Adaptive Management for Large-Scale Water Infrastructure Projects

The Missouri River Recovery Program

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ERDC Environmental Laboratory

Restore the Mississippi River Delta
July 26, 2018
New Orleans, LA
Missouri River Basin

Congressionally Authorized Project Purposes

Bank Stabilization and Navigation Project
Sioux City, IA – St. Louis, MO

Missouri River Basin

Fort Peck
Garrison
Oahe
Big Bend
Fort Randall

Interior Least Tern
Piping Plover
Pallid Sturgeon
USFWS 2000/2003 Biological Opinions (BiOp) found Corps’ operations would jeopardize the continued existence of the pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sternula antillarum athalassos*) and the piping plover (*Charadrius melodus*).

Identified a Reasonable and Prudent Alternative (RPA) to jeopardy consisting of several actions, including adaptive management.

Missouri River Recovery Program (MRRP) initiated in 2006 to implement requirements in the BiOp.

“The Corps should embrace an adaptive management process that allows efficient modification/implementation of management actions in response to new information and to changing environmental conditions to benefit the species . . .” (USFWS 2000)
MRRP Overview

MRRP Purpose:
► To implement the requirements of the BiOp and restore a portion of the Missouri River ecosystem and habitat for fish and wildlife, while maintaining the congressionally-authorized uses of the river

MRRP Elements:
► Pallid Sturgeon-
  ➢ Shallow Water Habitat Construction
  ➢ Hatchery Propagation/Stocking
  ➢ Spring Pulse System Release
► Tern and Plover
  ➢ Emergent Sandbar Habitat Construction
  ➢ System Operation to Reduce Nest Damage
► Monitoring and Evaluation
The **EMERGENT SANDBAR HABITAT PROGRAM**

- Mechanically building and maintaining sandbars
- Clearing existing sandbars of vegetation

The **SHALLOW WATER HABITAT PROGRAM**

- Creating 20 - 30 acres per mile of new shallow water habitat by 2020
- Widening river channel
- Restoring chutes and side channels
Missouri River Recovery Implementation Committee (MRRIC)

- Authorized by Congress in WRDA 2007
- Provide guidance/recommendations to USACE on MRRP implementation
- Composed of:
  - 28 Stakeholder members
  - 8 States
  - 18 Tribes
  - 15 Federal agencies
Missouri River Recovery Program/MRRIC

Independent Science Advisory Panel (ISAP)

Effects Analysis

Human Considerations/ISETR

EIS Alternative Development

Adaptive Management Plan
Independent Science Advisory Panel (ISAP)

- 2009 MRRIC selection of independent science advisory panel
- Selection of 6 national experts in:
  - Geomorphology
  - Tern and Plover Biology
  - Pallid Sturgeon Biology
  - Ecology/Statistics
  - Conservation Biology
  - Riverine Ecology

Jan 2011 – MRRIC Finalized Initial Task to Independent Science Advisory Panel (ISAP)
2011 Flood

- >210% Normal basin runoff
- Flood of record
- >2X previous maximum reservoir release
- $85M direct impacts
- 5 deaths

(NWS 2012)
MRRIC Consensus Recommendation: 7 Proposed Actions from ISAP Report

1. Develop Effects Analysis
2. Develop Conceptual Ecological Models for listed species
3. Evaluate other Recovery programs
4. Develop overarching adaptive management strategy
5. Design monitoring programs
6. Identify decision criteria
7. Evaluate entire hydrograph effects on the listed species
Effects Analysis

Hydrologic/Geomorphic
Dr. Craig Fischenich
USACE Engineering Research Development Center

Pallid Sturgeon
Dr. Robb Jacobson
U.S. Geological Survey

Piping Plover/Least Tern
Dr. Kate Buenau
Pacific Northwest National Lab
Effects Analysis Activities

► Compile and assess *pertinent scientific and operational information*

► Develop *conceptual ecological models* to guide development of hypotheses and quantitative models

► Identify hypothesized *factors contributing to species population dynamics*

► Develop *quantitative models for forecasting* the effect of different actions on listed species performance

► Conduct analyses to inform *species objectives targets* and *management actions*

► Assess *effectiveness of alternative management strategies* relative to the No Action condition
Sources of information – lines of evidence

- **Theory**: natural flow paradigm, resource partitioning, niche utilization
- **Expert opinion**: understanding from other rivers, other species, from experience – “professional judgment”
- **Empirical evidence**: laboratory or field evidence of association, habitat selection; developmental rates; behavioral experiments
- **Quantitative models**: models constructed from theory, opinion, and/or empirical data to link management actions to biotic responses
  - We emphasize quantitative models but quantitative models need to be based on a strong theoretical or empirical foundation to be useful.
Pathways from Management Actions to Population Responses

- Social, Political, Legal, and Economic Drivers
- Climate, geology, land use
- Reservoir Operating Rules
- Basin Runoff
- Sandbar Construction
- Hydrology
- Geomorphology
- Habitat
- Nest Location
- Nest Density
- Survival by Life Stage
- Predation
- Food
- Dispersal
- Population Size
- Overwinter conditions
- Overwinter conditions
- Pathways from Management Actions to Population Responses
## CEM-Derived Hypotheses

**Plover biotic hypothesis**

Increases in area of suitable habitat increases survival of eggs to chicks and chicks to fledglings by reducing predation.

**Intermediate hypotheses**

For a given population size, increases in habitat area decrease nest density. Lower nest densities attracts fewer predators, reducing predation. Decreases in predation increase survival of eggs to chicks and chicks to fledglings.
Overarching Critical Uncertainties—Birds

- How much habitat is needed to maintain a resilient population of plovers and how should it be distributed?
- How are the Missouri River populations affected by migratory and metapopulation dynamics?
- How will changes in climate and channel morphology affect management effectiveness?
- How can the AM program buffer against natural (especially hydrologic) uncertainty?
- How can the AM program buffer against institutional and socioeconomic uncertainty?
- Management uncertainties: are actions necessary and effective?
Spawn over hard, coarse substrate, adhesive eggs, fertilize, 4-7 days incubation

11-14 days drift as free embryo (or 6-9?)

Migrate upstream hundreds of km

“Settle” into lotic marginal habitats

Grow to sexual maturity, 7-14 years

Pallid Sturgeon (*Scaphirhynchus albus*)

DeLonay and others (2009)
Component-level Conceptual Model

Upper Basin Pallid Sturgeon CEM
Gametes & Developing Embryos

Independent Drivers
Management & Restoration
Primary Ecological Factors
Secondary Ecological Factors
Primary Biotic Response
Secondary Biotic Response

Multiple Management Hypotheses

Dominant: biological Survival

Social, political, legal, and economic drivers of change
Channel management and restoration
Flow, geomorphology
Reservoir engineering operations
Operating rules
Passage structures
Water quality structures
Location

Physical habitat dynamics
Hydraulics
Substrate stability
Substrate quality
Water quality dynamics
Temperature
Dissolved oxygen
Turbidity
Contaminants
Aquatic community composition & dynamics
Predators
Disease vectors

Growth and Condition
Habitat
Scour or sedimentation
Lethal water quality
Predation
Disease
Toxicity
Reproductive Behaviors
Gamete Placement
Fertilization

Uncertainty
Importance
Management Hypotheses Expert Survey

- **Drawdown Lake Sakakawea** - drift
- **Stocking management** – genetic diversity
- **Remove, bypass, Intake, Cartersville** - drift
- **Sediment bypass Ft. Peck** – predation
- **Temp control Ft. Peck** – drift, growth
- **Naturalize Ft. Peck** – drift, cue, flow
- **Remove Ft. Peck** – drift, spawn, cue, flow

Less support  More support  Uncertainty
### Working set of management hypotheses and model types.

