Using effects analysis to build science-based adaptive management for the Missouri River

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Background

The Missouri River Recovery Program (MRRP) was initiated in 2006 by the US Army Corps of Engineers and the US Fish and Wildlife Service to implement requirements of a 2003 Biological Opinion to avoid jeopardy to three federally listed species: the piping plover (*Charadrius melodus*), the interior population of the least tern (*Sternula antillarum*), and the pallid sturgeon (*Scaphirhynchus albus*). The Missouri River has been highly altered by reservoirs and channelization, which are thought to have contributed to the decline of these species. The program has included habitat management and population protection and augmentation actions. Adaptive management plans were developed for habitat creation.

In 2011, a review of the MRRP by the Independent Science Advisory Panel followed by a recommendation from the Missouri River Recovery Implementation Committee, suggested the program take the following steps:

- Conduct an effects analysis (EA)
- Develop conceptual ecological models
- Evaluate other adaptive management (AM) programs
- Develop an overarching AM program for the MRRP
- Design monitoring programs to meet adaptive management needs
- Identify decision criteria
- Evaluate the entire hydrograph

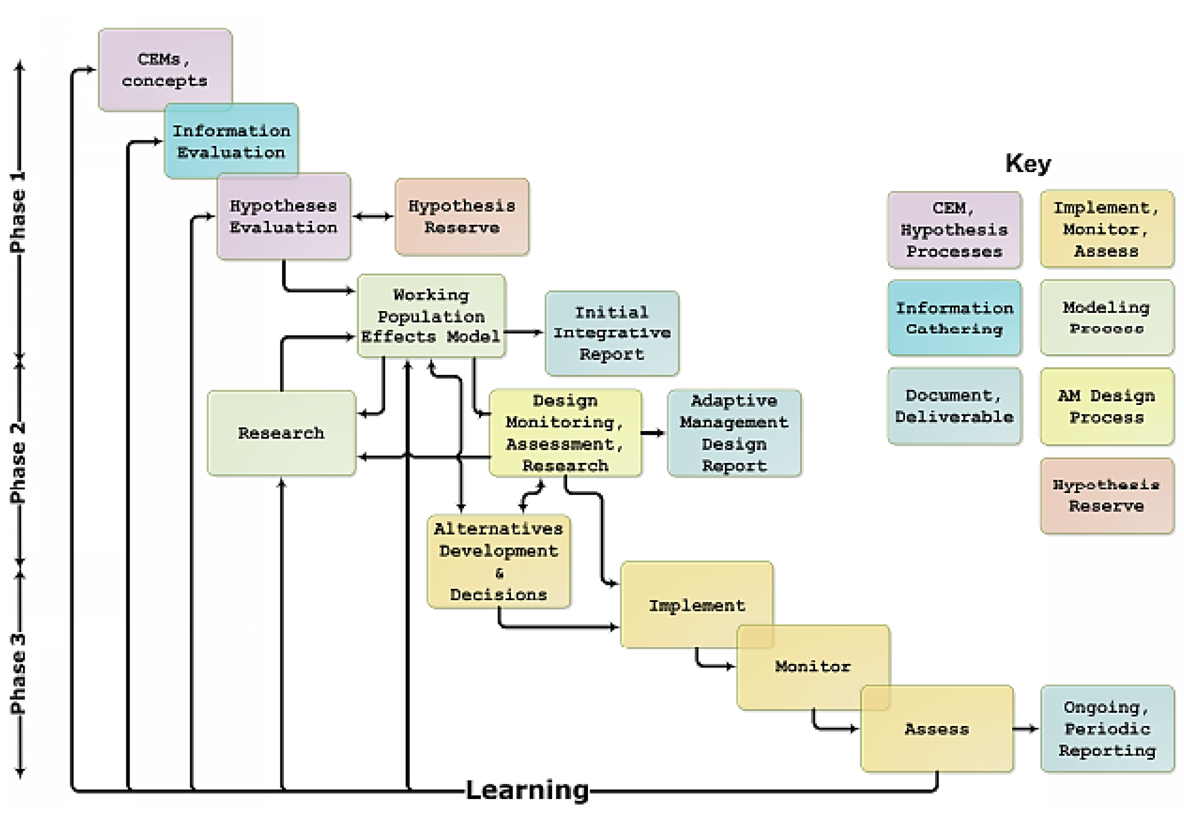
In 2013, the MRRP initiated the EA in collaboration with the Engineer Research and Development Center, US Geological Survey, and Pacific Northwest National Laboratory. The EA is providing the scientific foundation for a new Programmatic Environmental Impact Statement for the MRRP. It has also provided the scientific basis and many critical tools for the integrated AM program.

