assessment, and conservation or recovery planning projects for State and Federal Agencies, Indian Tribes, Private Industry, and Non-Governmental Organizations. Significant sturgeon-related projects have included conservation and recovery plans for upper Columbia River white sturgeon and Sacramento green sturgeon, status assessments and hatchery evaluations of Kootenai sturgeon, biological assessments of the effects of water project operations, and design of monitoring and evaluation programs. Ray has also provided extensive technical review and input on pallid sturgeon issues.

Previously, he worked for the Oregon Department of Fish and Wildlife as a management biologist for Columbia River salmon and sturgeon fisheries; staff analyst and agency representative for inter-jurisdictional Columbia River salmon, resident fish, and hydropower issues; and program and project leader for research on sturgeon stock assessments, predator control evaluation, warmwater fish management alternatives, adult and juvenile salmon passage at dams and diversions, and design and implementation of a system to facilitate exchange of salmon and steelhead data for the Columbia River basin (*StreamNet*).

Projects

Biological Assessment

Comments on green sturgeon portions of the Oroville Dam Draft Biological Opinion by the National Marine Fisheries Service. 2009. *California State Water Contractors.*

Comments on green sturgeon portions of the Biological Opinion on the Long-term Central Valley Project and State Water Project Operations Criteria and Plan. 2009. *California State Water Contractors.*

Kenai River Habitat Assessment. 2008. *Alaska Department of Fish and Game and the Kenai River Sportfishing Association.*

Status and limiting factors of ESA-listed lower Columbia and Willamette River chum, Chinook, coho, and steelhead in supplemental comprehensive analysis of the federal Columbia River power system and mainstem effects of the upper Snake and other tributary actions. 2007. *National Oceanic and Atmospheric Administration and the Bonneville Power Administration*.

Independent technical review of predation scenarios on juveniles salmonids in the Columbia River. 2007. *Battelle Pacific Northwest Laboratory*.

Independent technical review of evaluation of ladder use at John Day Dam by chinook salmon and steelhead trout. 2006. *Battelle Pacific Northwest Laboratory*.

Oregon Native Salmon and Steelhead Conservation Assessment. 2005. *Oregon Department of Fish and Wildlife*.

Population dynamics and extinction risks of Kootenai River burbot. 2004. *Kootenai Tribe of Idaho and Idaho Department of Fish and Game*.

Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. 2004. *California State Water Contractors*.

Stranding of juvenile fall chinook salmon in the Hanford Reach of the Columbia River as a result of hydropower operations. 2003. *Columbia River Intertribal Fish Commission for Alaska Department of Fish and Game*.

Green sturgeon status review. 2002. *Metropolitan Water District of Southern California*.

Indirect effects of water export on juvenile salmon in the Sacramento-San Joaquin Delta: a conceptual Foundation. 2002. *Metropolitan Water District of Southern California*.

Analysis of cutthroat trout population viability in Timothy Lake, Oregon. 2002. *Portland General Electric*.

Evaluation and modeling of steelhead capacity, population dynamics, and reintroduction potential above impoundments in the upper Deschutes River, Oregon. 2001. *Portland General Electric*.

Analysis of salmon rearing, migration, survival, and passage based on PIT tag detections for the Clackamas River. 2001. *Portland General Electric*.

Biological assessment of effects of Sherman Island Levee repairs on listed Delta smelt and Sacramento splittail. 2001. *James C. Hanson Engineers*.

Review of conservation assessment of steelhead populations in Oregon. 2001. *American Forest Resources Council*.

Documentation of existing and historic habitat, and native and introduced fish in the Clackamas basin, Oregon. 2001. *Portland General Electric*.

Relicensing studies of fish populations in the upper Stanislaus River, California. 2001. *Pacific Gas and Electric Company and Tri-dam Project*.

Assessments of biological and habitat effects of Otter Creek and South Fork to Black Bear Creek projects. 2001. *Alaska Power and Telephone*.

Conservation & Recovery Planning

Assessment of adult population objectives and monitoring needs for Pallid Sturgeon. March 23-24, 2009. Pallid Sturgeon Conference and Workshop. Billings MT.

Peer review of critical habitat designation for white sturgeon populations in British Columbia, Canada under the Species At Risk Act. 2009. *Department of Fisheries and Oceans Canada.*

Preparation of background materials for the development of the recovery plan for the southern distinct population segment of North American green sturgeon. 2009. *National Marine Fisheries Service Southwest Region.*

Lower Columbia salmon and steelhead recovery plan. 2009. *Washington Lower Columbia River Fish Recovery Board*.

Research, monitoring and evaluation program for Lower Columbia Salmon and Steelhead. 2008. *Washington Lower Columbia River Fish Recovery Board.*

Estimation of salmon recovery targets for ESA-listed lower Columbia and Willamette river coho, Chinook, Chum, and steelhead using population viability analysis. 2007. *Oregon Department of Fish and Wildlife and Washington Lower Columbia River Fish Recovery Board.*

Lower Columbia salmon and steelhead recovery plan (interim). 2002-2004. *Washington Lower Columbia River Fish Recovery Board*.

Kootenai River Burbot conservation plan. 2004. *Kootenai Tribe of Idaho*.

Upper Columbia River white sturgeon recovery plan. 2002. *Spokane Tribe of Indians, British Columbia Ministry of Water, Land and Air Protection, and BC Hydro Corporation*.

Fishery Management

Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 2009. *Pacific Fishery Management Council.*

Biometrics and fishery analysis support for the Pacific Fishery Management Council Scientific and Statistical Committee. 2009. *Oregon Department of Fish and Wildlife.*

Risk Analysis of All-H Recovery Strategies for Tule Fall Chinook. 2009. *Washington Lower Columbia River Fish Recovery Board.*

Peer review of Marine Stewardship Council assessment of the sustainability of British Columbia commercial salmon fishery. 2009. *TAVEL Certification.*

Problems and solutions in escapement goal management of upper Cook Inlet salmon fisheries. 2008. *American Fisheries Society Alaska Chapter Meeting.*

Marine Stewardship Council assessment of the sustainability of Russia's JSC Gidrostroy commercial salmon fishery on Iturup Island in the south Kuriles. 2008. *Scientific Certification Systems*.

Upper Cook Inlet salmon fishery model for analyzing harvest, allocation, and escapement effects of alternative management strategies. 2008. *Kenai River Sportfishing Association*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2008. *Kenai River Sportfishing Association*.

Fishery risk assessment for Columbia River coho based on population viability analysis. 2007. *Washington Department of Fish and Wildlife and the Lower Columbia Fish Recovery Board*.

Biological analysis of population and fishery effects of *de minimis* fisheries for Klamath Fall Chinook. 2007. *Pacific Fishery Management Council*.

Marine Stewardship Council assessment of the sustainability of Alaska commercial salmon fisheries. 2007. *Scientific Certification Systems and the Alaska Department of Fish and Game*.

Kasilof sockeye escapement goal analysis. 2007. Kenai River Sportfishing Association.

Analysis of size-selective Kenai King salmon fisheries and regulations. 2007. *Alaska Department of Fish and Game*.

ESA fisheries management and evaluation plan for lower Columbia River coho in Oregon freshwater fisheries of the lower Columbia River. 2005. *Oregon Department of Fish and Wildlife*.

Analysis of the potential effects and alternatives for selective fishing in the lower Columbia River commercial and recreational fisheries. 2005. *Bonneville Power Administration*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2005. *Kenai River Sportfishing Association*.

Review of the Coded Wire Marking Program for Columbia Basin Hatchery Salmon and Steelhead, Phase I. 2004. *Bonneville Power Administration*.

Review of live capture selective harvest methods study for Columbia River spring chinook. 2003. *Salmon for All*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2002. *Kenai River Sportfishing Association*.

Effects of large-mesh gillnet use on steelhead and salmon catch in Columbia River Zone 6 gillnet fisheries. 2001. *Yakama Nation and the Bonneville Power Administration*.

ESA fisheries management and evaluation plan for lower Columbia River chinook in Oregon freshwater fisheries of the lower Columbia River. 2001. *Oregon Department of Fish and Wildlife*.

ESA fisheries management and evaluation plan for upper Willamette Spring chinook in freshwater fisheries of the Willamette basin and lower Columbia River. 2000. *Oregon Department of Fish and Wildlife*.

Conservation risks of mixed stock fisheries for wild spring chinook salmon from Oregon's McKenzie River based on a population viability analysis. 2000. *Oregon Department of Fish and Wildlife.*

Peer review of certification report on sustainability of Alaska salmon fisheries. 2000. *Marine Stewardship Council*.

Hatchery Evaluation

Strategic and Hatchery Master Plans for impounded white sturgeon populations of the lower Columbia and Snake rivers. 2008-2009. Columbia River Inter-tribal Fish Commission.

Sturgeon hatchery planning and evaluation technical assistance. 2009. *Yakama Nation Fisheries.*

Upper Columbia sturgeon hatchery release strategy. 2008. *British Columbia Ministry of Environment and BC Hydropower*.

Kootenai River White Sturgeon Conservation Aquaculture Program Overview, 1990-2007. 2008. *Kootenai Tribe of Idaho*.

Kootenai River sturgeon hatchery and endangered species evaluations. 2001-2009. *Kootenai Tribe of Idaho*.

Hatchery genetic management plans for the Sandy and Clackamas River Hatcheries. 2005. *Oregon Department of Fish and Wildlife*.

Coeur d'Alene Tribe Trout Production Master Plan. 2002. *Coeur d'Alene Tribe*.

Scientific Publications

2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences 66:802-815. *(Justice, Pyper, Beamesderfer, Paragamian, Rust, Neufeld & Ireland).*

2008 Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234. *(Paragamian, Pyper, Daigneault, Beamesderfer & Ireland).*

2007 Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337. *(Beamesderfer, Simpson, & Kopp).*

2005 Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532. *(Paragamian, Beamesderfer & Ireland).*

2004 Dilemma on the Kootenai River - The risk of extinction or when does the hatchery become the best option? American Fisheries Society Symposium 44:377-385. *(Paragamian & Beamesderfer).*

2003 Growth estimates from tagged white sturgeon suggest that ages from fin rays underestimate true age in the Kootenai River, USA and Canada. Transactions of the American Fisheries Society 132:895-903. *(Paragamian & Beamesderfer).*

2002 Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650. *(Ireland, Beamesderfer, Paragamian, Wakkinen & Siple)*.

2000 Managing fish predators and competitors: Deciding when interspecific intervention is effective and appropriate. Fisheries 25(6):18-23. *(Beamesderfer).*

1997 Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417. *(Beamesderfer & Farr).*

1996 Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908. *(Beamesderfer, Ward & Nigro).*

1995 Growth, natural mortality, and predicted response to fishing for largemouth and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688-704. *(Beamesderfer & North).*

1995 Differences in the dynamics and production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society 126:857-872. *(Beamesderfer, Rien & Nigro).*

1994 Accuracy and precision in age estimates of white sturgeon using pectoral fin rays. Transactions of the American Fisheries Society 123:255-265. *(Rien & Beamesderfer).*

1994 Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80:161-170. *(Rien, Beamesderfer & Foster).*

1993 Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67:105-111. *(North, Beamesderfer & Rien).*

1993 A standard weight equation for white sturgeon. California Fish and Game 79:63-69. *(Beamesderfer).*

1992 Book review of "Pacific Salmon Life Histories." Fisheries 17:56-58. *(Beamesderfer).*

1992 Reproduction and early life history of northern squawfish (*Ptychocheilus oregonensis*) in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241. *(Beamesderfer).*

1991 Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447. *(Beamesderfer & Rieman).*

1991 Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458. *(Rieman, Beamesderfer & Poe).*

1990 Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304. *(Beamesderfer, Rieman, & Vigg).*

1990 Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76:174-180. *(Elliott & Beamesderfer).*

1990 Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241. *(Rieman & Beamesderfer).*

1990 White sturgeon in the lower Columbia River: Is the stock overexploited? North American Journal of Fisheries Management 10:388-396. *(Rieman & Beamesderfer).*

1988 Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510. *(Beamesderfer & Rieman).*

CURRICULUM VITAE

JAMES E. PARHAM, Ph.D.

President
Parham & Associates Environmental Consulting, LLC
1014 Blue Jay Way, Suite 100
Gallatin, TN 37066
615-989-1072
Email: Jim.Parham@ParhamEnvironmental.com

and

Hydrologist and Aquatic Biologist
Bishop Museum
1525 Bernice Street
Honolulu, HI 96817-2704
808-343-4487
Email: jparham@bishopmuseum.org

Education

Louisiana State University
Ph.D. in Biological Sciences, May 2002
Major Professor: J. Michael Fitzsimons
Dissertation: Spatial models of Hawaiian streams and stream fish habitats.
Internet location: http://etd.lsu.edu:8085/docs/available/etd-0419102-000538/

University of Guam
Master of Science Degree in Biology, December 1995
Major Professor: Stephen G. Nelson
Thesis: Habitat use by an assemblage of tropical oceanic island streamfishes.

Virginia Polytechnic Institute and State University
Bachelor of Science Degree in Fisheries Management, December 1989

Professional Experience – Research

Parham and Associates Environmental Consulting, LLC.
President, January 2008 to present

Owns and operates a consulting company focused on providing comprehensive instream flow and habitat assessments for riverine fishes.

Bishop Museum
Hydrologist and Aquatic Biologist, July 2005 to present

Responsible for project developing a rainfall to runoff model for estimating stream flow in Hawaiian streams for coordination with GIS habitat models. Also responsible for creating an Atlas of Hawaiian Watersheds covering all watersheds and aquatic resource data for the state of Hawaii.

University of Nebraska – School of Natural Resources Sciences
Postdoctoral Research Associate, December 2001 to June 2005

Developed GIS models to allow coordination among findings of multiple research projects on the habitat use of sturgeon with spatial data on habitat availability and river discharge in the lower Platte River. Additional responsibilities focused on the continuation of developing GIS habitat models for Hawaiian Streams.

Louisiana State University - Museum of Natural Science
Research Assistant, January 1998 to 2001

Designed and developed GIS models of Hawaiian streams for the Hawai'i Division of Aquatic Resources

Louisiana State University - Museum of Natural Science
Curatorial Assistant, July 1997 to December 1997

Maintained the collection of fishes, approximately 122,000 specimens, and processed loan requests.

University of Guam - Marine Laboratory
Research Assistant, September 1993 to February 1996

Monitored of the fishes and macrofauna of a tropical stream on Guam. Duties included field survey modification and implementation, comparison of the previous years results with current years survey and report writing.

University of Guam - Marine Laboratory
Research Assistant, January 1995 and January 1996

Surveyed the streamfishes of Palau and Pohnpei (Micronesia) to aid in mitigating the effects of proposed development projects. This project entailed surveys and collections in remote watersheds. Additional duties included data analysis and report preparation.

University of Guam - Water and Energy Research Institute
Research Assistant, May 1994 to May 1995

Determined the microhabitats of the streamfishes of the Asmafines River, a small tropical stream on Guam, with respect to instream flow requirements. Helped write proposal, determined site and survey method, carried out visual surveys, and wrote technical report.