<table>
<thead>
<tr>
<th>Where</th>
<th>What</th>
<th>Management Hypothesis</th>
<th>Model Type</th>
<th>Short Name</th>
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</thead>
<tbody>
<tr>
<td>Alter Flow Regime at Fort Peck</td>
<td>Naturalized flow releases at Fort Peck will result in increased productivity through increased hydrologic connections with low-lying land and floodplains in the spring, and decreased velocities and bioenergetic demands on exogenously feeding larvae and juveniles during low flows in summer and fall.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>DRIFT</td>
<td></td>
</tr>
<tr>
<td>Temperature Control, Multilevel-release Device at Fort Peck</td>
<td>Redistribution of mainstem Missouri flow from Fort Peck Dam during free embryo dispersal will decrease mainstem velocities and drift distance thereby decreasing downstream mortality of free embryos and exogenously feeding larvae.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>DRIFT</td>
<td></td>
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<tr>
<td>Sediment Bypass at Fort Peck or Other Sediment Augmentation.</td>
<td>Installing sediment bypass at Fort Peck will increase and naturalize turbidity levels, resulting in decreased predation on embryos, free embryos, and exogenously feeding larvae.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Mortality</td>
<td>DRIFT</td>
<td></td>
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<tr>
<td>Construct Fish Passage at intake on Yellowstone River</td>
<td>Fish passage at intake Dam on the Yellowstone will allow access to a additional functional spawning sites, increasing spawning success and effective drift distance, and decreasing downstream mortality of free embryos and exogenously feeding larvae.</td>
<td>Flow (Passage = migration + spawning); Flow = Morph, Disp Distance; + Temperature -&gt; Destination @ settling; + Destination Quality -&gt; Survival</td>
<td>DRIFT</td>
<td></td>
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<td>Upper Basin Propagation</td>
<td>Stocking with appropriate parentage and genetic diversity will result in increased survival of embryos, free embryos, exogenously feeding larvae, and juveniles.</td>
<td>Stocking decision -&gt; Population model -&gt; Population growth/decrease?</td>
<td>PROPAGATION</td>
<td></td>
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<tr>
<td>Lake Sakakawea</td>
<td>Drawing water down Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos and exogenously feeding larvae.</td>
<td>Drowning of Lake Sakakawea will increase effective drift distance, decreasing downstream mortality of free embryos, and exogenously feeding larvae.</td>
<td>DRIFT</td>
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<tr>
<td>Alter Flow Regime at Gavins Point</td>
<td>Naturalization of the flow regime at Gavins Point will improve flow cues in spring for aggregation and spawning of reproductive adults.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>SPAWNING CUE</td>
<td></td>
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<tr>
<td>Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
<td>Re-engineering of channel morphology in selected reaches will create optimal spawning conditions -- substrate, hydraulics, and geometry -- to increase probability of successful spawning, fertilization, embryo incubation, and free-embryo retention.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>SPAWNING CUE</td>
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<tr>
<td>Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for rooting and foraging of exogenously feeding larvae and juveniles.</td>
<td>Re-engineering of channel morphology will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>BIOENERGETICS</td>
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<tr>
<td>Re-engineering of channel morphology in selected reaches will increase channel complexity and serve specifically to intercept and retain drifting free embryos in areas with sufficient prey for first feeding and for growth through juvenile stages.</td>
<td>Re-engineering of channel morphology will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
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<td>Stocking at optimal size classes will increase growth rates and survival of exogenously feeding larvae and juveniles during low flows in summer and fall.</td>
<td>Stocking at optimal size classes will increase growth rates and survival of exogenously feeding larvae and juveniles.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>BIOENERGETICS</td>
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<tr>
<td>Temperature Management at Fort Randall and Gavins Point</td>
<td>Operation of a temperature management system at Fort Randall and/or Gavins Point will increase water temperature downstream of Gavins Point, providing spawning cues for reproductive adults.</td>
<td>Flow + Morph + Sediment + Temperature -&gt; Behavioral response -&gt; Viable gametes</td>
<td>SPAWNING CUE</td>
<td></td>
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<td>Lower Missouri River</td>
<td>Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
<td>Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
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<td>Channel Reconfiguration</td>
<td>Re-engineering of channel morphology will increase channel complexity and minimize bioenergetic requirements for rooting and foraging of exogenously feeding larvae and juveniles.</td>
<td>Re-engineering of channel morphology in selected reaches will increase channel complexity and bioenergetic conditions to increase prey density (invertebrates and native prey fish) for exogenously feeding larvae and juveniles.</td>
<td>BIOENERGETICS</td>
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<tr>
<td>Stocking of fish with appropriate genetic heritage and at their locations with appropriate habitats will increase growth and survival of exogenously feeding larvae and juveniles.</td>
<td>Stocking of fish with appropriate genetic heritage and at their locations with appropriate habitats will increase growth and survival of exogenously feeding larvae and juveniles.</td>
<td>Stocking decision -&gt; Population model -&gt; Population growth/decrease?</td>
<td>PROPAGATION</td>
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</table>

### 21 Hypotheses:
- **Bioenergetics**
- **Spawning cues**
- **Drift/dispersal**
- **Predation**
- **Propagation**

**Five core model types**
Overarching Critical Uncertainties—Sturgeon

► 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?
CEMs to Population Viability

Conceptual Ecological Models (CEMs)

Stage Structured Population Model

Survival to gametes
Stage structured Pallid Sturgeon population model

- Number of years to simulate: 10, 20, 50, 100
- Maximum age: 10, 20, 41
- Initial abundance juveniles (natural): 100, 5,000, 20,000
- Initial abundance juveniles (hatchery): 100, 5,000, 20,000
- Initial abundance adults (hatchery): 100, 5,000, 20,000
- Initial abundance adults (hatchery): 100, 5,000, 20,000
- Annual hatchery inputs (fingerlings): 100, 5,000, 20,000
- Annual hatchery inputs (yearlings): 100, 5,000, 20,000
- Early life survival (0-365 dph): 10, 0.0002, 0.1
- Probability of producing viable gametes: 0.0002, 0.01
- Survival to adult (age-1): 10, 0.0002, 0.01
- Adult survival (>age-1): 10, 0.532, 1
Free Embryo Drift and Survival
Upper Missouri & Yellowstone Rivers

Management Working Hypotheses:

- **Upper Missouri**
  - Low flows from Fort Peck
  - Increased temperatures from Fort Peck
  - Drawdown of Lake Sakakawea