Effects Analysis

The Missouri River EA was designed to evaluate the effects of reservoir management on the three listed species and effectiveness of management actions identified to protect or improve the populations and their habitats. The EA concept consists of three essential steps (Murphy and Weiland 2011):

- the collection of reliable scientific information,
- the critical assessment and synthesis of available data and analyses derived from those data, and
- the analysis of the effects of actions on listed species and their habitats.

Process and products for the effects analysis and adaptive management



Adaptive Management

The AM plan will integrate management across species to improve outcomes over time while actively addressing uncertainties. It includes:

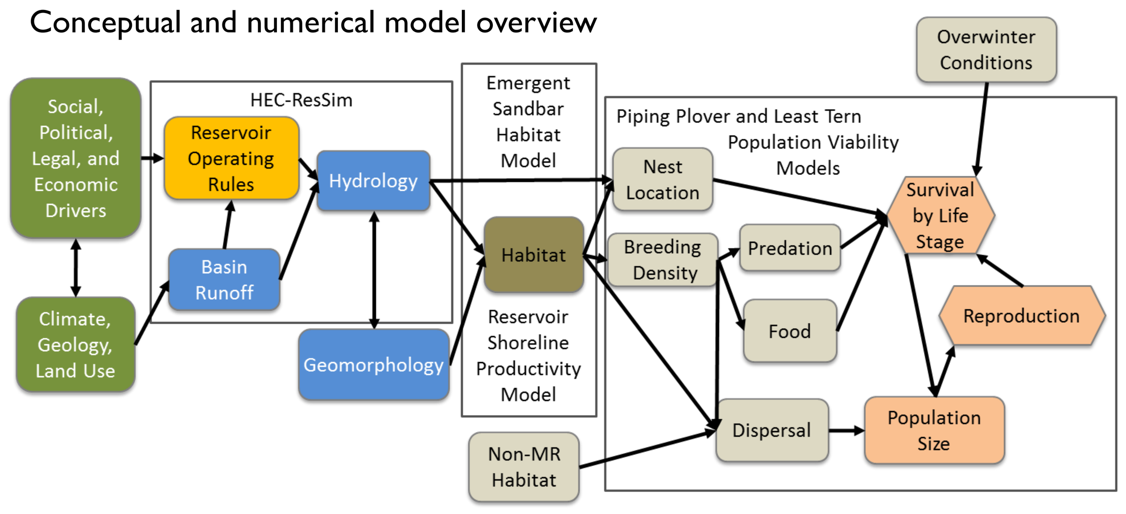
- management for species in the context of competing socioeconomic uses and other legal requirements for reservoirs and river reaches;
- a Science Update process to annually evaluate and synthesize monitoring and research information;
- emphasis on modeling and other quantitative decision support tools;
- accountable governance to manage responsively across a wide range of potential activities and adjustments;
- active roles for stakeholders and independent review; and
- decision criteria to help ensure decisions reflect the best available science and human interest concerns.

Effects Analysis Findings and Adaptive Management Tools for Piping Plovers and Least Terns

Models and hypotheses

Using conceptual models, the bird EA identified 18 biological hypotheses and 11 management actions with 16 related management hypotheses. Numerical models developed for the EA allow most of these hypotheses to be evaluated quantitatively. The fundamental relationships between hydrology, habitat, and bird populations are understood, but uncertainty remains about the form and strength of relationships and the effects of highly variable hydrology and long-term change.