Environmental Systems Planners, Inc.
Biologist, January 1991 to March 1992
Worked on mangrove restoration projects and environmental impact statements in Southwest Florida.

Certified in ArcView GIS, Spatial Analyst, and ArcHydro by ESRI.
Certified Advanced Scuba Diver by PADI.
Certified Research Scuba Diver by AAML.

Professional Experience - Teaching

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2004
Co-Instructor for undergraduate Introduction to GIS in Natural Resources class

University of Nebraska – School of Natural Resources Sciences
Instructor, Fall 2003 - Spring 2004
Designed and taught a distance-learning course for biologists, hydrologists, and land managers in Hawaii on GIS modeling of fish habitats and surface flows.

China Tropical Lands Project – Guangzhou, China
Assistant Coordinator – November 2003
Assisted with a conference and workshop on improving natural resource management in China's degraded lands for environmental NGO's and scientists.

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2003
Instructor for graduate/undergraduate Fisheries Biology Class

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2002
Instructor for undergraduate Natural Resources Seminar

Louisiana State University - Department of Zoology
Teaching Assistant, January 1997 to June 1997
Laboratory Instructor for two classes of Introductory Biology.

University of Guam - College of Arts and Science
Teaching Assistant, September 1993 to December 1994
Laboratory instructor for Environmental Biology class for three semesters.

Publications

Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds and their Aquatic Resources. Division of Aquatic Resources, DLNR, Hawaii. 5 volumes. 4,500+ pgs.

Shuman, DA, JE Parham, and EJ. Peters. 2007. Stock characteristics of shovelnose sturgeon in the lower Platte River, Nebraska. Journal of Applied Ichthyology. 23 (2007), 484–488

Swigle, BD, JE Parham, and EJ Peters. 2007. Movement and Habitat Use by Shovelnose and Pallid Sturgeon in the Lower Platte River, Nebraska. Transactions of the American Fisheries Society.

Kuamo'o, D. G. K., G. R. Higashi, and J. E. Parham. 2007. Structure of the Division of Aquatic Resources Survey Database and use with a Geographic Information System. In: Biology of Hawaiian Streams and Estuaries, N. L. Evenhuis & J. M. Fitzsimons, eds. Bishop Museum Bulletin in Cultural and Environmental Studies 3:315-322.

Steinauer, ML, JE Parham, and BB Nickol. 2005. Geographic Information System Analysis of the Patterns of Host Use, Habitat Use and Development of a Fish Parasite *Leptorhyncoides thecatus* (Acanthocephala: rhadniorhynchidae). Journal of Parasitology.

Parham. JE. 2005. Aquatic Survey Techniques on Oceanic Islands: Important Design Considerations for the PABITRA Methodology. Pacific Science. 59:2. pgs 283-291.

Fitzsimons JM, JE Parham, LK Benson, MG McRae, and RT Nishimoto. 2005. Biological Assessment of Kahana Stream, Island of O'ahu, Hawai'i, with the Use of Procedures from the PABITRA Manual for Interactive Ecology and Management. Pacific Science. 59:2. pgs 273-281.

Fitzsimons, JM, RT Nishimoto, and JE Parham. 2005. Methods for Analyzing Stream Ecosystems. Chapter 7 in Biodiversity Assessment of Tropical Island Ecosystems: PABITRA Manual for Interactive Ecology and Management (D. Mueller-Dombois, KW Bridges and CC Daehler, eds.)

Fitzsimons, JM, JE Parham, and RT Nishimoto. 2002. Similarities in behavioral ecology among amphidromous and catadromous fishes on the oceanic islands of Hawai'i and Guam. Environmental Biology of Fishes. 65:123-129.

Nelson, SG, JE Parham, RB Tibbatts, FA Camacho, TA Leberer, and BD Smith. 1997. Distributions and microhabitats of the amphidromous gobies in streams of Micronesia. Micronesica. pg 83-91.

Technical Reports

Parham, JE. 2008. Development of a Database Modeling Tool to Predict Aquatic Species Distributions within Hawaiian Streams. Division of Aquatic Resources, DLNR, State of Hawaii. 56 p.

Parham, JE. 2008. Development of Database Reporting Tools and Results from DAR Rapid Bioassessment Surveys Conducted on Nine North Shore Streams, Oahu, Hawaii. Division of Aquatic Resources, DLNR, State of Hawaii. 55 p.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waihe'e Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Piinaau Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waiehu Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Honopou Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waiokamilo Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Honopou Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 50p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Hanehoi Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 46p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Piinaau Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 43p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Wailuanui Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 34p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Waiokamilo Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 32p.

Parham, JE. 2007. Hydrologic Analysis of the lower Platte River from 1954 -2004, with special emphasis on habitats of the Endangered Least Tern, Piping Plover, and Pallid Sturgeon. 2007. Nebraska Game and Parks Commission. Lincoln, NE. 175p.

Peters EJ and JE Parham. 2007. Ecology and management of pallid sturgeon and sturgeon chub in the Platte River, Nebraska. Nebraska Game and Parks Commission. Lincoln, NE. 232 p.

Parham, JE, EJ Peters, CN Reade, and J Olnes. 2005. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River. Final report May 2005. The Pallid Sturgeon and Sturgeon Chub Task Force. 544 p.

Parham, JE. 2003. GIS Habitat Modeling of Native Hawaiian Stream Fishes: Project Report. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii.

Fitzsimons, JM, JE Parham, LK Benson, and MG McRae. 2002. Biological Assessment of Kahana Stream, Island of O'ahu: Final Report. Division of Aquatic Resources and Commission on Water Resources Management, Department of Land and Natural Resources, State of Hawaii.

Peters, EJ, M Kaminski, J Olnes, JE Parham, CN Reade, R Ruskamp, S Sedlacek, D Shuman, and B Swigle. 2002. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River: Progress report May 2001 / May 2002. The Pallid Sturgeon and Sturgeon Chub Task Force.

Peters, EJ, J Olnes, JE Parham, CN Reade, R Ruskamp, D Shuman, VA Snook, and B Swigle. 2001. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River: Progress report May 2000 / May 2001. The Pallid Sturgeon and Sturgeon Chub Task Force.

Olnes, J, R Ruskamp, JE Parham, and EJ Peters. 2001. Water quality monitoring within the lower Platte River Basin: Annual report for 2000/2001. US Fish and Wildlife Service.

Smith, BD, JE Parham, and SG Nelson. 1996. Annual report on the monitoring of the Ugum River Weir for the Public Utility of Guam 1995.

Nelson, SG, BD Smith, JE Parham, B Tibbatts, and F Camacho. 1995. A survey of the streamfishes of the upper reaches of the Ngermeskang River, Palau, with recommendations for conservation and monitoring. University of Guam Marine Laboratory, Technical Report # 100, pp. 18.

Invited Presentations (presenter in **bold**)

Parham, J.E. 2009. Annual occurrence of suitable pallid sturgeon habitat and habitat connectivity in relation to historic river discharge throughout the lower Platte River, Nebraska. Sturgeon Symposium. Annual Meeting of the American Fisheries Society, Nashville, TN.

Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2009. Synthesizing results from current and historical stream surveys in Hawaii to determine fish distribution and habitat use at multiple spatial scales. National Fish Habitat Mapping Symposium. Annual Meeting of the American Fisheries Society, Nashville, TN.

Parham, J.E. 2009. The use of GIS and database systems to facilitate collaboration and improve information flow in large fisheries projects. Tennessee Chapter of the American Fisheries Society. Montgomery Bell State Park, TN.

E.J. Peters and J.E. Parham. 2009. Pallid Sturgeon Literature Review. Platte River Recovery Implementation Program. Columbus, NE.

Parham, J.E., **G.R. Higashi**, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds and Their Aquatic Resources – an important tool to aid in statewide watershed management. Workshop on the Ecology, Restoration, and Management of Hawaii Stream and Riparian Systems. Kaneohe, HI.

Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Stream Species – describing habitat and distribution of stream animals statewide. Workshop on the Ecology, Restoration, and Management of Hawaii Stream and Riparian Systems. Kaneohe, HI.

Parham, J.E., G.R. Higashi, **E.K. Lapp**, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds and Their Aquatic Resources – an important tool to aid in statewide watershed management. Hawaii Conservation Conference. Honolulu, HI.

Parham, J.E., **G.R. Higashi**, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Stream Species – describing habitat and distribution of stream animals statewide. Hawaii Conservation Conference. Honolulu, HI.

JE Parham. 2007. DLNR Stream Program. Presentation for the special envoy representing the President of the United States. Honolulu, HI.

JE Parham. 2007. Rule of Thumb Instream Flow Standards. Division of Aquatic Resources and Commission on Water Resources Management. Honolulu, HI.

Higashi, GR, DGK Kuamo'o, and **JE Parham.** 2006. Division of Aquatic Resources' Aquatics Surveys Database: Use and Applications. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE. 2005. Instream Flow Modeling for Hawaiian Streams. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE, **EJ Peters**, CN Reade, and JJ Olnes. 2005. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River. The pallid sturgeon and sturgeon chub task force. Columbus, NE.

Parham JE, 2005. The Basis for an Instream Flow Program in the Hawaiian Islands. Symposium on Hawaiian Streams and Estuaries. Hilo, HI.

Kuamo'o, DGK, GR Higashi, and JE Parham. 2005. Structure of the Division of Aquatic Resources Surveys Database and Use with a Geographic Information System. Symposium on Hawaiian Streams and Estuaries. Hilo, HI.

Parham, JE. 2005. Instream flows for sturgeon habitat and movement in the Platte River, Nebraska. Fisheries and Wildlife Departmental Seminar, University of Missouri. Columbia, MO.

Peters, EJ, Parham, JE, and JJ Olnes. 2005. Estimates of Shovelnose and Pallid Sturgeon Densities in the Platte River, Nebraska, 2000-2004. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE, BD Swigle, and EJ Peters. 2005. River Connectivity for Migrating Shovelnose Sturgeon in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE, BD Swigle, DA Shuman, VA Snook and EJ Peters. 2005. The Relationship between River Discharge and Instream Habitat for Sturgeons in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Shuman, DA, JE Parham, and EJ Peters. 2005. Evaluation of the Condition, Distribution, Structure, and Growth of Shovelnose Sturgeon in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE. 2004. Determining Suitable Habitat for Endangered Species in the Lower Platte River. US Fish and Wildlife Service. Grand Island, NE.

Parham, JE and EJ Peters 2004. Instream Flow Estimation for Endangered Species in the Lower Platte River, Nebraska. Wildlife Club Seminar. Lincoln, NE.

Parham, JE. 2003. Degraded Lands and Water Resources. International Workshop on Degraded Lands and Sustainable Agriculture. South China Agricultural University. Guangzhou, China.

Parham, JE. 2003. Statewide Instream Flow Estimations – Model version 1. Hawai'i Division of Aquatic Resources. Honolulu, HI.

Parham, JE. 2002. Habitat Modeling for Fish Conservation – Examples from Hawai'i and Nebraska, School of Natural Resources Sciences, University of Nebraska. Lincoln, NE.

Parham, JE. 2002. Pallid Sturgeon Habitat Availability Assessment on the Lower Platte River, Nebraska. Lower Platte River Corridor Alliance. Lincoln, NE.

Parham, JE. 2002. The Ecology and Management of Sturgeon on the Lower Platte River, Nebraska. Papio-Missouri Natural Resource District. Omaha, NE.

Parham, JE. 2002. Determining Habitat Availability on the Lower Platte River. Nebraska Game and Parks Commission. Lincoln, NE.

Parham, JE. 2002. Multi-spatial Modeling and Instream Flow Management: an Example from Hawaiian Streams. Instream Flow Council Biennial Meeting. Crossnore, NC.

Parham, JE and JM Fitzsimons. 2002. Habitat Assessment and Geographic Information Systems. Hawaii Water Quality Conference. Honolulu, HI.

Parham, JE. 2002. Spatial Models of Hawaiian Stream Fishes. Habitat Modeling Workshop. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce, Lincoln, NE.

Parham, JE and JM Fitzsimons. 2000. Multi-dimensional GIS: a Powerful Tool for the Conservation of Stream Fishes. GIS Symposium at the Annual Meeting of the American Fisheries Society, St. Louis, MO.

General Presentations (presenter in **bold**)

Parham, JE, BD Swigle, DA Shuman, VA Snook, and EJ Peters. 2004. Relationships between habitat availability and river discharge for *Scaphirhynchus* sturgeons in the lower Platte River, Nebraska. 4th World Fisheries Congress. Vancouver, BC.

Parham, JE, BD Swigle, DA Shuman, VA Snook, and EJ Peters. 2003. Comparisons between river discharge and habitat availability for sturgeons in the lower Platte River, Nebraska. 64th Midwest Fish & Wildlife Conference. Kansas City, MO.

Parham, JE. 2003. Predicting instream habitat and reach occupancy for native Hawaiian stream fishes. Ecological Society of America's Annual Conference, Savannah, GA.

Steinauer ML and **JE Parham**. 2003. Geographic distribution of host and habitat use of an acanthocephalan parasite, *Leptorhynchoides thecatus*. Ecological Society of America's Annual Conference, Savannah, GA.

Peters, EJ, JE Parham, DA Shuman, and BD Swigle. 2003. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River, Nebraska. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce meeting. Ponca State Park, Ponca, NE.

Peters, EJ, MT Kaminski, JE Parham, CN Reade, DA Shuman, BD Swigle, and LA Vrtiska. 2003. Current Research on Pallid Sturgeon in the lower Platte River, NE. Middle Basin Pallid Sturgeon Recovery Work Group, St. Louis, MO.

Kuamo'o, DL and JE Parham. 2002. Using ArcView 3.x to Edit USGS Attribute Tables with Tributary Codes for Use With HDAR Stream Database. Waipi'o Valley Conference, sponsored by Bishop Museum and USDA NRCS. Honolulu, HI, USA.

Parham, JE. 2002. Summary and Recommendations from the Habitat Workshop – Determining Habitat Availability on the Lower Platte River. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce meeting. Gavins Point, NE.

Parham, JE. 2002. Spatial Modeling at the Island Scale and its Implications on Larval Recruitment Dynamics. Hawai'i Division of Aquatic Resources. Honolulu, HI.

Parham, JE. 2002. Development of a Geospatial Database. Habitat Modeling Workshop. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce. Lincoln, NE.

Parham, JE and JM Fitzsimons. 2001. Habitat Modeling for Native Hawaiian Stream Fishes. Annual Meeting of the American Fisheries Society. Phoenix, AZ.

Parham, JE. 2001. Spatial Models of Hawaiian Streams and Stream Fish Habitats. Dissertation Exit Seminar, Louisiana State University Museum of Natural Sciences. Baton Rouge, LA.

Parham, JE and JM Fitzsimons. 2001. The Use of Geographic Information Systems (GIS) in Water Resources Planning, Management and Allocation Issues in the Hawaiian Islands – Project Update. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE and JM Fitzsimons. 2001. Spatial Modeling to Aid in Instream Flow determination of Native Hawaiian Stream Fishes. Annual Meeting of the Society of Conservation Biology. Hilo, HI.