- **Yellowstone**
  - Provide passage at Intake
  - Drawdown of Lake Sakakawea
## Preliminary Effectiveness of Management Actions

### Percent Larvae U/S of Pool at T = 4 Days

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<td>Exceed Ft. Peck</td>
<td>1805.0</td>
<td>1812.6</td>
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### Percent Larvae U/S of Pool at T = 6 Days

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### Percent Larvae U/S of Pool at T = 8 Days

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### Percent Larvae U/S of Pool at T = 10 Days

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Habitat and population modeling

- Habitat actions
- Fledglings
- Population growth rate
- Population protection
- Adult birds
- Population viability models
- Reservoir habitat model
- Flow modification
- Sandbar model
- Hydrograph
Emergent Sandbar Habitat

Year 1

Year 2

Available ESH

Maximum July flow

Standard flow

Standardized ESH

Gavins Point Reach

Garrison Reach

Basin Line ESH (acres)

Flow (cfs)

Baseline ESH (acres)

Available ESH (acres)
Species Models

- Species models were developed and are used to forecast population ranges for alternative management scenarios.
- Additional modeling is addressing specific biological hypotheses critical to decision making.
Useful Model Analyses

500 ac in one year ($25M)
Occurs one year in ten
Useful Model Analyses

Effectiveness of Summer Low Flows:
Seasonal Adjustment to Available ESH for Given Flow

Decrease mean summer flow to 25kcfs
Synthesis: Best Available Science Based on Lines of Evidence and Model Projections
Effects Analysis Report Review Process

Effects Analysis Reports

1. ISAP Review
2. MRRIC Brief
3. ISAP Review

ERDC
Engineer Research and Development Center
Human Considerations

- Purpose is to assess effects of potential management actions on human interests
- Identified and developed with MRRIC-2013-2014
- MRRIC Consensus Recommendation-2014
- PrOACT process truncated in 2015
Environmental Impact Categories (Human Considerations)

- Agriculture
- Commercial Sand Dredging
- Cultural Resources
- Environmental Conservation
- Fish and Wildlife
- Flood Risk Reduction
- Hydropower
- Implementation Costs
- Irrigation
- Navigation
- Recreation
- Thermal Power
- Water Supply
- Wastewater
Tools for Stakeholders

Omaha, NE, Stage, 10th Percentile

MRRIC Hydrology Visualization Tool
Round 2 Bird Alternatives; "Existing Conditions" Aggradation / Degradation Scenario

Select location:

Flow Stage / Elevation

Single Alternative
- Each year in grey
- Pick year (Select below)
- max
- 90th
- 50th
- Mean
- 10th
- min

Select Alternative

Alternatives
- ALT1_NOACTION
- ALT28_FALLS-35SL
- ALT24_FALLS-30SL
- ALT22_FALLS-42M AF
- ALT21_FALLS-31MAF
- ALT16_FALLS-35SL-25KCFPS
- ALT27_FALLS-30SL-25KCFPS
- ALT28_FALLS-42M AF-25KCFPS
- ALT20_FALLS-31MAF-25KCFPS

Multiple Alternatives
- Pick year (Select below)
- max
- 90th
- 50th
- Mean
- 10th
- min

Duration

Pick Yr

From To
Independent Socio-Economic Review Panel & Government to Government Consultation

ISETR Engagement

- MRRIC selection of 3 national experts in:
  - Resource Economics
  - Social Science
  - Mathematics and Quantitative Modeling


Consultation with Tribes Under Executive Order 13175 (2009)

- Direct engagements to fulfill Trust Responsibilities
- Tribal Working Group for MRRIC
Missouri River Recovery Program/MRRIC
Independent Science Advisory Panel (ISAP)
Effects Analysis
Human Considerations/ISETR
EIS Alternative Development
Adaptive Management Plan
Management Plan EIS

Problem Statement:
Develop a management plan that includes a suite of actions that removes or precludes jeopardy status for the piping plover, interior least tern, and pallid sturgeon, and that

• Complies with the authorization requirements from Section 601(a) of WRDA 1986, as modified by Section 334(a) of WRDA 1999, and further modified by Section 3176 of WRDA 2007.
• Continues to serve the Missouri River authorized purposes and accounts for human considerations; and
• Includes an EIS and establishes an AM process for implementing the preferred alternative.
Pallid Sturgeon Framework

- Provides an organizational framework for actions
- Utilizes adaptive management as an essential component
- Incorporates a phased implementation over a reasonable timeframe

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Population Level Biological Response</th>
<th>Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: Research</td>
<td>Studies without changes to the system (laboratory studies or field studies under ambient conditions)</td>
<td>NOT Expected</td>
<td>Time</td>
</tr>
<tr>
<td>Level 2: In-river Testing</td>
<td>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.</td>
<td>NOT Expected</td>
<td>Time</td>
</tr>
<tr>
<td>Level 3: Scaled Implementation</td>
<td>In terms of reproduction, numbers, or distribution, 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. The range of actions within this level is not expected to achieve full success (i.e., Level 4).</td>
<td>NOT Expected</td>
<td>Time</td>
</tr>
<tr>
<td>Level 4: Ultimate Required Scale of Implementation</td>
<td>Implementation to the ultimate level required to remove as a limiting factor.</td>
<td>Expected</td>
<td>Time</td>
</tr>
</tbody>
</table>
Management Plan Objectives

**Piping Plover Fundamental Objective**: Avoid jeopardizing the continued existence of the piping plover due to USACE actions on the Missouri River.

- **Sub-Objective 1 (Distribution)**: Maintain a geographic distribution of piping plovers in the river and reservoirs in which they currently occur in both the Northern and Southern River Regions.
  - **Means Objective**: Meet sub-objectives 2, 3, and 4 in both the Northern and Southern Regions.

- **Sub-Objective 2 (Population)**: Maintain a population of Missouri River piping plovers with a modeled 95 percent probability that at least 50 individuals will persist for at least 50 years in both the Northern and Southern Regions.
  - **Means Objective (ESH)**: Provide sufficient ESH (in-channel riverine habitat) on the Missouri River to meet the persistence target.
  - **Metric**: Number of standardized and available ESH acres measured annually.
  - **Target**: Targets are shown in Table 1-1.
  - **Timeframe**: Median standardized ESH targets (450 acres in the Northern Region; 1,180 acres in the Southern Region) must be met for 3 out of 4 years. Median available acres must be met or exceeded for the specified percent of years over a running 12-year interval.
Management Plan Objectives

**Sub-Objective 3 (Population Dynamics):** Maintain a stable or increasing long-term trend in population size in both regions.

- **Metric:** Population growth rate ($\lambda$): the ratio of population size $N$ between the current year and previous year ($N_t/N_{t-1}$); calculated annually.
- **Target:** $\lambda \geq 1$ (a growth rate greater than or equal to 1).
- **Timeframe:** The growth rate target must be met as a 3-year running geometric mean calculated as the cube root of the product of the growth rates for each of the 3 years (i.e., $(\lambda_1 \cdot \lambda_2 \cdot \lambda_3)^{1/3}$).