Conceptual and numerical model overview



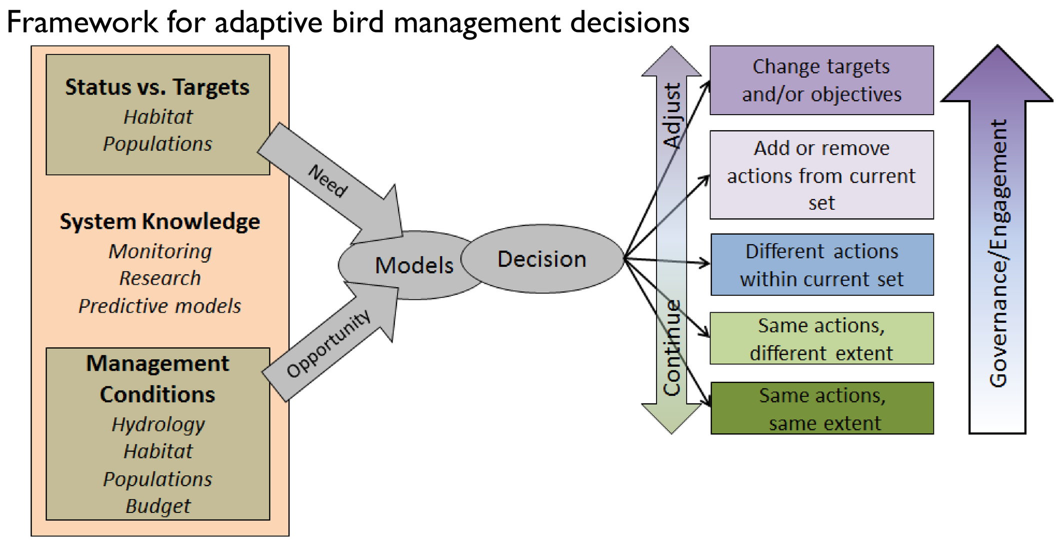
Decision criteria

Quantitative criteria for implementing actions connect science findings to decision, facilitate decisions that must be made quickly, help account for multiple considerations within decisions and make trade-offs explicit.

AM framework

Adaptive management for birds is centered around the use of models to link management needs with current opportunities for modifying flows and/or habitat. Recognizing that no single management action will meet program needs at all time, the AM plan advocates for a toolbox approach that selects from a range of actions as appropriate and modifies them as learning occurs.

Framework for adaptive bird management decisions



Overarching critical uncertainties

- How much habitat is needed to maintain a resilient population?
- How are the Missouri River populations affected by migratory and metapopulation dynamics?
- How will changes in climate and channel morphology affect management?
- How can management decisions buffer against natural uncertainty?
- How can management actions buffer against institutional and socioeconomic uncertainty?

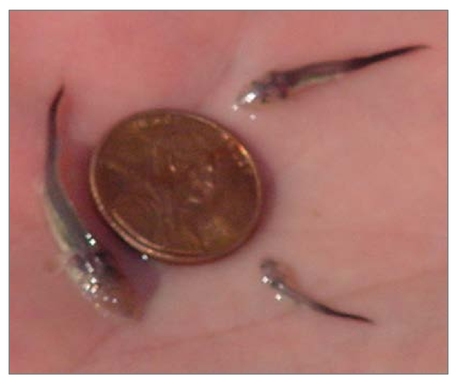
Monitoring

Bird monitoring plans are under development with the objectives of continuing to inform numerical models, allow for evaluation of action effectiveness, and track progress towards targets. Cost-effectiveness, ability to estimate observation error, and ability to adjust monitoring effort to habitat conditions will be critical to monitoring effectively in the context of the AM program as a whole.

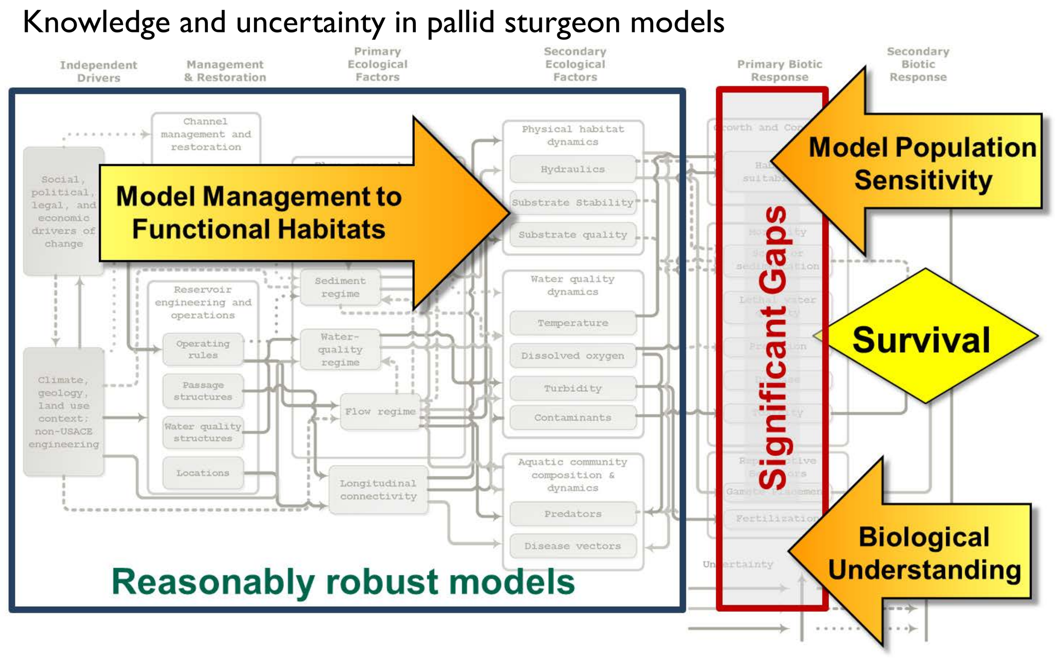
Effects Analysis Findings and Adaptive Management Tools for Pallid Sturgeon