Parham, JE and JM Fitzsimons. 2000. The Use of Geographic Information Systems (GIS) in Water Resources Planning, Management and Allocation Issues in the Hawaiian Islands. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE. 2000. The Spatial Ecology and Conservation of Native Hawaiian Stream Fishes. Ecology and Evolution Seminar at the University of Nebraska. Lincoln, NE.

Parham, JE and JM Fitzsimons. 1999. Spatial Modeling of Habitat Dynamics for Native Hawaiian Stream Fishes. XVIII Pacific Science Congress. Sydney, Australia.

Parham, JE. 1999. Revisiting the Niche as an N^{th} Dimensional Hypervolume: a Multi-dimensional GIS Analysis for the Conservation of Native Freshwater Fishes in the Hawaiian Islands. Louisiana State University Annual Biograds Symposium. Baton Rouge, LA.

Parham, JE and JM Fitzsimons. 1999. A Multi-scale GIS Analysis for the Management of Native Freshwater Fishes in the Hawaiian Islands. Annual Meeting of the American Fisheries Society. Charlotte, NC.

Parham, JE and **JM Fitzsimons**. 1999. GIS Modeling Predicts Gain and Loss of Fish Habitat Associated with Changes of Flow in Hawaiian Streams. LSU Ecology Forum. Baton Rouge, LA.

Parham, JE. 1998. Island Hopping in Paradise: An Ichthyologist in Micronesia. Audubon Society of Louisiana. Baton Rouge, LA.

Parham, JE. 1997. Integrating GIS and Microhabitat Surveys for the Conservation of Native Fishes. Louisiana State University Museum of Natural Science. Baton Rouge, LA.

Nelson, SG and JE Parham. 1995. Diversity and Microhabitat: a Study of Stream Fishes of Micronesia. XVII Pacific Science Congress. Beijing, China.

Nelson, SG and JE Parham. 1994. Within Stream Distributions and Microhabitats of Micronesian Stream Fishes. Symposium on the Tropical Biosphere, University of the Ryukyus. Okinawa, Japan.

Computer Models, Spatial Datasets, and Databases developed

Parham, JE**. Hawaiian Stream Habitat Evaluation Protocol.** 2009. A multi-spatial model to provide standardized evaluation for stream animal habitat in Hawaiian streams to assess the impacts of land use change, flow diversion, habitat manipulation, and water quality issues. Hawaii Division of Aquatic Resources

Parham, JE. **Predictive habitat models for Hawaiian stream fishes.** 2008. GIS models that show expected distributions of stream fishes throughout Hawaii. Version 1. Hawai'i Division of Aquatic Resources.

Parham, JE. **Reach Classification for Hawaiian Streams.** 2006. A GIS model that classified streams into reaches using their major geomorphological characteristics. Version 1. Hawai'i Division of Aquatic Resources.

Parham, JE. **Lower Platte River Habitat Availability Model.** 2005. A GIS-based river discharge to habitat availability model for the lower 150 km of the Platte River. Version 1.0.

Parham, JE. **Lower Platte River Connectivity Model.** 2005. A GIS-based river discharge to river connectivity model for fish passage for the lower 150 km of the Platte River. Version 1.0.

Parham, JE and J Gilsdorf. **UNL Deer Project Database,** 2005. Designed database for long term tracking of deer throughout Nebraska for behavior, habitat use, and Chronic Wasting Disease studies by the University of Nebraska - School of Natural Resources. Version 1.0

Parham, JE, J Fisher, and T Barada. **Nebraska Statewide Stream Survey Database.** 2004. Designed database for a 3 year statewide stream surveys of 119 streams in Nebraska for the University of Nebraska - School of Natural Resources and Nebraska Game and Parks Commission. Version 1.0

Parham, JE. **Lower Platte River Fish Survey Database**. 2002 and continuous updates to 2005. Designed database for integration of multiple projects focused on endangered fishes in the lower Platte River. University of Nebraska - School of Natural Resources. Versions 1 to 6.0.

Parham, JE. **Statewide Instream Flow Estimator**. 2003. A GIS model for estimating stream discharge from annual rainfall, solar radiation, and topography data for Hawaiian streams. Version 1. Hawai'i Division of Aquatic Resources. Version 2 is currently being developed to calculate daily discharge.

Parham, JE. **Hawaii Stream Type Classification Model.** 2003. A GIS model that classified streams by their major geomorphological characteristics based on data from 150 Hawaiian streams. Version 1. Hawai'i Division of Aquatic Resources. Version 2 is near completion with data from all Hawaiian watersheds.

Parham, JE, DGK Kuamo'o, and GR Higashi. **Hawai'i Division of Aquatic Resources Surveys Database.** 2002-2006. A database to store historical and current fisheries surveys in nearshore, esturine, and stream environments. Versions 1-4. Hawai'i Division of Aquatic Resources.

Professional Affiliations

The American Fisheries Society
Community of Science
Fellow at the Center for Great Plains Studies

CURRICULUM VITA

EDWARD JAMES PETERS
PROFESSOR-EMERITUS
School of Natural Resource Sciences
UNIVERSITY OF NEBRASKA-LINCOLN
LINCOLN, NEBRASKA

CURRENT ADDRESS
6270 N County Road M
Loretta, WI 54896
PHONE
(715) 266-2550
EMAIL
epeters@unlnotes.unl.edu

EDUCATIONAL BACKGROUND

Ph D 1974 BRIGHAM YOUNG UNIVERSITY
MAJOR: ZOOLOGY MINOR: GEOLOGY
DISSERTATION TITLE: The effects of highway construction on the fish populations in the Weber River near Henefer, Summit County, Utah.

M S 1970 BRIGHAM YOUNG UNIVERSITY
MAJOR: ZOOLOGY MINOR: BOTANY
THESIS TITLE: Changes with growth in selected body proportions of the woundfin minnow (*Plagopterus argentissimus* Cope: Cyprinidae).

B S 1967 WISCONSIN STATE UNIVERSITY-STEVENS POINT
MAJORS: CONSERVATION and BIOLOGY

TEACHING EXPERIENCE

UNIVERSITY OF NEBRASKA - LINCOLN: SCHOOL OF NATURAL RESOURCE SCIENCES (1997 to 2005)

FISHERIES SCIENCE
ICHTHYOLOGY
FISHERIES BIOLOGY
FOOD, AGRICULTURE, AND NATURAL RESOURCE SYSTEMS (recitation)

UNIVERSITY OF NEBRASKA-LINCOLN: DEPARTMENT OF FORESTRY, FISHERIES AND WILDLIFE (1975 to 1997)

FISHERIES SCIENCE: Developed and taught since 1976. This was the first Fisheries course taught in the College of Agriculture and it emphasized the estimation of biological statistics of fish populations and their application to fish management.

INTRODUCTION TO NATURAL RESOURCES: Developed and taught since 1976. This was the first Natural Resources course taught at UNL and was currently the basic course in the Natural Resources Major.

FISHERIES BIOLOGY: Developed and taught since 1978. Emphasized the study of factors which influence fish productivity in freshwater.

ICHTHYOLOGY: Taught since 1980. This course emphasized the anatomy, physiology, ecology, evolution and systematics of fishes.

INTEGRATED RESOURCES MANAGEMENT: Developed and taught 1990 to 1993. This capstone course for Natural Resources Majors emphasized the interrelated nature of management decisions.

MOUNT MERCY COLLEGE: DEPARTMENT OF BIOLOGY (1972 to 1975)

INVERTEBRATE ZOOLOGY
VERTEBRATE ZOOLOGY
NONVASCULAR PLANTS
VASCULAR PLANTS
ECOLOGY
EVOLUTION
DESERT ECOLOGY (field trip course)

BRIGHAM YOUNG UNIVERSITY: DEPARTMENT OF ZOOLOGY (1971 to 1972)

GENERAL ZOOLOGY

RESEARCH EXPERIENCE

2008
Initiated work on a literature review on pallid sturgeon funded by the Platte River Recovery Implementation Program

2006
Completed the Final Report on the Nebraska stream fisheries inventory project.

2005
Completed field work and submitted the Final Report on the jointly funded Platte River project.
Completed field work on the Nebraska stream fisheries inventory project.

2004
Continued field work on the jointly funded Platte River project.
Continued field work on the Nebraska stream fisheries inventory project.

2003
Continued field work on the jointly funded Platte River project.
Initiated field work on the Nebraska stream fisheries inventory project funded by the Nebraska Game and Parks Commission.
Graduated three MS students.

2002
Continued field work on the jointly funded Platte River project.
Completed field work and submitted the Final Report on the Branched Oak lake project.

2001
Continued field work on the jointly funded Platte River project.
Completed field work and submitted the Final Report on the Lake Ogallala project.
Graduated three MS students.

2000
Continued work on the Lake Ogallala project.
Continued work on the Branched Oak Lake project.
Completed work on U. S. Fish and Wildlife Service grants on Platte River.
Initiated work five year project on the lower Platte River funded jointly by a consortium of Natural Resources Districts, the Nebraska Game and Parks Commission and the US Fish and Wildlife Service.

1999
Continued work on the Platte River and Lake Ogallala projects.
Initiated work on the Branched Oak Lake project funded by the Nebraska Game and Parks Commission.

1998
Initiated work on the Platte River project which included larval fish sampling and pallid sturgeon telemetry and habitat use funded by the US Fish and Wildlife Service.
Continued work on the Lake Ogallala project.
Graduated two MS students.

1997
Continued work on the Lake Ogallala project.
Participated in the Lake Ogallala chemical renovation.
Graduated one MS Student.

1996
Completed the final report on the initial lake Ogallala project.
Completed Final Report on the EPA R-EMAP project.
Initiated work on the revised Lake Ogallala Project funded by the Nebraska Game and Parks Commission.
Completed field work on the Sturgeon Project.
Graduated three MS students and two PhD students.

1995
Completed work and submitted the Final Report on the thermal tolerance study.
Continued work on the Lake Ogallala project
Continued work EPA R-EMAP project.
Initiated work on the biology of sturgeon in the Platte River funded by the US Fish and wildlife Service.
Graduated four M.S. students.

1994
Completed the final report for the Platte River project.
Continued work on the thermal tolerance study.
Initiated work on the Lake Ogallala project funded by the Nebraska Game and Parks Commission
Initiated work on a stream survey project funded by the US EPA through R-EMAP.

1993
Completed research on development of suitability criteria for Platte River fishes and the creel survey of the lower Platte River.
Initiated work on thermal tolerances of selected Platte River fishes supported by the US Fish and Wildlife Service.

1992
Initiated a creel survey study on the lower Platte River and began comparison of habitat suitability criteria between the lower Platte and the central Platte fishes.
Graduated one M.S. student.

1991
Initiated study on Biodiversity of the central Platte River (fishes) funded by the US Fish and Wildlife Service.
Finalized contracts with four Natural Resources Districts, the Platte River Whooping Crane Trust and the Nebraska Game and Parks Commission under the title "Biological and economic analyses of the fish communities in the Platte River".
Completed work and prepared the final report for the Studies of Channel catfish in the lower Platte River project.

1990
Continued work on the Platte River project.

1989
Continued work on the Platte River project.
Graduated one M.S. student.

1988

Completed work and prepared the final report for on the Platte River project.
Initiated study on the Platte River funded by the U.S. Army Corps of Engineers and the Nebraska Game and Parks Commission.
Completed faculty development leave.
Graduated one M.S. student.

1987
Continued work on the Platte River project.
Began faculty development leave.
Graduated two M.S. students.

1986
Developed contracts with the Lower Platte North Natural Resources District and the Nebraska Game and Parks Commission for study of instream flow requirements of fish and aquatic invertebrates in the lower Platte River.
Completed courses on the use and application of Instream Flow Incremental Methodology.
Graduated one M.S. student.

1985 Began negotiations for the study of instream flow requirements of fish and aquatic invertebrates in the Platte River. Research appointment adjusted to 30%.

1984 Completed introductory course in the Instream Flow Incremental Methodology. Graduated four M.S. students.

1983 Completed work on the Maple Creek Model Implementation Plan study. Continued fish population surveys in the Little Blue River drainage. Graduated one M.S. student.

1982 Continued work on Maple Creek. Continued fish population surveys in the Little Blue River drainage.

1981 Continued work on Maple Creek. Continued fish population surveys in the Little Blue River drainage.

1980 Completed study of white perch in Buckley Creek Reservoir and completed evaluation of liming project. Continued work on Maple Creek. Conducted fish population survey of the Big Blue River Basin for the U.S. EPA.

1979 Conducted application of lime to Buckley Creek Reservoir to reduce turbidity. Initiated study of channel catfish movement and growth in the Little Blue River. Continued the Maple Creek project.

1978 Completed work on the Nine Mile Creek irrigation return flow study. Continued work on the white perch project. Conducted research on the impacts of the Guernsey silt run on fish and macroinvertebrates in the North Platte River. Initiated an evaluation of watershed erosion and sediment control on the fishes of Maple Creek. Obtained research appointment of 21 %. Graduate two M.S. students.

1977 Began study of the impact of an introduced fish species (white perch) on the fisheries of Buckley Creek reservoir. Started a study of the impacts of irrigation return flow on the invertebrates and trout spawning habitat of Nine Mile Creek. Awarded a summer faculty research fellowship to develop an Experiment Station project.

1976 Initiated research program at UNL (no official research appointment). Received two University Research Council grants to support graduate thesis research projects on the study of fish distribution in the Salt Creek drainage and a study of the production rates of aquatic insects in a turbid reservoir.

1974 to 1975 Directed undergraduate independent study research studies in biology at Mount Mercy College.

1967 to 1974 Graduate thesis and dissertation research under the direction of Dr. David White. Assisted with a variety of aquatic and terrestrial research projects.

1966 Wild rivers fish, macroinvertebrate and water chemistry survey of northeast Wisconsin under the direction of Dr. George Becker. Conducted an undergraduate research project on the distribution of fishes in the Wisconsin River in Portage County, Wisconsin.

RELATED PROFESSIONAL EXPERIENCE
American Fisheries Society: member since 1968, active in state chapter activities, regular participant in North Central Division meetings, elected to and served on state, division and national committees.

American Society of Ichthyologists and Herpetologists: member since 1970.

North American Benthological Society: member since 1970, irregular participant in national meetings.

Nebraska Academy of Sciences: member since 1975, regular participant and contributor to annual meetings, elected biological and medical sciences section coordinator, session chairman on several occasions.

Wisconsin Academy of Sciences, Arts and Letters: member since 1965 (life member 2000).

Society of Sigma Xi: elected to membership 1970, elected to Nebraska chapter offices: membership coordinator 1984-1986, President 1989-1990.
Center for Great Plains Studies: elected a Fellow 1982.

State and University committees including; the Aquaculture Task Force, the Prairie Bend Technical Advisory Group, the 404 Task Force, the UN Water Policy Steering Committee, UNL Faculty Senate, College of Agriculture Instructional Improvement Committee, the Natural Resources Curriculum Committee, the Agricultural Research Division Advisory Council and the Curriculum Revitalization Task Force.