**Sub-Objective 4 (Reproduction):** Maintain fledgling production by breeding pairs sufficient to meet the population growth rate objectives within both the Northern and Southern Regions on the Missouri River.

- **Metric:** Fledge Ratio: Number of fledglings observed/(number of breeding adults/2), calculated annually.
- **Target:** $\geq 1.14$ chicks fledged per breeding pair.
- **Timeframe:** The fledge ratio target met as a 3-year running arithmetic mean.

<table>
<thead>
<tr>
<th>Acres of Emergent Sandbar Habitat</th>
<th>Northern Region</th>
<th>Southern Region</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.5%ile</td>
<td>Median</td>
</tr>
<tr>
<td>Standardized ESH Acres</td>
<td></td>
<td></td>
</tr>
<tr>
<td>190</td>
<td>450</td>
<td>2160</td>
</tr>
<tr>
<td>Available ESH Acres Exceeded for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>75%</td>
<td>170</td>
<td>270</td>
</tr>
<tr>
<td>50%</td>
<td>420</td>
<td>680</td>
</tr>
<tr>
<td>25%</td>
<td>960</td>
<td>1920</td>
</tr>
<tr>
<td>10%</td>
<td>1965</td>
<td>3000</td>
</tr>
</tbody>
</table>
**MRRP Goal:** develop a suite of actions that meets ESA responsibilities for pallid sturgeon (PS), while continuing to operate the Missouri River System to meet its authorized purposes.

**FWS Fundamental Objective for Pallid Sturgeon:** Avoid jeopardizing the continued existence of the pallid sturgeon from the USACE actions on the Missouri River.

**Sub-objective 1:** Increase pallid sturgeon recruitment to age 1.

- **Metric 1.1:** catch rates of naturally produced age 0 and age 1 PS
- **Metric 1.2:** model-based estimates of abundance of naturally produced age 0 and age 1 PS using data for age 0-4 fish
- **Metric 1.3:** model-based estimates of survival of naturally produced PS to age 1, using data for age 0-4 fish

**Target:** measurable recruitment to age 1

**Sub-objective 2:** Maintain or increase numbers of pallid sturgeon as an interim measure until sufficient and sustained natural recruitment occurs.

- **Metric 2.1:** population estimates for PS by size class, age (particularly ages 2 to 3) and origin
- **Metric 2.2:** catch rates of all PS by size class and origin (to maintain legacy data)

**Target:** TBD. Possible targets: 1) \( \lambda > 1 \) for PS age 2 and older; 2) survival rates of all size/age classes sufficient to provide stable population of PS age 2 and older; 3) acceptable probabilities of persistence and recovery (> 0.95) over 50 years (utilizing population models); and 4) > 5000 self-sustaining, genetically diverse PS in each adult population unit.
## Management Actions & Alternatives

<table>
<thead>
<tr>
<th>Management Actions</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 3</th>
<th>Alternative 4</th>
<th>Alternative 5</th>
<th>Alternative 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least Tern and Piping Plover</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Mechanical ESH Construction</td>
<td></td>
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<tr>
<td>Vegetation Management</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Predator Management</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Human Restriction Measures</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Flow Management to Reduce Take</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
</tr>
<tr>
<td>Spring Habitat-Creating Flow Release</td>
<td></td>
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<td></td>
<td>X</td>
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<tr>
<td>Fall Habitat-Creating Flow Release</td>
<td></td>
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<td></td>
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<tr>
<td>Monitoring and Research</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pallid Sturgeon (both Upper and Lower River)</td>
<td></td>
<td></td>
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<tr>
<td>Propagation and Augmentation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Pallid Sturgeon Population Assessment Project</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Level 1 and 2* Studies</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pallid Sturgeon: Upper River</td>
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<tr>
<td>Monitoring and evaluation related to recruitment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pallid Sturgeon: Lower River</td>
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<td></td>
</tr>
<tr>
<td>Spawning Habitat Construction</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Early Life Stage Habitat Construction</td>
<td>X (SWH)</td>
<td>X (SWH)</td>
<td>X (IRC)</td>
<td>X (IRC)</td>
<td>X (IRC)</td>
<td>X (IRC)</td>
</tr>
<tr>
<td>Spawning Cue Release</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Low Summer Flow</td>
<td></td>
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<tr>
<td>Floodplain Connectivity</td>
<td></td>
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</tr>
<tr>
<td>Habitat Development and Land Management on MRRP Lands</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Source: USFWS 2003

* Note that some Level 2 studies would require additional NEPA compliance beyond the scope of this EIS.
Scope of Actions in AM Plan relative to EIS & Preferred Alt

- **Universe of Potential Management Actions**
- **Full Suite of Management Actions Identified in the EA**
- **Management Actions in AM Plan (i.e. Evaluated in MRRMP/EIS)**
- **Management Actions in the Selected Alternative**

- **Not Immediately Implementable**
  - Requires New Decision Document
  - Requires NEPA Evaluation
  - Flows Require MM Update

- **Not Immediately Implementable**
  - Requires New Decision Document
  - Requires NEPA Evaluation
  - Flows Require MM Update

- **Conditionally Implementable**
  - Requires New Decision Document
  - May Require Supplemental NEPA
  - Flows Require MM Update

- **Fully Implementable**
Requirements for Action Implementation

Issues:

- Scope of actions in the preferred alternative aren’t the same as the actions referenced in the AM Plan.
- Under AM, the scope of actions COULD change.

Diagram:

1. WAS IT EVALUATED IN EIS?
   - NO → NEPA PROCESS REQUIRED
   - YES → IS ANALYSIS STILL ADEQUATE?
     - NO → NEW DECISION DOCUMENT NEEDED
     - YES → IS IT IN RECORD OF DECISION?
       - NO → PROCESS TO MODIFY MASTER MANUAL
       - YES → ARE CRITERIA IN MASTER MANUAL?
         - NO → IMPLEMENT
         - YES → IMPLEMENT

Full Suite of Management Actions Identified in the EA

Management Actions in AM Plan (i.e., Alternatives in MRRMP/EIS)

Management Actions in the Preferred Alternative
Adaptive Management Plan

- Developed concurrently with MRRMP-EIS
- Four draft versions shared with stakeholders and/or ISAP
- Organization
  - Ch1 – Executive Summary
  - Ch2 – Governance
  - Ch3 – Birds
  - Ch4 – Fish
  - Ch5 – Human Considerations
  - Ch7 – Data & Communications
- Monitoring Plans in Appendices
- 540/680 pgs, respectively
Table 4. Summary of time limits for level 3 implementation and scope of actions.