Models and hypotheses

Sturgeon conceptual models resulted in hundreds of hypotheses, which were refined through expert elicitation to 23 dominant hypotheses and 21 management hypotheses. The EA modeled management effects on habitat and for population dynamics, but significant knowledge gaps have hindered modeling to fully connect management actions to habitats and population responses. The ability of management actions to remove barriers to recruitment remains highly uncertain.



Knowledge and uncertainty in pallid sturgeon models



Decision criteria

Decision criteria have been developed for acting based upon the outcomes of research and management actions. Quantitative criteria are being developed for specific actions. Answering "yes" to the series of questions supports moving to scaled implementation.

Overarching critical uncertainties

Uncertainties for pallid sturgeon center around the effects of management actions on reproduction, recruitment, and survival. The situation is complicated by the fact that geographically separated subpopulations likely experience different causes of recruitment failure. Critical uncertainties include:

- are flow manipulations necessary to cue spawning, contribute to effective dispersal of free embryos?
- are water temperature manipulations necessary for reproductive cues, or increased productivity and growth?
- is dispersal distance limiting for age-0 pallid sturgeon survival, and if so, what combination of flow manipulation and other engineering actions would remove that limit?
- are food-producing or foraging habitats limiting for age-0 pallid sturgeon, and if so, what combination of flow manipulation and channel reconfiguration would remove that limit?
- are spawning habitats limiting for successful reproduction, and if so what combination of flow manipulation and channel reconfiguration would remove that limit?
- is sediment augmentation necessary to achieve recruitment?
- what approaches to population augmentation are necessary to maintain the population temporarily and will do so with least harm to genetic diversity?

AM framework

Sturgeon AM is focused on resolving significant uncertainty while ensuring management is sufficient to avoid jeopardy. Levels of activity from research to implementation at scales needed to remove limiting factors form the basis of the management plan.

Framework for sturgeon research and implementation

Level 1: Research	Population Level Biological Response IS NOT Expected	Studies without changes to the system (Laboratory studies or field studies under ambient conditions)
Level 2: In-river Testing		Implementation of actions at a level sufficient to expect a measurable biological, behavioral, or physiological response in pallid sturgeon, surrogate species, or related habitat response.
Level 3: Scaled Implementation	Population Level Biological Response IS Expected	Initial implementation should occur at a level sufficient to expect a meaningful population response progressing to implementation at levels that result in improvements in the population; not expected to achieve full success.
Level 4: Ultimate Required Scale of Implementation		Implementation to the ultimate level required to remove a limiting factor.

Decision criteria for moving from Level 2 to Level 3

	Question	Y	U	N
1	Is this factor limiting pallid sturgeon reproductive and/or recruitment success?			
2	Are pallid sturgeon needs sufficiently understood with respect to this limiting factor?			
3	Do one or more management action(s) exist that could, in theory, address these needs?			
4	Has it been demonstrated that at least one kind of management action has a sufficient probability of satisfying the biological need?			
5	Have other biological, legal, and socioeconomic considerations been sufficiently addressed to determine whether or how to implement management actions to Level 3?			

Monitoring

The state of science for the pallid sturgeon will require continued investment in foundational research. As science matures, field experiments and scaled implementations will be evaluated through directed, hypothesis-driven process monitoring. Process monitoring will be complemented with population-level monitoring to discern status and trends. Population-level monitoring is presently being redesigned to improve cost effectiveness and better link to management hypotheses and models.

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References

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