FUNDED RESEARCH PROJECTS (chronological listing)

1976
A distributional study of the fishes in the Salt Creek drainage, UNL Research Council, $700, (1976-1978)

Production rates of aquatic insects in a turbid reservoir, UNL Research Council, $813, (1976-1978)

1977
Effects of irrigation return flow on Nine-Mile Creek, Nebraska Natural Resources Commission, $14,299, (1977-1978)

Impact of an introduced species on the fisheries resources of Nebraska, Nebraska Water Resources Center, $20,000, (1977-1980)

Summer faculty research fellowship, Nebraska Agricultural Experiment Station, $1,500 (1977)

1978
Effects of a silt run on the biota of the North Platte River near Guernsey, Wyoming, Nebraska Water Resources Center, $8,500 (1978)

Impact of watershed sediment control on the biota of Maple Creek, Nebraska Department of Environmental Control, $75,000 (1978-1983)

1979
Effects of applications of lime on the turbidity in Buckley Creek Reservoir, Nebraska Water Center and the Little Blue Natural Resources District, $6,600 (1979-1984)

1980

A fish population survey of the Big Blue River basin, U.S. Environmental Protection Agency, $873 (1980)

1986
Instream flow requirements of fish and aquatic invertebrates in the lower Platte River, Nebraska Game and Parks Commission, $190,400 (1986-1988)

Instream flow requirements of fish and aquatic invertebrates in the lower Platte River, Lower Platte North Natural Resources District, $40,000 (1986-1988)

1988
Platte River Fisheries Study, U.S. Army Corps of Engineers, $40,000 (1988-1990)

Studies of Channel Catfish in the lower Platte River, Nebraska Game and Parks Commission, $196,140 (1988-1991)

1991
Distribution and abundance of fishes in the central Platte River, U.S. Fish and Wildlife Service, $22,300 (1991-1992)

1992
Biological and economic analyses of fish communities in the Platte River, (1992-1993)
Nebraska Game and Parks Commission, $176,264
Central Platte Natural Resources District, $10,000
Lower Platte North Natural Resources District, $10,000
Lower Platte South Natural Resources District, $10,000
Papio/Missouri Natural Resources District, $10,000

Development of an aquatic mesocosm facility, U.S. Fish and Wildlife Service, $50,000 (1992-1993)

Influences of vegetation on wildlife and fisheries populations in the central Platte, River, U.S. Fish and Wildlife Service, $80,000 (1992-1994)

1993
Critical thermal maxima of selected fishes in the Platte River, U.S. Fish and Wildlife Service, $80,000 (1993-1995)

1994
Population structure and food habit analyses of alewife, rainbow trout and other selected fishes in Lake Ogallala, Nebraska Game and Parks commission, $133,500 (1994-1996)

Measuring the health of Nebraska's fisheries, Nebraska Department of Environmental Quality, $156,235 (1994-1995)

1995
Studies of sturgeon in the Platte River, U.S. Fish and Wildlife Service, $54,000 (1995-1997)

1996
Alewife and trout studies in Lake Ogallala, Nebraska Game and Parks Commission, $170,010 (1996-1999)

1998
Pallid sturgeon in the lower Platte River, U. S. Fish and Wildlife Service, $96,720 (1998 - 2001)
Endangered fishes of the lower Platte River, U.S. Fish and Wildlife Service, $76,560 (1997 - 2001)

1999
Branched Oak Reservoir evaluation project, Nebraska Game and Parks Commission, $193,413 (1999 - 2001)

2000
Ecology and management of sturgeons in the lower Platte River, Nebraska Game and Parks Commission, $701,000 (2000 - 2005)
Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River, Pallid sturgeon / sturgeon chub task force, $550,000 (2000 - 2005)

2003
Nebraska statewide stream fisheries inventory, Nebraska Game and Parks Commission, $459,575 (2003-2006)

2006
Publication of the Ecology and management of sturgeon in the lower Platte River, Nebraska, Nebraska Game and Parks Commission, $40,000 (2006 – 2008)

2008
A review of literature which pertains to the use of the lower Platte River by pallid sturgeon, Platte River Recovery Implementation Program, $32,000 (2008)

GRADUATE STUDENT THESES (all at the University of Nebraska – Lincoln)

1978
Lund, J.C.
Production rates of benthic insects in a turbid reservoir. M.S.
Maret, T.R.
The fishes of the Salt Creek basin, Nebraska. M.S.
1983
Winter, R.L.
A test of lake chubsucker, *Erimyzon succetta*, as forage for largemouth bass, *Micropterus salmoides*, in small eastern Nebraska impoundments. M.S.
1984
Chapin, C.A.
Effects of agricultural lime on the water quality and benthic fauna in a turbid Nebraska reservoir. M.S.
Klammer, J.A.
Food and feeding of rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*) in two Nebraska sandhills streams. M.S.
Shadle, J.J.
A study of the crayfish (*Orconectes immunis*) in an intermittent Nebraska stream. M.S.
Walker, S.R.
Abundance and movement of channel catfish, *Ictalurus punctatus*, in the Little Blue River, Nebraska. M.S.
1986
Schleiger, S.L.
Interspecific interactions of a green sunfish (*Lepomis cyanellus*) and creek chub (*Semotilus atromaculatus*) in small stream in southeast Nebraska. M.S.
1987
Angle, L.A.
Effects of sediment addition on the drift of aquatic macroinvertebrates in Nine Mile Creek, Nebraska. M.S.
Zaroban, D.W.
A field test of habitat evaluation procedures for creek chub (*Semotilus atromaculatus*) and channel catfish (*Ictalurus punctatus*). M.S.
1988
Bunnell, D.B.
Habitat utilization and movement of adult channel catfish and flathead catfish in the Platte River, Nebraska. M.S.
1989
Callam, M.A.
Use of prepositioned electrofishing grids to assess habitat suitability for *Notropis stramineus*, *N. lutrensis* and *N. blennius* in the Platte River, Nebraska. M.S.
1992
Yu, Shyi-Liang
Logistic regression models of habitat use by three cyprinids in the Platte River, Nebraska. M.S.
1995
Chapman, R.C.
Movements of channel catfish in the Platte River, Nebraska. M.S.
Ihrie, D.B.
A test of the ecoregion classifications of Nebraska streams using discriminant analysis. M.S.
McBride, M.J.
Aquatic macroinvertebrates of the central Platte River, Nebraska. M.S.
Michl, G.T.
A test of the Index of Biotic Integrity for streams in the sandhills region of Nebraska. M.S.

1996

Fessell, B.P.
  Thermal tolerances of Platte River fishes: Field and laboratory studies.   M.S.

Laux, E.A.
  The biology of alewife *Alosa pseudoharengus* in Lake Ogallala, Nebraska.   M.S.

Messaad, I.A.
  Histological responses of red shiner (*Cyprinella lutrensis*) to atrazine terbufos, and their mixture.   PhD

Porath, M.T.
  Influence of prey availability on walleye *Stizostedion vitreum*.   M.S.

Yu, S.L.
  Factors affecting habitat use by fish species in the Platte River, Nebraska.   PhD

1997

Hofpar R.L.
  Biology of shovelnose sturgeon in the lower Platte River, Nebraska   M.S.

1998

Barrow, T. M.
  Factors affecting movements of rainbow trout (*Oncorhynchus mykiss*) in Lake Ogallala, Nebraska. M.S.

2000

Pearson, T. J.
  The use of benthic macroinvertebrates by rainbow trout (*Oncorhynchus mykiss*) in Lake Ogallala, Nebraska. M.S.

Reade. C. N.
  Larval fish drift in the lower Platte River, Nebraska. M.S.

2001

Hodkin, C. A.
  Population characteristics and food habits of the white perch (*Morone americana*) in Branched Oak Lake, Nebraska. M.S.

Huxoll, C. M.
  Movement of rainbow trout and brown trout in relation to water quality and food availability in Lake Ogallala, Nebraska. M.S.

Snook, V. A.
  Movements and habitat use by hatchery-reared pallid sturgeon in the lower Platte River, Nebraska. M.S.

2003

Kopf, S. M.
  Habitat use by chubs of the genera *Macrhybopsis* and *Platygobio* in the lower Platte River, Nebraska. M.S.

Shuman, D. A.
  The age and size distribution, condition, and diet of the shovelnose sturgeon *Scaphirhynchus platorynchus* in the lower Platte River, Nebraska. M.S.

Swigle, B. D.
  Movements and habitat use by shovelnose sturgeon and pallid sturgeon in the lower Platte River, Nebraska. M.S.

PUBLICATIONS (chronological listing)

White, D.A. and E.J. Peters. 1969. A method of preserving color in aquatic vertebrates and invertebrates. Turtox News, 47:296-297.

Barton, J.R., D.A. White, P.V. Winger, and E.J. Peters. 1971. The effects of highway construction on the hydrology and hydrobiology of the Weber River near Henefer. Final report to the Utah Division of Fish and Game and the Utah Department of Highways. 86p.

Barton, J.R., E.J. Peters, D.A. White, and P.V. Winger. 1972. Bibliography on the physical alteration of the aquatic habitat (channelization) and stream improvement. Brigham Young University, Multilith Series, Provo, Utah. 30p.

Barton, J.R., D.A. White, P.V. Winger, and E.J. Peters. 1972. The effects of highway construction on fish habitat in the Weber River, near Henefer, Utah, p. 17-29 In Ecological impact of water resource development. U.S. Bureau of Reclamation Report Number, REC-ERC-27-17.

Winger, P.V., E.J. Peters, M.J. Donahoo, J.R. Barnes, and D.A. White. 1972. A checklist of the macroinvertebrates of the Provo River, Utah. Great Basin Naturalist, 32:211-219.

Peters, E.J. 1976. New course emphasizes total resource concept. Farm, Ranch and Home Quarterly, 23:17.

Maret, T.R. and E.J. Peters. 1979. Food habits of the white crappie, *Pomoxis annularis*, Rafinesque, in Branched Oak Lake, Nebraska, Transactions of the Nebraska Academy of Sciences, 7:75-82.

Maret, T.R. and E.J. Peters. 1980. The fishes of Salt Creek basin, Nebraska. Transactions of the Nebraska Academy of Sciences, 8:35-54.

Lund, J.C. and E.J. Peters. 1981. Production rates of aquatic insects in a turbid reservoir. Transactions of the Nebraska Academy of Sciences, 9:23-34.

Peters, E.J. 1983. New distributional records of the common shiner (*Notropis cornutus*) and the bluntnose minnow (*Pimephales notatus*) in the Little Blue River system in Nebraska. The Prairie Naturalist, 15:38-40.

Peters, E.J. 1987. The sunfish, NEBRASKAland Magazine, 65:10-17.

Peters, E.J., R.S. Holland, M.A. Callam, and D.L. Bunnell. 1988. Habitat utilization, preference and suitability criteria for fish and aquatic invertebrates in the lower Platte River. Final Report, Federal Aid Project No. F-78-R, 260p.

Holland, R.S. and E.J. Peters. 1989. Persistence of a chemical gradient in the lower Platte River, Nebraska. Transactions of the Nebraska Academy of Sciences, 17:111-115

Peters, E.J., R.S. Holland, M.A. Callam, and D.L. Bunnell. 1989. Habitat utilization, preference and suitability criteria for fish and aquatic invertebrates in the lower Platte River. Nebraska Game and Parks Commission Technical Report No. 17, 135p.

Kaminski, M.T., E.J. Peters and R.S. Holland. 1991. Pectoral spine embedding to facilitate sectioning for age analysis of young channel catfish. Transactions of the Nebraska Academy of Sciences, 18:99- 100.

Holland, R.S. and E.J. Peters. 1992. Differential catch by hoop nets of three different mesh sizes in the lower Platte River. North American Journal of Fisheries Management, 12:237-243.

Peters, E.J., R.S. Holland and B.C. Chapman. 1992. Studies of the channel catfish (*Ictalurus punctatus*) in the lower Platte River, Nebraska. Final Report, Federal Aid Project No. F-78-R. 39p.

Holland, R.S. and E.J. Peters. 1992. Age and growth of channel catfish in the lower Platte River, Nebraska. Transactions of the Nebraska Academy of Sciences, XIX:33-42.

Michl, G.T. and E.J. Peters. 1993. New distributional record of the Topeka Shiner in Nebraska. The Prairie Naturalist, 25(1):51-54.

Holland, R.S. and E.J. Peters. 1994. Biological and economic analyses of the fish communities in the Platte River: Creek survey of fishing pressure along the lower Platte River. Final Report to the Nebraska Game and Parks Commission, Federal Aid in Fish Restoration Project No. F-78-R: Job III-1.

Peters, E.J. and R.S. Holland. 1994. Biological and economic analyses of the fish communities in the Platte River: Modifications and tests of habitat suitability criteria for fishes of the Platte River. Final Report to the Nebraska Game and Parks Commission, Federal Aid in Fish Restoration Project No. F-78-R: Job III-2.

Fessell, B.P., E.J. Peters and R.S. Holland. 1995. Critical thermal maxima of three Platte River fish species relative to water temperature regimes. Proceedings of the 1995 Platte River basin ecosystem symposium, p. 36-47.

McBride, M.J. and E.J. Peters. 1995. Benthic macroinvertebrate communities associated with forested and open riparian areas along the central Platte River. Proceedings of the 1995 Platte River basin ecosystem symposium, p.11-35.

Messaad, I.A., E.J. Peters, D.G. Rogers and K.W. Lee. 1995. A SEM study of atrazine effects on red shiner (*Cyprinella lutrensis*) p. 1012-1013 *In*: Bailey, G.W., M.H. Ellisman, R.A. Hennigar and N.J. Zaluzec (editors). Proceedings of Microscopy and Microanalysis 1995. Jones and Begell Publishing, New York, N.Y.

Yu, S.L. and E.J. Peters. 1995. Habitat use by fish in the Platte River, Nebraska. Proceedings of the 1995 Platte River basin ecosystem symposium, p.145-152.

Yu, S.L. and E.J. Peters and W.W. Stroup. 1995. Application of logistic regression to develop habitat suitability criteria for sand shiner, *Notropis stramineus*. Rivers 5(1):22-34.

Laux, E.A., M.T. Porath and E.J. Peters. 1996. Alewife and trout studies in Lake Ogallala. Final Report to the Nebraska Game and Parks Commission. Federal Aid in Fish Restoration Project. No F-112-R Study I.

Hofpar, R.L. and E.J. Peters. 1997. Population structure, distribution, habitat use and food habits of shovelnose sturgeon in the lower Platte River, Nebraska. Proceedings of the 1997 Platte River basin ecosystem symposium. Kearney, Nebraska.

Porath, M.T. and E. J. Peters. 1997. Use of walleye relative weights (Wr) to assess prey availability. North American Journal of Fisheries Management 17:628-637.

Porath, M.T. and E. J. Peters. 1997. Walleye prey selection in Lake McConaughy, Nebraska: A comparison between stomach content analysis and feeding experiments. Journal of Freshwater Ecology 12 (4): 511-520.