<table>
<thead>
<tr>
<th>Action Category</th>
<th>Time Limit*</th>
<th>Minimum Scope</th>
<th>Maximum Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population augmentation</td>
<td>Immediate</td>
<td>Current avg. stocking rate</td>
<td>Variable over time</td>
</tr>
<tr>
<td>IRC habitat development</td>
<td>2 years</td>
<td>Add 260K ac-d-yr</td>
<td>Add 500k ac-day-yr</td>
</tr>
<tr>
<td>Spawning habitat</td>
<td>2 years†</td>
<td>2 spawning sites</td>
<td>Spawning decision tree‡</td>
</tr>
<tr>
<td>Spawning cue flows</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Anticipated as Level 2 pilot projects focused on developing and evaluating high-quality spawning habitat.
† Spawning habitat implementation will be guided by the decision tree and associated decision criteria as described in the section below on spawning habitat.
‡ Pallid population modeling will be used to set minimum spawning flow needs; bird impacts and status may inform decisions regarding spawning cue flows below Gavin’s Point Dam in any particular year.

Decision Trees

- Successful fertilization, incubation, and hatch?
  - Yes
  - No

- Can free embryos survive turbulence?
  - Yes
  - No

- Can free embryos transition, feed in the thalweg?
  - Yes
  - No

- Is interception habitat limiting?
  - Yes
  - No

- Is food or foraging limiting?
  - Yes
  - No

Potential to implement:
- Reconfigure channel for spawning habitats
- Increase number of adults
- Manipulate flows and/or temperature for reproductive cues

Potential to implement:
- Decreased discharges to lower velocities
- Increase interstitial space in spawning substrates

Hypotheses

- Remove, bypass, Intake, Cartersville - drift
- Naturalize Ft. Peck – drift, cue, flow
- Drawdown Lake Sakakawea - drift

Targets & Decision Criteria
Governance Structure: Working Level

[Diagram showing the governance structure with levels and teams]

- MRRIC
- Agency Leadership (Oversight)
- Agency Management Team
  - Corps/USFWS
- Implementation Level
  - Bird Team
    - Corps/USFWS Implementation Staff
    - Bird PM
    - MRRIC Bird WG
  - Fish Team
    - Corps/USFWS Implementation Staff
    - Fish PM
    - MRRIC Fish WG
  - HC Team
    - Corps/USFWS Technical Staff
    - MRRIC PM
    - MRRIC HC WG
- Technical Team
Communication and collaboration among scientists, managers and stakeholders

This process map depicts the proposed governance activities to be undertaken annually by the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (USFWS), and the Missouri River Recovery Implementation Committee (MRRIC) in the implementation of Adaptive Management (SAM). Adjustments to the timing and details of specific activities may shift from year to year.
EA process yields 21 action hypotheses

Recognize 4 levels of implementation:
- **Level 1**: foundational science
- **Level 2**: field experimentation
- **Level 3**: initial implementation -> population response
- **Level 4**: full implementation

Science components address level 1 and level 2
- 74 components, 2016 – 2032

Levels 2-4: Hypothesis-driven monitoring (piloting updated concepts of channel reconfigurations):
- Implementation – action completed?
- Process, action effectiveness – ecological response?
- Population – growing, attaining the right size?
Pallid Sturgeon Decisions

- Find the right balance between science at Levels 1, 2 and 3 to improve understanding and actions at Levels 2, 3 and 4 to benefit sturgeon.
- Guide the evaluation of multiple lines of evidence on priority hypotheses and the effectiveness of actions.
- Guide decisions to move from L1 -> L2 -> L3 -> L4 in a logical sequence, or to adjust L3 / L4 actions.
- Clarify trade-offs across multiple factors to make better decisions.
- Provide a clear timetable for implementing L2 / L3 / L4 actions to help sturgeon, accelerate learning and motivate planning.
- Evaluate progress towards meeting species sub-objectives and targets.
- Reduce likelihood of adverse impacts to HC; facilitate rapid decisions.
Overall decision tree

**Overarching Decision Criteria**

For LMR Levels 1 and 2: *Have USFWS criteria or time limits been reached for triggering Level 3 implementation?*

- **No**

For Levels 1, 2 and 3: *Is there sufficient evidence to move to next Level of implementation?*

- **No**

For Levels 1 to 4: *Is there sufficient evidence to reject hypothesis and conclude action will definitely not work?*

- **Uncertain**

For Levels 2 to 4: *Is there sufficient evidence to conclude that action still has merit, but needs to be adjusted to be more effective?*

- **Yes**
  - **Yes**
    - **Move to next Level (i.e., L1 → L2; L2 → L3; or L3 → L4); NEPA process may be needed; revise hypotheses if required**
  - **No**
    - **Discontinue this action. Consider other options to improve survival; revise hypotheses**

- **No**
  - **Continue action, if necessary adjust monitoring or hypotheses**

- **Yes**
  - **Implement at Level 3 even if evidence of effectiveness uncertain**

**Decision**
## Decision Criteria for Moving from Level 2 to Level 3 (Table 22)

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

### Decision Criteria for Level 3 implementation

1. A "Yes" to all five questions triggers Level 3 implementation

2. A "Yes" to four of five, with an "Uncertain" for either #1 or #2 triggers a two-year clock to either reject the hypothesis or implement at Level 3
Simplified decision tree for Lower Missouri River

Potential to implement:
- Reconfigure channel for spawning habitats
- Increase number of adults
- Manipulate flows and/or temperature for reproductive cues

Potential to implement:
- Decreased discharges from Gavins Point to lower velocities
- Increase interstitial space in spawning substrates IF interstitial residency is validated.

Potential to implement:
- Reconfigure channel for interception

Potential to implement:
- Reconfigure channel to increase food-producing habitats

Potential to implement:
- Reconfigure channel to increase bioenergetically favorable foraging habitats

Look for other recruitment failure hypotheses
<table>
<thead>
<tr>
<th>Action Category</th>
<th>Time Limit*</th>
<th>Minimum Scope</th>
<th>Maximum Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population augmentation</td>
<td>Immediate</td>
<td>Current stocking rate as directed by USFWS Basin-wide Stocking and Augmentation Plan</td>
<td>Variable over time as directed by USFWS Basin-wide Stocking and Augmentation Plan</td>
</tr>
<tr>
<td>IRC habitat development</td>
<td>Stage 1: study phase (years 1-3 post-ROD)</td>
<td>Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr of suitable habitat, using staircase design(^1). Assess potential for refurbishing existing SWH sites as IRCs</td>
<td>Build 2 IRC sites per year (paired with control sites), adding 33,000 ac-d/yr(^1) of suitable habitat. Refurbish SWH sites in addition to study sites (rate TBD).</td>
</tr>
<tr>
<td></td>
<td>Stage 2 – continue study phase (years 4-6 post-ROD)</td>
<td>Stage 2 – continue study phase (years 4-6 post-ROD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stage 3 - Level 3 implementation (years 7-10 post-ROD)</td>
<td>Stage 3 - Level 3 implementation (years 7-10 post-ROD)</td>
<td>Continue assessing IRC sites and refurbishing new SWH sites, adding at least 66,000 ac-d/yr(^1) of suitable habitat. Determine required rate of Level 3 implementation based on stages 1 and 2.</td>
</tr>
<tr>
<td>Stage 4 – Level 4 implementation</td>
<td></td>
<td>Stage 4 – Level 4 implementation</td>
<td>Remove IRC habitat limitations to pallid sturgeon survival by implementation at Level 4.</td>
</tr>
<tr>
<td>Spawning habitat(^2)</td>
<td>2 years</td>
<td>1 spawning site</td>
<td>See decision tree in Figure 77</td>
</tr>
<tr>
<td>Spawning cue flows</td>
<td>9 years</td>
<td>Requirement for spawning cue flows (and appropriate scope) depends on the outcome of Level 1 and Level 2 monitoring and modeling studies during years 1-9.</td>
<td></td>
</tr>
</tbody>
</table>
### Interception / Rearing Habitat