Yu, S-L. and E.J. Peters. 1997. Use of Froude number to determine habitat selection by fish. Rivers 6(1): 10-18.

Messaad, I. A., E. J. Peters and L. Young. 2000. Thermal tolerance of red shiner (*Cyprinella lutrensis*) after exposure to atrazine, terbufos and their mixtures. Bulletin of Environmental Toxicology 64:748-754.

Barrow, T. M. and E. J. Peters. 2001. Movements of rainbow trout in response to dissolved oxygen and food availability in Lake Ogallala, Nebraska. Journal of Freshwater Ecology 16(3): 321-329.

Snook, V. A., E. J. Peters and L. J. Young. 2002. Movements and habitat use by hatchery-reared pallid sturgeon in the lower Platte River, Nebraska. American Fisheries Society Symposium 28:161-174.

Yu, S-L. and E. J. Peters. 2002. Diel and seasonal habitat use by red shiner (*Cyprinella lutrensis*). Zoological Studies 41(3): 229-235.

Peters, E. J. 2003. Nebraska's endangered species part 2: Threatened and endangered fishes. Museum Notes, Number 114, University of Nebraska State Museum, Lincoln, Nebraska.

Porath, M. T., E. J. Peters and D. L. Eichner. 2003. Impact of alewife introduction on walleye and white bass condition in Lake McConaughy, Nebraska, 1980-1995. North American Journal of Fisheries Management 23:1050-1055.

Vrtiska, L. A., E. J. Peters and M. T. Porath. 2003. Flathead catfish habitat use and predation on a stunted white perch population in Branched Oak Reservoir, Nebraska. Journal of Freshwater Ecology 18(4): 605-613.

Yu, S-L. and E. J. Peters. 2003. Diel and seasonal abundance of fishes in the Platte River, Nebraska, USA. Fisheries Science 69: 154-160.

Galat, D. L., C. R. Berry Jr., E. J. Peters and R. G. White. 2005. Missouri River. Pages 427-480 *in* A. C. Benke and C. E. Cushing (editors). Rivers of North America, Elsevier, Oxford.

National Research Council. 2005. Endangered and threatened species of the Platte River. The National Academies Press, Washington, DC.

Peters, E. J. and S. Schainost. 2005. Historical changes in fish distribution and abundance in the Platte River, Nebraska. American Fisheries Society Symposium 45: 239-248.

Yildirim, A. and E. J. Peters. 2006. Life history characteristics of red shiner, *Cyprinella lutrensis*, in the lower Platte River, Nebraska, USA. Journal of Freshwater Ecology 21(2): 307-314.

Peters, E. J. and J. E. Parham. 2006. Pallid sturgeon and sturgeon chub in the lower Platte River 2000-2004. Final report to the Pallid Sturgeon / Sturgeon Chub Task Force, Lincoln, Nebraska.

Shuman, D. A. and E. J. Peters. 2007. Evaluation of pulsed gastric lavage on the survival of captive shovelnose sturgeon. Journal of Applied Ichthyology 23(2007): 521-524.

Shuman, D. A., J. E. Parham and E. J. Peters. 2007. Stock characteristics of shovelnose sturgeon in the lower Platte River, Nebraska. Journal of Applied Ichthyology 23(2007): 484-488.

Peters, E. J. and J. E. Parham. 2008. Ecology and management of sturgeon in the lower Platte River, Nebraska. Nebraska Game and Parks Commission, Technical Report No. 18, Lincoln, Nebraska.

MANUSCRIPTS IN PREPARATION

Peters, E. J. , R. Hrabik, S. Schainost, R. Stasiak. 200x. Field guide to the fishes of Nebraska. University of Nebraska, School of Natural Resources, Lincoln, Nebraska.

HONORS AND AWARDS

1979
Elected President of the Nebraska Chapter of the American Fisheries Society

1991
Elected President of the Nebraska Chapter of the American Fisheries Society

1989
Elected President of the University of Nebraska Chapter of the Society of Sigma Xi

Outstanding Professor Award
by Delta Tau Delta Fraternity

1993
University of Nebraska-Lincoln, Outstanding Teaching Award

2003
Appointed to the Committee on Endangered and Threatened Species of the Platte River
by the National Research Council of the National Academy of Science

2004
Holling Family Award for Teaching Excellence
by the University of Nebraska-Lincoln, College of Agricultural Sciences and Natural Sciences

Outstanding Club Advisor Award
by the University of Nebraska Wildlife Club

2005
Award of Excellence
by the Nebraska Chapter of the American Fisheries Society

Citation of Achievement
by the State of Nebraska, Game and Parks Commission

Lifetime Achievement Award
by the Nebraska Wildlife Federation

Appendix 2: Documents Reviewed by the Panel

MRRIC Questions and Responses (October 6, 2009 version)

Draft EA (September 11, 2009 version – Note: The structure of the portable document format file provided by Reclamation was not suitable for inclusion in this appendix and is incorporated by reference.)

Missouri River Recovery Implementation Committee Questions on the Intake Project

A. <u>Larval Drift</u>

A. 1 Question: Where above Intake on the Yellowstone River does spawning substrate exist? What is the likelihood of the pallid using the newly opened area for spawning? And if they use it, is adequate drift distance/time provided for larvae survival?

A.1 Answer: <u>Spawning Substrate Location</u> Specific spawning substrate has not been identified in the upper Missouri River Basin including the Yellowstone River; however, there are data supporting the existence of spawning substrates above Intake.

Pallid sturgeon spawning currently occurs in the Yellowstone River downstream of Intake Diversion Dam (Fuller et al. 2008). Intensive relocation and spatial analysis of telemetered pallid sturgeon of known gender and sex stage suggest that fish spawn in bluff pool habitats in the Yellowstone River. In 2007 seven male and one gravid female pallid sturgeon aggregated in a bluff pool for about three days and subsequent recapture of the female pallid sturgeon indicated that spawning had occurred (Fuller et al. 2008).

Similar aggregations in this bluff pool were observed by Bramblett and White (2001) who speculated that spawning occurred downstream of Intake. This observation is supported by telemetry data from the middle and lower Missouri River where female pallid sturgeon in spawning condition are believed to have spawned over or adjacent to hard, coarse substrates in relatively deep water on outside bends where flows converge (Aaron DeLonay, U.S.Geological Survey (USGS), personal communication).

Bluff pool habitats occur when the outside bend of the channel scours against bedrock at the valley margin. These habitats are generally longer, have lower average and bottom velocities, higher maximum and average depths, and a higher percentage of coarse, hard boulder and bedrock substrates than other habitats in the valley bottom (Jaeger et al. 2008). Terrace pool habitats are similar in their attraction to pallid sturgeon but are found adjacent to alluvial terraces (Jaeger et al 2005a). There are over 4,000 acres of bluff and terrace pool habitats between Intake and Cartersville Diversions (Matthew Jaeger, FWP, personal communication) and substrates throughout this reach are predominately hard gravel and cobble (Bramblett and White 2001).

In general, other sturgeon species spawn over hard substrates, which supports the conclusion that pallid sturgeon most likely spawn over hard substrates. Other sturgeon spawning substrates are as follows:

- Short nose sturgeon (*Acipenser brevirostrum*) spawn over rubble (Taubert 1980);

- Lake sturgeon (*A. fulvescens*) spawn over coarse gravel and rounded cobble (Manny and Kennedy 2002) and where substrates were predominantly cobble (Chiotti et al. 2008);
- White sturgeon (*A. transmontanus*) spawn over a diversity of substrates, including boulder, bedrock, cobble, and sand (Parsley et al. 1993; Perrin et al. 2003); and
- Gulf sturgeon (*A. oxyrinchus*) spawning areas consist of hard substrates and gravel (Heise et al. 2004).

Given the association of pallid sturgeon spawning with hard substrates and bluff pool habitats and the abundance of hard substrates and high habitat diversity, including bluff pools, upstream of Intake Dam it is reasonable to infer that suitable spawning substrate for the species exists upstream of Intake Dam.

<u>Pallid Sturgeon Using the Newly Opened Area for Spawning</u> The likelihood of pallid sturgeon using a newly opened area for spawning is uncertain, as with most restoration actions for endangered species. However, like most sturgeon species, pallid sturgeon generally move upstream to spawn, and spawning is believed to occur at or near the apex of this movement (Aaron DeLonay, USGS, Personal Communication). Telemetry data indicate that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008).

Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication). Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994), and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955).

It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement, pallid sturgeon would continue to move above this point to satisfy various life history needs, including spawning.

<u>Adequate Drift Distance/Time</u> Natural variability in water temperature and velocity will result in a wide range of drift distances for pallid sturgeon larvae produced upstream of Intake Diversion Dam in the Yellowstone River. The free-drifting phase of pallid sturgeon larvae is a developmental stage that occurs between hatching and yolk sac absorption. The duration of this developmental stage is influenced by water temperature. At 16^{o}C the time between hatching and yolk sac absorption is 13 to 15 days, but at 24^{o}C it is reduced to 7 to 9 days (Kevin Kappenman, U.S. Fish and Wildlife Service (Service), personal communication). Temperatures on the lower Yellowstone River when larvae are expected to hatch and enter the free drifting phase typically range between 20^{o}C and 25^{o}C, which result in an expected drift time of 7 to 10 days.

While total drift time is dictated by water temperature, both laboratory and field trials indicate that drift rates of larval pallid sturgeon are related to water velocity. Thus, cumulative drift distance is related to both drift time and drift rate. Simply put, at a given temperature larvae drift farther at higher velocities (Kynard et al. 2007; Braaten et al. 2008), but in reality it is much more complex.

Larval drift rates decrease from average water velocities as habitat complexity increases due to entrainment of drifting larvae in areas of reduced velocity, such as eddies (Kynard et al. 2007; Braaten et al. 2008). Continuous exposure to eddies and channel complexity during the entire larval drift period will likely reduce cumulative distance drifted by larvae, as suggested by Braaten et al. (2008) and observed during 2007 when larval pallid sturgeon were allowed to free drift throughout a 180-km [112 miles] reach of the mainstem Missouri River (Braaten et al., in preparation).

For example, Bratten et al. (2008) observed a three-fold increase in the average durations for all observed 1 to 9 day old larvae to drift 4,265 feet compared to 328 feet. Similarly, the deviation from water traveling at average velocity for the entire observed distributions of 1 to 9 day old larvae was 3 times greater at 4,265 feet than at 328 feet (Braaten et al. 2008). The further larvae drift through complex habitat, the greater the range of time it will take all larvae to drift a given distance. Based on the observations of Braaten et al. (2008), it is expected that the entire distribution of drifting larvae would require an additional 4 days of travel time to cover the same distance as a drop of water traveling at average column velocity over a distance of 317 miles, which is the cumulative amount of riverine habitat between Cartersville Diversion and the present headwaters of Sakakawea Reservoir.

Higher habitat complexity in the Yellowstone River as compared to previous studies suggests that drifting larvae will be more frequently exposed to and resultantly entrained in lower velocity habitats, such as eddies, secondary channels, and boundary layers associated with coarser substrates. This will likely reduce drift rates and cumulative drift distance relative to average water velocity more than previously reported.

Previous larval drift studies were conducted in smooth-bottomed tanks with limited rock material (Kynard et al. 2007) or over sand and silt substrates (Braaten et al. 2008), whereas Yellowstone River substrate above Intake Diversion Dam is predominately gravel and cobble (Bramblett and White 2001). Increased roughness associated with gravel and cobble substrates results in a thicker, low-velocity boundary layer on the stream bottom. In other words, the water traveling along the river bed substrate interface moves more slowly over coarse substrates than it does over sand or silt substrates (Gordon et al. 1992). Because larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008), entrainment in low-velocity boundary layers or interstitial spaces within the substrate could reduce drift rates and distances from those predicted based on average column velocity alone.

Laboratory studies incorporating limited rock cover provide somewhat contradictory results. Pallid sturgeon did not attempt to use rock cover at low velocities (Kynard et al. 2002) but did try to hold position behind rocks at higher velocities (Kynard et al. 2007). Larval drift rates associated with gravel substrates are lower than those associated with sand substrates for other sturgeon species (Nechako White Sturgeon Recovery Initiative 2007).

There are approximately 176 miles of seasonal and perennial secondary channels accompanying 236 miles of mainstem channel below Cartersville Dam on the Yellowstone River (Jaeger 2004). Average and bottom velocities of secondary channel habitats are significantly lower than those of mainstem habitats ($P < 0.001$; Jaeger et al. 2008). These lower velocities effectively reduce drift rates of fish entering these habitats.

The Yellowstone River has 35% - 50% more area of slow current velocity habitat patches than the Missouri River during periods when larval drift occurs (Bowen et al. 2003). This likely reduces larval drift rates on the lower Yellowstone River relative to average water velocity than modeled in the Missouri River. Accordingly, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances modeled under lower habitat complexity or considering only average water velocity inappropriate.

In summary, it is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. A combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift time and thus drift distances for some larvae relative to those predicted by water velocities alone. Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years.

It is expected that the fastest drifting larvae traveling at approximately the same rate as the average water column velocity at relatively cool temperatures and resultantly long drift times (10 days) will require over 497 miles of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae, which will deviate by several days from drift times predicted by water traveling at average velocity, at relatively warm temperatures and resultantly short drift times (7 days) will requires less than 217 miles of drift distance. Thus, we anticipate that adequate larval drift distance will be available for a portion of any naturally produced larvae spawned in currently inaccessible reaches upstream of Intake Diversion Dam during most years.

<u>Summary</u> The potential for natural recruitment and enhancement by providing passage at Intake Diversion Dam has been a position long held by pallid sturgeon biologists (Service 2000a; Service 2003). This was confirmed more recently by the Upper Missouri Basin Pallid Sturgeon Workgroup (Workgroup). The Workgroup was asked by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) to address habitat availability and larval drift issues for pallid sturgeon in the Yellowstone River. The Workgroup (2009) concurred that additional ecosystem and connectivity restoration efforts could further increase the amount of habitat available for larval drift in the Yellowstone River. Furthermore, the Workgroup agreed that if pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that adequate larval drift distances exist for natural recruitment to occur. Details of the Workgroup's assessment are summarized in their report (Workgroup 2009).

A.2 Question: What is the current speed during the high water period on the Yellowstone May 15--to July 15, at Cartersville and below and what velocity rate (or range of rates) is appropriate to calculate larval drifts?

A.2 Answer: In regard to spawning and larval drift, Question A.2 proposes too broad a time period. Spawning does not occur until about mid-June through early July (Fuller et al. 2008). Larvae hatch and begin drifting about 3 to 5 days following egg fertilization and drift for 7 to 10 days at temperatures common for the Yellowstone River (K. Kappenman, personal communication). This answer, therefore, focuses on the period when larvae are drifting, which is typically during the descending hydrograph from mid- to late-June through mid-July.

Determining "what velocity rate (or range of rates) is appropriate to calculate larval drifts" on the Yellowstone River is difficult because of the range of physical factors. These factors include velocities and temperatures during the time of larval drift and the complexity and diversity of habitats in the river. However, information collected by biologists over time can give us a picture of what is appropriate to calculate larval drift. Assuming a fish is drifting in the main channel in late June to early July, it is reasonable to use 2.9 feet per second.

Velocity will vary among years in relation to discharge and within years at a given discharge. This will occur at different locations in the Yellowstone River. River velocities generally increase as discharge increases (Leopold et al. 1964). At average discharges of 4,400 cubic foot per second (cfs) average velocities between Cartersville Diversion and the confluence with the Missouri River are 2.77 feet per second (f/s) (M. Jaeger, personal communication). By comparison, at flood stage (i.e. discharges of over 100,000 cfs) average velocity measurements at a single station with an artificially confined channel at Sidney Bridge are about 10 f/s (Leopold et al. 1964).

Average discharge on the Yellowstone River over the past 20 years from mid-June to early July is about 25,000 cfs near Sidney, Montana. Although river-wide average velocities have not been measured at this specific discharge, it is expected that average velocities during periods of larval drift may exceed 3.28 f/s (Workgroup 2009) but will be less than 6.56 f/s. For example, Bramblett (1996) measured velocity at points associated with sturgeon locations at discharges ranging from about 2,000 cfs to 50,000 cfs and the maximum average velocity recorded was 5.93 f/s while mean average velocity was 3.34 f/s.

However, it is also expected that velocity will vary considerably in the Yellowstone River at a given discharge. Jaeger et al. (2008) reported significant differences in average velocities among different habitat types in the Yellowstone River. Measurement of velocity at 4,400 randomly selected points indicated that average velocities ranged from 11.05 f/s to 0.00 f/s (M. Jaeger personal communication). Additionally, larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008) where velocities can be significantly lower than average velocities. Bottom and average velocities are substantially different on the Yellowstone River ($P < 0.001$); bottom velocities are about 21% lower than average velocities (M. Jaeger, personal communication).

As discussed above, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances based only on average water velocity inappropriate. It is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. However, a combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift distances for some larvae relative to those predicted by water velocities alone.

Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years. Yellowstone River temperatures during periods of larval drift indicate that larvae will likely drift for 7 to 10 days. Distributions of larval drift rate and distance relative to water traveling at average velocity in the Missouri River suggests that some larvae will lag up to 4 days behind water traveling at average velocity over distances comparable to providing passage at Intake Diversion (510 km). Additionally, given the higher complexity of the Yellowstone River, it is expected that the deviation of the entire distribution of drifting larvae from water traveling at average velocity would be greater on the Yellowstone River than described above on the Missouri River.

It is expected that the fastest drifting larvae traveling near the velocity of average water at relatively cool temperatures and resultantly long drift times (10 days) will require over 800 km of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae at relatively warm temperatures and resultantly short drift times (7 days) will require less than 350 km of drift distance. Thus, we anticipate larval drift distance would be adequate for some larvae spawned upstream of Intake Diversion Dam during most years.

Reclamation asked the Upper Basin Pallid Sturgeon Recovery Workgroup to provide their best biological judgment about drift issues. This paper (Workgroup 2009) is appended.

A.3 Question: What data is available to support the conclusion that any larvae would actually survive without ending up in the head waters of Lake Sakakawea where they would die?

A.3 Answer: Hatchery-reared larvae released when 5 to 17 days old have been recaptured months or years later in the Yellowstone River and Missouri River below the confluence. This indicates that habitat in these river reaches is suitable for survival of pallid sturgeon larvae (M. Jaeger, personal communication). However, these findings are based on fish that have artificially reduced drift rates because a portion of their drift phase was spent in a hatchery environment. By increasing drift distance, it is anticipated that naturally-produced larval pallid sturgeon would settle in the same areas capable of supporting these hatchery-reared study fish.

The Workgroup (2009) reports:

> "The near-natural hydrograph and associated temperature and sediment regimes characteristic of the unimpounded Yellowstone River (White and Bramblett 1993) combine to provide one of the best habitat templates and opportunities to support pallid sturgeon recovery in the upper Missouri River basin. Current habitat conditions include intact migration and spawning cues and habitats; most extant adult pallid sturgeon in [Recovery-Priority Management Area] RPMA 2 migrate into the lower Yellowstone

River each spring (Bramblett and White 2001) and subsequent spawning has been documented (Fuller et al. 2008). However, inadequate larval drift distances (~150 kilometers) [93 miles] between known spawning reaches and the present headwaters of Sakakawea Reservoir may not exist. Accordingly, inadequate larval drift distances are one of the leading hypotheses to explain recruitment failure in RPMA 2."

While there is no way to guarantee survival of larval pallid sturgeon that may result following implementation of passage and entrainment protection at Intake Diversion Dam, the data provided above suggest that habitat diversity in the Yellowstone River may make larval drift rate data from other studies (i.e. Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008) difficult to directly extrapolate to the Yellowstone River. However, data available from these studies suggest that not all pallid larvae drift at the same rate (Braaten et al. 2008), and development of larvae influences drift (Kynard et al. 2007). The Workgroup paper (2009) also addresses larval drift distances.

Furthermore, water temperature influences larval development rates; larvae develop faster in warm water. Temperature profiles for the Yellowstone River indicate that larval development rates (based on degree days) are higher than the Missouri River downstream from Fort Peck Dam. Therefore, we anticipate that while some larvae will drift into Lake Sakakawea, a portion of the slowest drifters likely will not.

A.4 Question: What are the anticipated drift rate and distance required for larval pallid sturgeon in the relevant reaches? What is the required water level in Lake Sakakawea to attain this distance? How often should these conditions exist? What is the level of uncertainty in the drift rate and distance calculations? How was this data considered when planning the Intake project?

A.4 Answer: Not all larvae drift at the same rate – some drift faster than mean velocity, some drift at about mean velocity, and some drift slower than mean velocity. Although there are uncertainties relative to larval drift speed and distance in relation to high velocities and coarse substrates in the Yellowstone River, it is likely that at least a portion of the larvae hatched upstream of Intake Diversion Dam would survive (note previous discussions above).

If pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that larval drift distances would be adequate for some natural recruitment to occur (Workgroup 2009). Construction of a fish passage alternative at Intake Diversion Dam would provide between 253 and 317 miles of natural free-flowing river between Cartersville Dam, which is the next upstream barrier on the Yellowstone River and Lake Sakakawea.

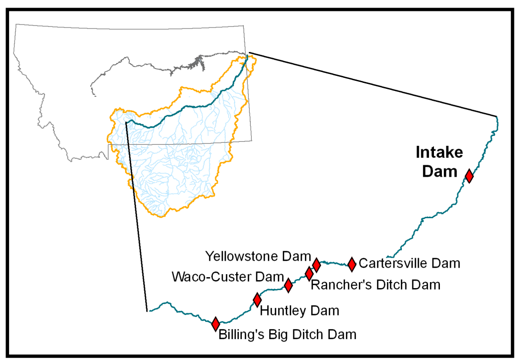
While the range of available habitat is related to pool elevations of Lake Sakakawea, any requirements for specific pool elevations have not been determined, because the current focus is on providing passage to as much upstream habitat as possible. This additional increase in the length of free-flowing riverine habitat likely would provide adequate drift distance for at least a portion of the larvae (Workgroup 2009). Further discussion of drift rates and distance calculations can be found in the Workgroup's (2009) white paper and above. Specific calculations on drift distances can also be found in the recent Montana Fish, Wildlife & Parks (FWP) presentation to MRRIC (Jaeger 2009).

Any specific recommendations for pool elevation manipulations may be discussed through the adaptive management process as pallid spawning and recruitment success is monitored. It is not known how often this species needs to accomplish a successful spawn/recruitment year class, but the spawning periodicity of adult females is every two to three years. With the long-lived nature of pallid sturgeon, it is likely they do not need to successfully spawn every year in order to accommodate a wild population of naturally reproducing fish, as evidenced by the natural fluctuations in historic flow regimes.

In planning the Intake Diversion Dam Modification, Lower Yellowstone Project (Intake Project), the best available scientific data were considered. This is documented in the draft environmental assessment (EA) prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, Corps, Service, USGS, and state biologists have all participated in planning the Intake Project.

A.5 Question: Is there a need to modify other upstream dams to allow enough drift distance for larvae? What progress/plans have been made on modifying upstream structures?

A.5 Answer: There are six low-head diversion dams on the Yellowstone River downstream from Billings, Montana (see Intake EA, page 3-6). Huntley Dam and Intake are federally-owned, while the middle four (Waco-Custer, Rancher's Ditch, Yellowstone, and Cartersville) are privately-owned and managed by the local irrigation districts. These structures present some degree of impediment to fish passage; however, the extent of fish blockage at these dams seems to depend on river stage and the swimming ability of the various species trying to negotiate the dams (see Helfrich et al. 1999).



Diversion Dams Along the Yellowstone River (adapted from Jenkins 2007).

At present, three of these diversion structures fall within what is generally considered to be the historical range of pallid sturgeon. In addition to Intake, fish passage needs at the Cartersville Dam near Forsyth, Montana, are under discussion. The Cartersville Dam is privately owned but FWP, the Service, the Corps, and the Nature Conservancy are working together to find a solution. To date, a value engineering study has identified a suite of potential options for passage of native species, including sturgeon (FWP and Enlien Consultants 2009). FWP has hired an engineering and consulting firm to analyze these potential passage options, prepare an environmental assessment, and identify a preferred alternative.

Dams on tributaries to the Yellowstone have also been modified to address fish passage issues including the T&Y Dam and the Mobley Dam on the Tongue River. These new fish passage projects open additional miles of pallid sturgeon habitat on the Tongue River.

A.6 Question: Can/should a study be conducted on the Yellowstone River to provide drift information specific to this reach?

A.6 Answer: The best available scientific information, many biologists, and researchers concur that larval drift distance on this reach would be adequate for a portion of pallid sturgeon larvae most of the time once the passage issue at Intake has been resolved. A study could be conducted, but there are several complicating factors involved with such a study on the Yellowstone, such as:

- Are there sufficient numbers of pallid sturgeon larvae available for study? Adult female pallid sturgeon typically produce between 0 to 243,450 larvae, although average production is about 100,000 larvae (Rob Holm, Service, personal communication). Previous mainstem drift tests required about 428,285 larvae at a discharge of about 6,400 cfs (R. Holm, personal communication). At discharges expected in the Yellowstone River during times of larval drift (25,000 cfs) about 1,672,988 larvae would be required for a comparable drift test to account for dilution associated with increased discharges.

  Because the slowest drifting portion of larvae are of most interest, it would be essential to release adequate numbers of larvae to accurately describe the entire distribution of drift times and distances in the Yellowstone River for the study to be worthwhile. About 17 gravid adult female pallid sturgeon would be needed to produce the required number of larvae. It is estimated that there are currently 40 female pallid sturgeon remaining in RPMA 2 (Gillian Hadley, personal communication), about half of which will spawn in any given year (Fuller et al. 2008). The highest number of gravid female pallid sturgeon ever captured in a year was 16 in 2007. In 2009 one of the lengthiest broodstock collection efforts to date resulted in capture of only seven gravid female pallid sturgeon. Accordingly, it is unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- Would these larvae be better used for a different recovery project or study? Although applied research remains a high priority for pallid sturgeon recovery efforts within the Upper Missouri River Basin, preventing extinction of the species through a conservation stocking program is the highest priority for hatchery-reared pallid sturgeon (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). As such, the propagation and conservation stocking program will require at least the first seven gravid female pallid sturgeon captured in any year until stocking goals in each RPMA are attained (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). Most larvae allocated to a drift study on the

Yellowstone River would need to be produced by gravid female pallid sturgeon captured subsequent to the seven fish required by the propagation program. Accordingly, it is increasingly unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- The presence of naturally produced shovelnose sturgeon larvae concurrent with the time that pallid sturgeon larvae will be available for a Yellowstone River drift test will require genetic analysis of all captured sturgeon larvae. Gravid shovelnose sturgeon occupy the entire reach of the Yellowstone River between Cartersville Diversion and the confluence with the Missouri River each year (Haddix and Estes 1976; M. Jaeger, personal communication). It is suspected that shovelnose sturgeon spawning occurs throughout this reach (Haddix and Estes 1976; M. Jaeger, personal communication) and naturally produced shovelnose sturgeon larvae are commonly captured (Penkal 1981; Braaten and Fuller 2005). To distinguish pallid sturgeon larvae captured as part of the drift test from naturally produced shovelnose sturgeon genetic analyses of all captured sturgeon larvae likely will be necessary. Analysis costs are about $50 per fish (G. Jordan, personal communication). Braaten et al. (2008) recaptured about 5,800 larvae during a side channel drift test on the Missouri River. Although it is unknown what number of pallid and shovelnose sturgeon larvae would be captured by a comparable Yellowstone River drift test, analysis costs for the number of fish captured during the side channel study would be about $290,000.

- There is little time left before wild pallid sturgeon are extirpated in the Upper Missouri River Basin. While there is some debate over the year that local extirpation will occur (2017 – 2024), maintaining the status quo is not addressing long-term pallid sturgeon recovery goals.

- Conservation of genetic variability within pallid sturgeon is an important component of long-term recovery goals. The upper Missouri River Basin pallid sturgeon are genetically distinct from those in the lower parts of the species' range (Campton et al. 2000; Schrey and Heist 2007; Tranah et al. 2001). The wild pallid sturgeon population is facing extirpation due to several decades of failed spawning and/or recruitment (Service 2007). Furthermore, approximately 136 wild pallid sturgeon remain in RPMA 2 (Service 2007) that would likely benefit from these recovery efforts on the Yellowstone River.

FWP, Reclamation, the Service, and the Corps have been studying pallid sturgeon issues at Intake for 20 years. Unfortunately, the declining population of mostly mature wild pallid sturgeon in the Yellowstone River and Missouri River between Fort Peck Dam and Lake Sakakawea is expected to be locally extirpated in the near future if reproduction and survival of the young fish does not improve. Given the limited time to resolve the problem, it was decided that priority should be given to resolving passage and entrainment issues at Intake instead of continuing to study the problem.

B. <u>Fish Passage</u>

B.1 Question: Will the project allow passage of pallid sturgeon for spawning and will it allow larval pallid sturgeon passage downstream and lead to their survival?

B.1 Answer: The Corps and Reclamation are using the best available science to design a fish passage structure for pallid sturgeon at Intake, Montana, and will use adaptive management to make sure that it works. Although there are no fish passage projects in existence specifically built for pallid sturgeon, successful fish passage projects for other sturgeon species have been constructed in the western United States.

An example is the Glen Colusa Irrigation District gradient facility built by the Corps on the Sacramento River for salmonids. This facility is similar to the Rock Ramp Alternative proposed for the Intake Project. The Glen Colusa passage successfully provides passage for other sturgeon species, specifically the green and white sturgeon. Other successful projects for sturgeon species include:

- Red Bluff Diversion Dam in the Sacramento River,
- Through Delta Project facility in California,
- Heiberg Dam and a dozen other passage projects for lake sturgeon on the Red River Basin in North Dakota/Minnesota.