#### Level 1

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>C1 Screening: limitations of food or forage habitats</td>
<td></td>
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<td>C2 Tech. dev. For IRC sampling, modeling, measurement</td>
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<td>C3 Field studies along gradients, food and forage habitats</td>
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<td>C4 Mesocosm studies: quantitative habitat – survival</td>
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#### Contingent upon outcome of C3

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<td>C5 Design studies for IRC experiments</td>
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<td>C6 Field expts. with IRCs and SWH (stages 1 and 2)</td>
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#### Implement IRC staircase design & SWH refurbishment

#### Level 3

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<td>Implement more IRCs if found to be successful (stage 3)</td>
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**Figure 3.** Geography of drift and dispersal. Presently available models indicate that a free embryo hatched at river mile 700 is likely to settle between river mile 290 on the Missouri River and 200 miles down the Middle Mississippi River.

**Figure 1.** Concept of an interception-rearing complex near river mile 162. Flow expansion is shown by modeled current velocity and direction (arrows) angled away from the main channel towards the right descending bank.
Power analysis evaluated ability to detect various increases in catch / effort (CPUE) over various time frames

**Bottom line:** Can detect 75% increase in CPUE over 7-year period with 12 treatment-control pairs, building 2 sites per year.
Staircase design for implementation of IRCs
[2 paired sites / year over 7 years]

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Initiation of Construction X
## Monitoring IRCs

<table>
<thead>
<tr>
<th>Level 2 / 3 Action</th>
<th>Implementation monitoring</th>
<th>Process monitoring</th>
<th>Population monitoring / modeling</th>
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<tbody>
<tr>
<td>IRC Habitat [H17, H18, H19]</td>
<td>- “effective acreage” (acre-days of available IRC habitat/year)</td>
<td>- habitat metrics based on measures of depths, velocities, substrate, habitat complexity</td>
<td>- survival of hatchery-reared first-feeding pallid sturgeon larvae in IRCs, refurbished SWH, thalweg, and to age 1</td>
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<tr>
<td>Metrics: sections 4.2.6.3.5 and 4.2.6.4.5</td>
<td>- trends in % SWH area with suitable habitat after refurbishment to IRCs</td>
<td>- CPUE and Pr (apparent presence) at meso-habitat and project level;</td>
<td>- population size structure analysis (length-frequency distributions of age-1+ fish)</td>
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<td>- production of food/area</td>
<td>- fish condition (% empty/full stomachs; genetics; lipid content; length frequency distribution of age-0 fish) and bioenergetics modeling</td>
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<table>
<thead>
<tr>
<th>Action</th>
<th>Question [Level, Location]</th>
<th>Methods of evaluating action effectiveness</th>
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<tr>
<td>Interception and Rearing Complexes (IRCs)</td>
<td>Do free embryos and exogenously feeding larvae leave the thalweg and enter IRCs? [L3, Lower]</td>
<td>Predicted fate of free embryos from advection/dispersion models. Testing of these predictions with field monitoring (see below). Before-After (BA), Before-After-Control-Impact (BACI) or Staircase design comparisons of IRC habitat sites with reference areas and times, using the metrics listed in section 4.4 (e.g., CPUE, probability of apparent presence, food production/area, condition, growth and survival of age-0 fish), and applying covariates to help explain year to year variation (e.g., index of upstream spawning success).</td>
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<tr>
<td>[H17, H18, H19]</td>
<td>Is there sufficient food in IRCs for exogenously feeding larvae to grow better and maintain a healthier condition than reference areas and times? [L3, Lower]</td>
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<td>Do age-0 fish that occupy IRCs survive better than age-0 fish in reference areas and times? [L3, Lower]</td>
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<td>What’s the population-level effect of improved survival of age-0 fish in IRCs? [L3, Lower]</td>
<td>Population model projections of the consequences of improved age-0 survival rates.</td>
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## Decision Criteria at Level 3 for IRCs

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<th>Level 2 / 3 Action [Hypothesis]</th>
<th>Decision Criteria / Questions</th>
<th>Answers</th>
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<td>Do free embryos and exogenously feeding larvae leave the thalweg and enter IRCs? [L3, Lower]</td>
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<td>Do age-0 fish that occupy IRCs have a higher survival probability than age-0 fish in reference areas and times? [L3, Lower]</td>
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<td>What’s the population-level effect of improved survival of age-0 fish in IRCs? [L3, Lower]</td>
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### Answers
- **Clearly NO.**
- **Likely NO.**
- **Inconclusive**
- **Likely YES.**
- **Clearly YES.**
Ten Enabling Characteristics for Effective Adaptive Management

1. Stakeholder engagement early and throughout
2. Clear articulation of objectives and program scope
3. Effects analysis to establish the best available science
4. Monitoring in an experimental framework
5. Identifying appropriate metrics and contingent decision criteria
6. Modeling to forecast outcomes from proposed management actions
7. Applying structured decision-making strategies to acknowledged trade-offs
8. Integrating human considerations into all aspects of risk assessment
9. Adaptive management governance structure and process
10. Independent scientific advice and review
Following slides are not part of the presentation but are available to help address questions.
Lessons Learned Review
Key Take-Aways

► **Role of AM** – The science and AM program must be integrated into how the overall recovery/restoration program does business in order to gain understanding and support, and effectively inform management decision-making. Learning must be a priority of the recovery/restoration program.

► **AM Approach** – Most restoration/recovery programs use a passive AM approach, with some active AM experiments to address critical uncertainties that limit achievement of program goals and objectives.

► **Stakeholder Involvement** – The definition of stakeholders differs from program to program, dependent upon funding sources and local and regional interests. The most important time for stakeholder engagement is during development of the AM Plan when the governance structure and collaborative processes are crafted; however, establishing ongoing opportunities for dialogue with stakeholders and including them in a shared decision-making process increases the probability of program success.
Governance Structure – While governance can generally be grouped into two different models, (i.e., 1) collaborative governance entity created for AM implementation and 2) implementing agencies serve as decision makers), each AM program has a slightly different approach to decision-making based on its particular circumstances. Stakeholders sit on a decision-making body in several programs, but the federal agency(ies) often retain ultimate decision-making authority. In all cases the governance structure employs the basic tenants of AM to establish opportunities to learn and adjust management actions over time. Several programs have considered or implemented adjustments to their governance structures to better meet program and stakeholder needs. Regardless of the governance structure there is a need for open communication within and among agency/stakeholder groups and extensive vetting leading up to decisions.