The Corps and Reclamation, in consultation with the Service and FWP, are working cooperatively to ensure that the best available science and fish passage technology is used in the design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Any problems would be corrected through adaptive management.

Once pallid sturgeon can pass over or around the Intake Diversion Dam, they will have access to an additional 165 miles of river for spawning. They will also have access to the tributaries within this reach, including the Powder and Tongue Rivers.

The available options at this time to increase larval drift distances in the upper Missouri River basin are:

1) removal of Fort Peck Dam,
2) removal of Garrison Dam,
3) maintaining Lake Sakakawea at lower reservoir pool elevations to increase riverine habitats upstream of this reservoir, and
4) providing access to habitats further up the Yellowstone river via implementation of fish passage and entrainment protection measures.

When these options are compared, the Intake Project provides one of the best opportunities to achieve natural pallid sturgeon recruitment in the upper Missouri River Basin with the lowest ancillary costs, i.e. no adverse effects to hydropower generation, water intakes, flood control, navigation, irrigation, etc.

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B.2 Question: Will the rock ramp design allow passage of pallid sturgeon?

B.2 Answer: There is an opportunity for pallid sturgeon passage with a rock ramp design (also known as a gradient facility), which is similar to other dams that have been modified in the western United States to allow passage of other sturgeon species (see answer to question B.1). Performance tests to quantify the swimming capabilities of pallid sturgeon and identify physiological and behavioral parameters were completed prior to design of the Intake Project alternatives (White and Medford 2002). The results were used in the design specifications.

Several Yellowstone River riffles and rapids of relatively high gradient that adult and juvenile pallid sturgeon are known to pass at a variety of discharges were extensively surveyed to provide further design criteria. A physical model is currently being built at Reclamation's Denver Technical Research Center to refine the rock ramp design and ensure its effectiveness for pallid sturgeon. In addition, an adaptive management plan would be implemented to fine-tune the selected alternative after construction.

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B.3 Question: What data is available to support the thesis the majority of the fish even would go up to Cartersville if there was a fish passage?

B.3 Answer: Although we have not suggested that the majority of fish would go up to Cartersville with fish passage at Intake, pallid sturgeon have been documented at least 112 miles upstream of Intake, Montana, which is about 267 miles above the present headwaters of Lake Sakakawea (Brown 1955; Brown 1971). They were observed at this location consistent with times of the year when spawning is known to occur in the Yellowstone River (Fuller et al. 2008). Watson and Stewart (1991) captured a pallid sturgeon near Fallon, Montana, in 1991 in conjunction with studies associated with the Tongue River Project. There are other reports from the 1920s and 1930s that document pallid sturgeon above Intake Diversion Dam and in the vicinity of the Tongue River (Service 2000b).

Furthermore, if we generalize based on what is known about pallid and other sturgeon species spawning habitats in combination with the historical record, then suitable spawning substrate exists above Intake. Telemetry data indicates that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008). Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication).

Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994) and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955). It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement pallid sturgeon would continue to move above this point to satisfy various life history needs including spawning. Additionally, telemetered juvenile pallid sturgeon have traveled up to the

Intake Diversion Dam, were unavailable to pass, and turned to swim back downstream (Jaeger et al. 2008). Initial study results indicate that spawning habitats upstream of the Intake Diversion Dam are suitable for pallid sturgeon restoration efforts (Jaeger et. al 2008).

B.4 Question: Is the project design the best available technology for migration and protection of the pallid sturgeon population?

B.4 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from FWP, the Service, the Corps, and Reclamation, agree that it is the best available technology. The action alternatives evaluated in the Intake EA were formulated through an iterative and collaborative process initiated during informal Endangered Species Act (ESA) consultations with the Service in 1997. The following documents were developed to help formulate and evaluate alternatives:

- Lower Yellowstone River Fish Passage and Protection Study (Reclamation and FWP 1997)
- Concept I Report (Mefford et al. 2000)
- Fish Entrainment Study (Hiebert et al. 2000)
- Assessment of Sturgeon Behavior and Swimming Ability for Design of Fish Passage Devices (White and Mefford 2002)
- 2002 Alternatives Report (Corps 2002)
- 2002 Value Engineering Study (Reclamation 2002)
- Test Results of Intralox Traveling Screen Material (Reclamation 2003)
- Concept II Report (Glickman et al. 2004)
- Value Planning Study (Reclamation 2005)
- Technical Team Recommendations (Technical Team 2005)
- Biological Review Team Comments (Jordan 2006)
- *Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report* (Corps 2006)
- Biological Review Team Comments (Jordan 2008)
- *Intake Diversion Dam*, *Trashrack Appraisal Study for Intake Headworks*, Lower Yellowstone Project – Montana-North Dakota (Cha et al. 2008)
- *Intake Diversion Dam, Assessment of High Elevation Intake Gates,* Lower Yellowstone Project – Montana-North Dakota (Mefford et al. 2008)
- L*ower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Report* (Corps 2008)

After careful consideration of more than 110 alternatives, two were further evaluated in the Intake Project EA – the Rock Ramp Alternative and the Relocate Main Channel Alternative.

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.5 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from Montana FWP, the Service, the Corps, and Reclamation, agree that it is. The screen design uses the best available technology, including the smallest effective screen size and velocities recommended by the Service's Biological Review Team. This screen system is designed to meet Yellowstone River conditions, Lower Yellowstone Irrigation Project needs, and provide the best protection for pallid sturgeon and other native fish at Intake, Montana. The screen size is the smallest that can be used effectively, in accordance with the National Oceanic and Atmospheric Administration (NOAA) juvenile salmonid criteria.

A laboratory study evaluated the best technology available to use to meet the NOAA screening criteria for juvenile and larval pallid sturgeon that are < 3.9 inches long (Mefford and Sutphin 2008). The study evaluated four related topics: 1) swimming endurance, 2) impingement survival, 3) screening effectiveness, and 4) recovery of impinged fish from traveling fish screens. The study was used to identify and design fish screens for the Intake Project. It was conducted at the Reclamation Water Resources Research Laboratory in Denver, Colorado, using hatchery-spawned pallid sturgeon larvae.

Results of the study indicated that larvae <0.8 inches long displayed little swimming ability and easily passed through NOAA criteria fish screen material. Fish larger than about 1.6 inches long were capable of swimming several minutes against a typical fish screen approach velocity of 0.4 feet/second. This study indicates that NOAA criteria effectively protect pallid sturgeon >1.6 inches long. Screen impingement for periods up to 10 minutes (maximum impingement time evaluated) had no effect on fish mortality, when fish were recovered by back-flushing the screen.

B.6 Question: Is the by-pass design the best for pallid sturgeon?

B.6 Answer: Appendix E, Intake EA uses scoring criteria developed by the Biological Review Team (Jordan 2009) and hydraulic modeling (Corps 2009) to score alternatives on relative comparison scales. Although the Corps used pallid sturgeon life history, biology, and ecology to design the Relocate Main Channel Alternative, Intake EA Appendix E found that this alternative scores lower and less favorably for pallid sturgeon than the Rock Ramp Alternative.

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.7 Answer: The screen designs evaluated to date are anticipated to prevent entrainment of pallid sturgeon ≥ 1.5 inches long (Mefford and Sutphin 2008) While the success of this screen with other fish species has not been tested, it is reasonable to assume that it will prevent entrainment of other fish species ≥ 1.5 inches long. Monitoring post-Project construction and adaptive management will be implemented to ensure effectiveness.

B.8 Question: (if so what design)? Supporting information?

B.8 Answer: See discussion above in answer B.5. The fish screen is described in chapter two of the Intake EA, pages 2.9 – 2.10.

B.9 Question: Given the location where pallid sturgeon larvae drift, will larvae either be trapped in the pool behind the Intake dam or end up in the diversion?

B.9 Answer: Given what we know from larval drift studies, it would be unlikely that the larvae would be trapped in the pool behind the dam, because the smooth concrete dam design would allow for free flow over the dam. Furthermore, chapter three of the Intake EA documents sedimentation behind the dam. Corps bathymetry data indicate there is not a characteristic wedge of sediment deposited directly upstream of the dam structure, as often occurs with such structures (figure 3.6, page 3-11). Therefore larvae would likely flow over the dam along with sediments and flow. However, it is possible that upstream larvae could flow toward the Intake headworks main canal screens. Entrainment would be monitored post-construction. If significant issues affecting the survival of pallid sturgeon larvae are identified, adaptive management would be used to resolve this survival issue.

B.10 Question: If pallid sturgeon did go up to Cartersville what data is available regarding predation in that location, that would convince anyone the eggs or larvae would survive?

B.10 Answer: Not all fish eggs and larvae survive in natural settings. However, fish species have evolved mechanisms to mitigate for natural mortality rates associated with things like predation. One mechanism relies on the amount of progeny produced annually. Individual female pallid sturgeon in the upper Missouri River basin release as many as 150,000 – 170,000 eggs when spawning (Rob Holm, personal communication). Not all of these eggs need to hatch nor do all hatching fry need to survive to perpetuate the species. In a self sustaining population, the life history goal is to achieve natural recruitment into the adult population at a level comparable to natural adult mortality. Recruitment is the number of fish hatched in a given year that survive to a specified age.

The physical traits of pallid sturgeon, i.e. small eyes, sensory barbels, etc, suggest this species evolved in low-visibility environments. In rivers suspended particles, often referred to as turbidity, and other materials reduce the amount of available light, which in turn reduces visibility, thus affording some level of concealment from sight-feeding predators, like walleye, goldeye, and sauger. Thus, the occupied environment of the species and conditions during and post-spawning can serve as natural mechanisms to offset predation.

Turbidity is quantified with nephelometric turbidity units (NTU); a measure of how much light can pass through a water sample. On the NTU scale, low values equate to clear water. Relative to the range of pallid sturgeon, Jordan et al. (2006) reported turbidity levels < 12 NTU downstream of Fort Randall Dam, South Dakota. The smallest level reported was 5 NTU. In Lake Sharpe, South Dakota, measured turbidity levels were 80-100 NTU (Erickson 1992). Conversely in a more natural system like the Yellowstone River, turbidity levels seasonally exceed 1,000 NTU (Braaten and Fuller 2002; Braaten and Fuller 2003; Matt Jaeger, personal communication, 2008). To put these reported Yellowstone River values in perspective, the U.S. Environmental Protection Agency's national primary drinking water regulations (http://www.epa.gov/safewater/contaminants/index.html#primary) turbidity may never exceed 1

NTU and must not exceed 0.3 NTU in 95% of daily samples in any month. With high turbidity on the Yellowstone River, predation of pallid sturgeon larvae on the Yellowstone River is not likely a significant issue.

Additionally, there are studies that document predation on other sturgeon species eggs and juveniles (Miller and Beckman 1996; Gadomski and Parsley 2005a). Most of these studies explore predation rates in altered environments downstream of dams or in laboratory settings in tanks with low turbidity levels, e.g. Gadomski and Parsley (2005a) report study with turbidity levels < 1 NTU. Outside of the laboratory, these studies are downstream of structures similar to the mainstem Missouri River dams that trap sediment and result in clear water downstream.

In many of these studies, predation rates are high and often because of altered conditions below dams (Gadomski and Parsley 2005b). However, none of the irrigation diversion structures on the Yellowstone River (i.e. Cartersville or Intake Diversion dams) significantly trap sediment and alter the resultant seasonally high turbidity levels on the Yellowstone River. Given the relatively high fecundity of pallid sturgeon, the high turbidity levels in the Yellowstone River during and post spawning, and the diversity of habitats in this river, it is reasonable to assume that predation can and will occur, though not at a level exceeding those with which this species evolved.

The most convincing data available regarding larval survival comes from recaptures of hatchery-reared pallid sturgeon initially stocked as larvae. As described above, it is expected that larvae originating from reconnecting reaches upstream of Intake Dam would be distributed throughout the lower Yellowstone River and Missouri River below the confluence. Pallid sturgeon larvae stocked from 5 to 17 days old have been recaptured in subsequent months and years in the Yellowstone River and Missouri River below the confluence, indicating that habitats and biotic conditions (i.e. the presence of predatory fishes) in these reaches of river allow for survival of pallid sturgeon larvae and juveniles (M. Jaeger, personal communication).

C. <u>Impacts on Pallid Populations</u>

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.1 Answer: When dealing with an endangered species like the pallid sturgeon, there will always be some level of uncertainty. In planning the Intake Project, the best available scientific data were considered. This is documented in the draft Intake EA prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, the Corps, the Service, the USGS, and state biologists have all participated in planning the Intake Project. The best available science suggests that conditions on the Yellowstone River are suitable for pallid sturgeon restoration, including intact migration and spawning clues, suitable spawning habitats, adequate larval drift distances, and suitable rearing habitats.

The Corps and Reclamation, in consultation with the Service and FWP, are continuing to work cooperatively to ensure that the best available science and fish passage technology are used in the final design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Of the available options despite a moderate level of uncertainty with regard to the level of benefit to the species and the native fish community, this one is technically feasible, comparatively cost-effective, acceptable and amenable to most users. It is justifiable given the immediate risk of extirpation and the potential benefit to species recovery in the foreseeable future.

As with passage and entrainment projects across the west, including those successful ones mentioned above in response B.1, there will be benefits, but it is difficult to precisely quantify them prior to implementation. We are reasonably certain the proposed Intake Project will pass native fish, including pallid sturgeon, and will reduce entrainment of hundreds of thousands of native fish annually. It could ultimately create an opportunity for the recovery of the pallid sturgeon. This Project would also allow the Lower Yellowstone irrigation districts to continue to operation in compliance with the ESA.

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C.2 Question: How much will this project improve the pallid's survivability?

C.2 Answer: The Service's 5-year species review (Service 2007) states that without artificial supplementation in areas like the Yellowstone River, pallid sturgeon could face extirpation. The Service's Pallid Sturgeon Recovery Plan (1993 and most recent agency review draft pallid sturgeon recovery plan) also supports the Intake Project.

Current recruitment of pallid sturgeon in the Upper Missouri River Basin is zero. While adult fish have been found in spawning condition, there has been no documented recruitment in this aging pallid sturgeon population. If just one juvenile is recruited into the population, then the implementation of passage and entrainment protection will benefit pallid sturgeon. Even if 1-5% of the larvae make it to recruitment, it would be significantly greater than current conditions.

Available data indicate that today sturgeon are entrained into the lower Yellowstone Project (Hiebert et al. 2000) and that specifically, pallid sturgeon can be lost to this system (Jaeger et al. 2005b). This project will significantly reduce the likelihood of entrainment and increase survivability of hatchery and wild fish. Substantial loss of sturgeon chub and other minnow species have also been documented at Intake (Hiebert et al. 2000). These minnow species are believed to be a primary food source for pallid sturgeon (Gerrity et al. 2006). Thus, entrainment protection will help conserve adult pallid sturgeon food resources and may increase adult pallid sturgeon capacity in this system.

Benefits of upstream passage will increase available habitats on the Yellowstone River by 165 miles and will allow stocked fish to disperse into suitable habitats. This would also increase the accessibility of fish to major tributaries like the Tongue River with 106 miles of riverine habitats and the Powder River with 217 of additional potential habitat. Overall, the agencies working on this Project generally agree this is the best opportunity available to facilitate pallid sturgeon toward recovery in the upper Missouri River Basin.

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.3 Answer: Yes, see all of the information in above answers.

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at intake?

C.4 Answer: The pallid sturgeon could likely be extirpated in the Recovery Priority Management Area 2 (Service 2007). Wild pallid sturgeon in the Yellowstone and Missouri rivers, downstream of Fort Peck Dam and upstream of Lake Sakakawea will continue to exist only as a hatchery-augmented population as older adults die out or are removed for hatchery purposes. The conservation stocking program would be required long-term to artificially maintain the species in this reach.

Conservation stocking does not meet current or future delisting or downlisting requirements of the ESA. Rehabilitation of the reach of the Missouri River below Ft. Peck Dam and above the Yellowstone confluence or dramatically drawing down Lake Sakakawea reservoir levels remain as options to provide for some level of natural recruitment and achieving delisting or downlisting requirements. And at this point in time the options at Ft. Peck and Lake Sakakawea reservoirs are expensive and/or may not be publically acceptable.

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Appendix 3: Discharge, Velocity, and Drift Distance Estimates

Appendix 3, Table 1. Annual discharge, velocity, and pallid sturgeon larval drift distances estimated for the Yellowstone River, MT.

	Discharge (cfs)				Velocity (m/s)		Drift distance for average velocity (miles)			Drift distance for reduced velocity (miles)		
Year	May	June	July	min	v	60%v	1%	10%	25%	1%	10%	25%
1911	16,000	55,200	33,100	16,000	0.86	0.52	413	444	464	210	241	261
1912	26,400	55,200	56,800	26,400	1.02	0.61	507	538	558	266	297	318
1913	21,400	59,800	38,100	21,400	0.95	0.57	465	496	517	242	273	293
1914	45,000	50,800	27,500	27,500	1.03	0.62	515	546	567	271	302	323
1915	17,700	42,200	33,100	17,700	0.89	0.53	430	461	482	221	252	272
1916	18,600	40,800	61,400	18,600	0.91	0.54	439	470	491	226	257	277
1917	38,100	55,200	72,200	38,100	1.16	0.69	587	618	638	314	345	366
1918	21,400	89,250	34,300	21,400	0.95	0.57	465	496	517	242	273	293
1919	20,900	10,350	4,440	4,440	0.56	0.33	234	265	285	102	133	154
1920	25,400	53,800	53,800	25,400	1.01	0.60	499	530	550	262	293	313
1921	20,400	52,250	23,900	20,400	0.93	0.56	456	487	508	236	267	287
1922	20,000	49,000	21,400	20,000	0.93	0.56	453	484	504	234	265	285
1923	16,400	47,150	33,100	16,400	0.87	0.52	417	448	468	212	243	264
1924	45,700	43,600	37,200	37,200	1.15	0.69	581	612	632	311	342	362
1925	36,000	50,850	47,900	36,000	1.13	0.68	574	605	625	306	337	358
1926	31,600	28,600	23,200	23,200	0.98	0.59	481	512	532	251	282	302
1927	36,000	76,050	47,900	36,000	1.13	0.68	574	605	625	306	337	358
1928	45,000	33,250	56,800	33,250	1.10	0.66	556	587	607	296	327	347
1929	20,500	47,150	28,900	20,500	0.94	0.56	457	488	509	237	268	288
1930	13,600	24,600	15,200	13,600	0.81	0.49	385	416	437	194	225	245
1931	17,700	30,800	7,920	7,920	0.68	0.41	305	336	356	145	176	197
1934	12,400	12,900	4,670	4,670	0.57	0.34	239	270	291	106	137	157
1935	12,900	41,750	33,400	12,900	0.80	0.48	377	408	428	188	219	240
1936	22,400	31,300	11,100	11,100	0.76	0.46	353	384	405	174	205	226
1937	18,600	38,450	24,500	18,600	0.91	0.54	439	470	491	226	257	277
1938	22,000	47,700	40,400	22,000	0.96	0.58	471	502	522	245	276	296
1939	19,000	25,200	17,600	17,600	0.89	0.53	429	460	481	220	251	271
1940	17,400	26,600	11,700	11,700	0.77	0.46	361	392	413	179	210	231
1941	20,400	27,250	11,800	11,800	0.78	0.47	363	394	414	180	211	231
1942	26,100	39,950	28,900	26,100	1.02	0.61	504	535	556	265	296	316
1943	16,600	59,600	62,700	16,600	0.87	0.52	419	450	470	214	245	265
1944	32,500	61,100	48,600	32,500	1.09	0.66	551	582	602	293	324	344
1945	15,600	40,400	37,000	15,600	0.85	0.51	408	439	460	207	238	259
1946	12,500	35,350	25,400	12,500	0.79	0.47	372	403	423	185	216	237
1947	28,100	38,100	40,800	28,100	1.04	0.62	520	551	571	274	305	325
1948	26,300	56,700	31,100	26,300	1.02	0.61	506	537	557	266	297	317
1949	24,200	35,450	18,200	18,200	0.90	0.54	435	466	487	224	255	275
1950	15,400	40,500	40,700	15,400	0.85	0.51	406	437	457	206	237	257
1951	22,200	32,400	29,100	22,200	0.96	0.58	472	503	524	246	277	297
1952	22,000	37,150	16,000	16,000	0.86	0.52	413	444	464	210	241	261
1953	9,340	31,100	20,600	9,340	0.72	0.43	328	359	379	159	190	210
1954	23,600	17,400	25,200	17,400	0.88	0.53	427	458	479	219	250	270
1955	18,100	26,700	17,100	17,100	0.88	0.53	424	455	476	217	248	268
1956	23,900	40,600	19,300	19,300	0.92	0.55	446	477	497	230	261	281
1957	25,400	55,550	44,000	25,400	1.01	0.60	499	530	550	262	293	313
1958	19,400	27,850	17,600	17,600	0.89	0.53	429	460	481	220	251	271
1959	10,600	37,750	24,900	10,600	0.75	0.45	346	377	398	170	201	222
1960	7,200	22,550	7,720	7,200	0.66	0.39	292	323	344	138	169	189
1961	5,780	23,750	6,100	5,780	0.61	0.37	264	295	316	121	152	172
1962	23,000	48,700	32,200	23,000	0.97	0.58	479	510	531	250	281	301

Appendix 3, Table 1. Annual discharge, velocity, and pallid sturgeon larval drift distances estimated for the Yellowstone River, MT.

	Discharge (cfs)				Velocity (m/s)		Drift distance for average velocity (miles)			Drift distance for reduced velocity (miles)		
Year	May	June	July	min	v	60%v	1%	10%	25%	1%	10%	25%
1963	21,700	52,900	26,300	21,700	0.95	0.57	468	499	519	243	274	295
1964	24,200	48,150	47,800	24,200	0.99	0.59	489	520	541	256	287	307
1965	21,300	56,050	60,400	21,300	0.95	0.57	464	495	516	241	272	292
1966	12,000	16,400	11,000	11,000	0.76	0.45	352	383	403	174	205	225
1967	14,400	57,000	63,800	14,400	0.83	0.50	395	426	446	199	230	251
1968	13,800	51,100	27,700	13,800	0.82	0.49	388	419	439	195	226	246
1969	21,200	26,100	31,600	21,200	0.95	0.57	464	495	515	240	271	292
1970	27,900	47,500	37,600	27,900	1.04	0.62	518	549	570	273	304	325
1971	24,700	54,000	36,100	24,700	1.00	0.60	493	524	545	258	289	310
1972	25,100	41,800	20,600	20,600	0.94	0.56	458	489	510	237	268	289
1973	30,900	29,500	17,900	17,900	0.89	0.54	432	463	484	222	253	273
1974	14,000	42,600	43,500	14,000	0.82	0.49	390	421	442	196	227	248
1975	32,100	47,950	64,200	32,100	1.09	0.65	548	579	599	291	322	343
1976	35,400	40,000	28,800	28,800	1.05	0.63	525	556	576	277	308	329
1977	11,700	16,500	6,530	6,530	0.63	0.38	280	311	331	130	161	181
1978	46,600	47,900	42,200	42,200	1.20	0.72	611	642	662	329	360	380
1979	16,300	24,300	20,100	16,300	0.87	0.52	416	447	467	212	243	263
1980	16,100	25,300	18,700	16,100	0.86	0.52	414	445	465	211	242	262
1981	21,100	38,350	20,300	20,300	0.93	0.56	455	486	507	236	267	287
1982	15,300	29,500	45,100	15,300	0.85	0.51	405	436	456	205	236	257
1983	14,000	30,350	32,800	14,000	0.82	0.49	390	421	442	196	227	248
1984	27,300	31,450	30,500	27,300	1.03	0.62	514	545	565	270	301	322
1985	9,220	15,050	6,100	6,100	0.62	0.37	271	302	322	125	156	176
1986	15,700	45,250	22,400	15,700	0.85	0.51	409	440	461	208	239	259
1987	15,000	14,250	6,110	6,110	0.62	0.37	271	302	323	125	156	176
1988	20,100	18,450	6,370	6,370	0.63	0.38	276	307	328	128	159	180
1989	21,000	23,450	13,700	13,700	0.82	0.49	387	418	438	194	225	246
1990	11,200	23,350	21,400	11,200	0.76	0.46	355	386	406	175	206	227
1991	37,400	50,650	27,200	27,200	1.03	0.62	513	544	564	270	301	321
1992	16,900	17,500	25,900	16,900	0.88	0.53	422	453	474	216	247	267
1993	31,500	33,950	32,500	31,500	1.08	0.65	544	575	595	289	320	340
1994	21,900	15,850	6,940	6,940	0.65	0.39	287	318	339	135	166	186
1995	29,100	40,750	37,300	29,100	1.05	0.63	527	558	578	278	309	330
1996	30,700	49,000	35,400	30,700	1.07	0.64	538	569	590	285	316	337
1997	39,700	65,700	33,900	33,900	1.11	0.67	560	591	611	298	329	350
1998	12,500	19,600	33,500	12,500	0.79	0.47	372	403	423	185	216	237
1999	18,100	41,500	28,000	18,100	0.90	0.54	434	465	486	223	254	274
2000	14,100	22,800	14,500	14,100	0.82	0.49	391	422	443	197	228	249
2001	11,600	15,150	7,500	7,500	0.66	0.40	298	329	349	141	172	192
2002	12,300	24,000	12,400	12,300	0.79	0.47	369	400	421	184	215	235
2003	10,900	26,350	11,900	10,900	0.75	0.45	351	382	402	173	204	224
2004	6,940	12,850	13,100	6,940	0.65	0.39	287	318	339	135	166	186
2005	23,400	22,150	19,900	19,900	0.93	0.56	452	483	503	233	264	285
2006	26,500	19,000	10,100	10,100	0.74	0.44	339	370	391	166	197	217
2007	21,700	21,550	6,560	6,560	0.64	0.38	280	311	331	130	161	182
2008	21,900	41,350	46,100	21,900	0.96	0.57	470	501	521	244	275	296
2009	31,000	41,100	37,500	31,000	1.08	0.65	540	571	592	287	318	338

Appendix 4: Estimates of Average Velocity from Discharge Data

To estimate average river velocity from discharge, the Panel used the standard relationship of

$$V = K * Q^{a}$$

where V = mean velocity, K is a constant, Q = discharge, and a = 0.34 (see Jobson 1996).

K was determined from transect data on the lower Platte River, NE. The transect data collected by Nebraska Game and Parks Commission for an IFIM study of the lower Platte River and used in Peters and Parham (2008) to model pallid sturgeon habitat. The Yellowstone River (Appendix 4, Figure 1) is similar in geomorphology to the lower Platte River, NE (Appendix 4, Figure 2).

Appendix 4, Figure 1. Aerial image of the Yellowstone River upstream of the Yellowstone Diversion Intake near Schaffer Island. Note multiple channel and sandbar islands. Source: Google Earth.

Appendix 4, Figure 2. Aerial image of the Platte River downstream of Louisville, Nebraska. Note multiple channel and sandbar islands. Source: Google Earth.

To confirm that the value for K was similar to the K for the Yellowstone River the average of all K estimates from the Platte River transect data were compared with the estimate of 25,000 cfs having a 3.23 ft/sec average velocity on the Yellowstone River (MRRIC Questions and Responses 2009; Appendix 2).

Appendix 4, Table 1. Result for estimated K for lower Platte River transects and comparison with Yellowstone River estimate.

Location	Discharge (cfs)	Discharge (cms)	Average Velocity (m/s)	Estimated K
Platte River near Cedar Creek	1,451	41	0.38	0.11
Platte River near Cedar Creek	1,555	44	0.42	0.12
Platte River near Cedar Creek	1,626	46	0.34	0.09
Platte River near Cedar Creek	1,710	48	0.40	0.11
Platte River near Cedar Creek	3,838	109	0.41	0.08
Platte River near Cedar Creek	4,320	122	0.49	0.09
Platte River near Cedar Creek	5,116	145	0.46	0.08
Platte River near Cedar Creek	5,723	162	0.53	0.09
Platte River near Louisville	1,498	42	0.40	0.11
Platte River near Louisville	1,513	43	0.39	0.11
Platte River near Louisville	1,650	47	0.40	0.11
Platte River near Louisville	1,864	53	0.44	0.11

Appendix 4, Table 1. Result for estimated K for lower Platte River transects and comparison with Yellowstone River estimate.

Location	Discharge (cfs)	Discharge (cms)	Average Velocity (m/s)	Estimated K
Platte River near Louisville	4,935	140	0.62	0.12
Platte River near Louisville	5,571	158	0.48	0.09
Platte River near Louisville	5,986	170	0.53	0.09
Platte River near Louisville	6,767	192	0.59	0.10
Platte River near North Bend	1,181	33	0.36	0.11
Platte River near North Bend	1,208	34	0.34	0.10
Platte River near North Bend	1,251	35	0.41	0.12
Platte River near North Bend	1,264	36	0.35	0.10
Platte River near North Bend	1,280	36	0.41	0.12
Platte River near North Bend	1,379	39	0.42	0.12
Platte River near North Bend	1,380	39	0.33	0.09
Platte River near North Bend	2,456	70	0.53	0.13
Platte River near North Bend	2,487	70	0.51	0.12
Platte River near North Bend	2,530	72	0.54	0.13
Platte River near North Bend	2,577	73	0.54	0.13
Platte River near North Bend	2,799	79	0.51	0.12
All transect average				0.11
Yellowstone River estimate	25,000	708	1.00	0.11

The estimated values for the lower Platte River and for the Yellowstone River were 0.11. So the final equation used to estimate average velocity for the Yellowstone River from gage discharge information was:

$$\mathbf{V = 0.11 * Q^{0.34}}$$

where V = mean velocity in m/s and Q = discharge in cms.

Further confirmation would require data from transects on the Yellowstone River. These data should be available by request from the regional USGS water resources office.