AM Champion – Successful AM programs have an internal agency staff member assigned to facilitate and implement the AM Plan and a clear designation of roles and responsibilities, and long-term commitment of other involved parties.
Management Questions – Identify the most important management questions and information needs up front, and using those questions to communicate program progress with managers, stakeholders, and other involved parties.

Linking Components of AM Plan – Clearly identify and link the essential components of an AM Plan, including objectives, constraints, uncertainties, management questions, management actions, decision criteria, monitoring, and research. Continuously reinforce those connections, especially to decision makers, so they understand the applicability of monitoring and research.

Decision Criteria – While the ultimate goal is to have decision criteria, few recovery/restoration programs have quantitative numeric decision criteria and/or triggers. Instead they rely on the best available science and professional judgment of subject matter experts to assess management action performance and determine whether adjustments to management actions need to be made. These AM programs are designed to provide information to define quantitative targets and triggers over time.
Ability to Translate Science into Management Recommendations

– Several AM programs have protocols for taking assessment reports prepared by scientific technical experts and translating this information into recommendations for management actions that can be easily be understood by decision makers and stakeholders. Ensure that there are reasonable expectations for reports to be generated.

Decision Making – Clearly define the decisions that need to be made, the processes for making them, timelines, and associated roles and responsibilities at the outset of the AM program. Ensure that the process is nimble enough to be responsive to new information and make necessary adjustments to management action implementation.
Corps History With AM

- Extensive practical experience with the general concept.
- Relatively little discussion of AM prior to ecosystem restoration authorities.
- Numerous institutional barriers and challenging factors.
- WRDA 2007
  - Sec. 2036
  - Sec. 2039
- AM Implementation Guidance
- Major ER Programs
  - CERP
  - UMRR
  - MRRP
  - LCA
USACE Adaptive Management Examples

Great Lakes
Lake Ontario - St. Lawrence River
Adaptive Management Initiative

Comprehensive Everglades Restoration Plan (CERP) Overview

Missouri River Recovery Program

Louisiana Coastal Area (LCA)
Ecosystem Restoration Program

Upper Mississippi River
Illinois Waterway

Navigation and Ecosystem Sustainability Program

Columbia River Channel Improvement Project
Role and Limitations of AM

- AM should be considered for all ER Projects
- Not all projects lend themselves to AM. Three elements must be present for AM to proceed:
  1. One or more critical uncertainty
  2. Ability to learn through monitoring
  3. Ability to make adjustments based on new knowledge
- Additionally, AM should afford a more cost-effective strategy than other alternatives (difficult to know \textit{a priori})
- Finally, institutional commitment is needed (see #3 above); this can be elusive for various reasons
Is Adaptive Management Needed?

**QUESTIONS**

Is there sufficient flexibility within the project design and operations that permits adjustment of management alternatives?

If No, adaptive management is not possible
If Yes, continue with questions

Is the managed system well understood and are management outcomes readily predictable?

Do participants agree on the most effective design and operations to achieve goals and objectives?

Are the project/program goals and objectives understood and agreed upon?

**ANSWERS**

Yes to all
Adaptive Management is not needed

No to any
Adaptive Management can probably improve success
Options for Addressing Uncertainty

- Do nothing – wait until uncertainty is reduced to acceptable levels
- Scaled implementation using AM to refine scope and scale as knowledge improves
- Full implementation, factoring uncertainty into the scope and scale of actions
Linkages

- Goals, Objectives & Constraints
- Management Actions
  - Success Criteria
  - Performance Measures
  - Action Criteria
  - Monitoring & AM Plan
  - Contingency Actions

Governance
LCA AM IMPLEMENTATION AND REPORTING PROCESS

State processes

Federal processes

Public Engagement & Communication

Program Management Team

Regional Science and Leadership Group

Adaptive Management and Assessment Implementation Team

Data Collection and Processing Team

Project Delivery Teams / Project Operators

Senior level leaders from both the State and MVN
Makes decisions on both project and program AM actions if necessary — Led by USACE and State AM Leads

Multi-agency/ multi-disciplinary group that meets annually to review the report card and make recommendations for AM actions if necessary — Led by USACE and State AM Leads

Monitoring data will be collected and processed, statistically analyzed and summarized into a format that can be incorporated into the report cards

Team led by a USACE and a State AM Lead. Will package recommendations of RSLG and report out to PMT

Team coordinates RSLG meetings, prepared project report cards, manages budget, and coordinates with management Creates Assessments reports for both project level and program level evaluations of monitoring

CPRA

MVN

LCA AM Planning Team

Establishes process and plans for project AM
Federal Processes for AM Decision Making

- **District Commander**
  - **Regional Integration Team**
    - YES: AM action within project plan/authority?
      - YES: Decision criteria exceeded and AM team recommends actions
        - YES: Continue implementing/operating. Monitor for 10 years or until Success is determined.
        - NO: District Commander makes decision and instructs PDT/Project Operators to modify project (implement AM authority) based on project authorization language.
      - NO: Does AM Team recommend adaptive action(s)?
        - YES: Regional Science and Leadership Group
        - NO: Adaptive Management and Assessment Team
          - Applies decision criteria, provides assessments, and solicits recommendation from RSLG regarding AM needs.

- **Science Advisor**
  - **Division Commander**
    - YES: Division Commander makes decision and instructs PDT/Project Operators to modify project (implement AM authority) based on project authorization language.
    - NO: Any changes to the AM plan approved in the decision document must be coordinated with HQ at the earliest possible opportunity.

- **Regional Science and Leadership Group**
  - **Science Advisor**
    - YES: Regional Science and Leadership Group
    - NO: Adaptive Management and Assessment Team
      - Applies decision criteria, provides assessments, and solicits recommendation from RSLG regarding AM needs.

- **Adaptive Management and Assessment Team**
  - YES: AM action within project plan/authority?
    - YES: Decision criteria exceeded and AM team recommends actions
      - YES: Continue implementing/operating. Monitor for 10 years or until Success is determined.
      - NO: Does AM Team recommend adaptive action(s)?
        - YES: Regional Science and Leadership Group
        - NO: Adaptive Management and Assessment Team
          - Applies decision criteria, provides assessments, and solicits recommendation from RSLG regarding AM needs.

- **Project Delivery Teams / Project Operators**
  - YES: AM action within project plan/authority?
    - YES: Decision criteria exceeded and AM team recommends actions
      - YES: Continue implementing/operating. Monitor for 10 years or until Success is determined.
      - NO: Does AM Team recommend adaptive action(s)?
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    - NO: Any changes to the AM plan approved in the decision document must be coordinated with HQ at the earliest possible opportunity.

- **HQUSACE**
  - **Division Commander**
    - YES: Division Commander makes decision and instructs PDT/Project Operators to modify project (implement AM authority) based on project authorization language.
    - NO: Any changes to the AM plan approved in the decision document must be coordinated with HQ at the earliest possible opportunity.

- **Annual budget guidance to initiate a study for corrections should be followed.**

- **Possible reexamination under other authorities.**
What are the benefits of AM?

- Provides a precautionary approach to act in the face of uncertainty
- Improved probability of project/program success
- Incorporates flexibility and robustness into project/program design, implementation, and operations
- Process of developing an AM plan inevitably improves the plan formulation process & products
- Promotes collaboration and conflict resolution among agencies and stakeholders, scientists and managers while empowering all the above groups
- Moves the state of science and understanding of ecosystem restoration forward in a deliberate way
- Can improve cost effectiveness
Required Mindset for AM

- Be honest about uncertainties and tackle them head-on
- View choices/management actions** as ‘treatments’ to be tested
- Make a commitment to learning
- Mistakes are not all bad – they enhance learning
- Expect surprises and learn from them
- Encourage creativity and innovation
- Start small; build on successes

** ....where actions can include various management actions related to allocation, restoration, levels and patterns of disturbance, as well as policy-oriented measures related to permitting, incentives, and financing, among others.
Lessons from a Practitioner

- AM has a critical planning component that requires careful consideration of uncertainties and outcomes; it is not strictly a post-construction consideration
- Development of an AM plan is as much about the process as it is the product
- Not all projects or programs lend themselves to AM
- Governance is crucial and may be difficult to assure for some projects and programs
- Cost estimates are complicated by uncertainties
- Refinement during PED is likely, and flexibility in implementation is probably needed
- Successful efforts typically have an AM “champion”
Site-Specific Project Implementation

**INITiate**
- Year 1
- STRATEGIC PLAN → NEED
  - Quantity
  - Approx Location
  - Improvements

**PLan**
- Year 1 or 2
- SITE SELECTION PROCESS
- ENGINEERING & DESIGN
- SITE-SPECIFIC REGULATORY REQUIREMENTS
- PUBLIC COMMENT (& public meetings as appropriate)

**EXECute**
- Year 2 or 3
- CONSTRUCTION

**MONitor**
- Years 3 +
- BIOLOGICAL
- PHYSICAL
- RESULTS → FALL SCIENCE MEETINGS

**EXAMPLE FOR ONE PROJECT**
meanwhile, other projects are also being implemented

Next Cycle Starts: New Project

Strategic Plan

MRRIC Recommendation

AM Annual Report

AM Workshop

Fall Science Meeting
Focus of SP Update Process

- **CFY**
  - Minor adjustments based on appropriations

- **FY+1**
  - Minor adjustments based on new information and P-bud

- **FY+2**
  - Management actions, research and other studies or activities needed to meet objectives;
  - Developed at level of detail for budgeting purposes

- **FY+3**
  - Adjustments to former FY+4 strategic plan based on current projections
  - Updated risk management measures and priorities

- **FY+4**
  - New FY added to the strategic plan based on current projections
  - Risk management measures and priorities
Science Update Process

**Fall Science Meeting**

*Species (and HC) Teams* discuss initial results and findings
Researchers participate

**Adaptive Management Workshop**

*Researchers* present findings
*Technical Team* presents draft AM Report
*ISAP(/ISETR)* participation and initial evaluation of draft AM report
*Species (and HC) Teams* discuss monitoring and research results, including species and HC; develop initial recommendations for Annual Work Plan (informed by President’s Budget)
Annual Forum Webinar
Summarize AM Workshop and Final AM Report
Summarize ISAP review and Species (HC) Team recommendations

Draft Annual Work Plan Review Webinar
Management Team presents Annual Work Plan

MRRIC Annual Work Plan Recommendation Meeting
MRRIC plenary development of Annual Work Plan recommendations

MRRIC Meeting(s) (Topics Vary)
MRRIC plenary discussions of longer-term recommendations, HC, programmatic changes, etc.
Model applications

- Basic model behavior
- Model validation
- Effects of management actions
- Interactions of effects
- Comparison of management alternatives
- Effects of natural variability and extreme events
Quantitative decision criteria

- Increase likelihood of meeting targets under uncertainty
- Reduce likelihood of adverse impacts
- Make trade-offs explicit
- **Make scientific findings actionable**
- Increase efficiency of resource use
- Facilitate decisions that must be made quickly
- Provide justification for actions
- **Account for multiple factors in single decisions**
Decision criteria examples

If combined releases plus tributary flows exceed flood thresholds (71kcfs at Omaha, 82kcfs at Nebraska City, or 126kcfs at Kansas City), releases are decreased by 5 kcfs increments until downstream flow criteria are met or the release falls below 45 kcfs, at which point it is terminated.

If use of vegetation managed sandbars is less than 50% and/or fledgling production less than 80% that of new/unvegetated sandbars, use of methodologies should be reevaluated and discontinued if they cannot be improved to comparable levels.
Model Framework

1-D system model with embedded multi-dimensional models to inform/parameterize the systems models.

Long-term improvement strategy
SIMPLIFIED MODEL INTEGRATION WORK FLOW
Example for flow alternative downstream of Gavins Point

-period of record hydrologic flow data input to all ResSim and RAS models

NOTE 1: Missouri River trib ResSim (Kansas, Osage and Chariton) may not be necessary to run most alternatives.

NOTE 2: Red arrows with question marks indicate unknown plug-in capability in WAT.

Period of Record Hydrologic Flow

Connection uncertain. May be separate WQ RAS geometry

Multiple TUFLOW and ADH Models

Hydropower

Interior Drainage (EFM)

IMPLAN (Regional Econ)

RECONS (Regional Econ)

SIMPLIFIED

Yellowstone RAS Water Quality

MAINSTEM ResSim

OMAHA RAS REACH

KANSAS CITY RAS REACH

KANSAS ResSim

CHARITON ResSim

OSAGE ResSim

ESH Model

FIA

EFM

SEDIMENT/GEOM ORPH

BIRD MODELS

WATER QUALITY (RAS)

PALLID MODEL

Hydropower

Interior Drainage (EFM)

IMPLAN (Regional Econ)

RECONS (Regional Econ)

Multiple TUFLOW and ADH Models

CEQUAL-W2 (Water Quality)

FIA

EFM

2-D Models

Yellowstone RAS Water Quality

PALLID MODEL

WATER QUALITY (RAS)

PALLID MODEL

Sed/Geom

AVAIL WATT PLUG-INS

ResSim

RAS

BIRD MODEL

ESH Model

2-D Models

Human Handling Required

Multiple TUFLOW and ADH Models

Connection uncertain. May be separate WQ RAS geometry

Water Quality

Period of Record Hydrologic Flow

Connection uncertain. May be separate WQ RAS geometry
Terns and Plovers

- Reasonably well-understood relationships between habitat and population response
- Other factors contribute to productivity
- Flows to create/sustain habitat remain a critical uncertainty
Examples of preliminary results

**Habitat construction effort**

- No build
- Build

**Actions that increase egg/chick survival**

- No build
- Build

**Frequencies of habitat-forming flows and amount of habitat created**

- No build
- Build

**Habitat construction interacting with flow**

- All Flows
- Low Flows
- High Flows
Advection/dispersion Model Free-embryo Drift

Destination = function of distance, drift velocity, (mostly f(water velocity, discharge), development (= f(temperature)))

- At $T_{50} = 18C$, yolk plug expelled at 240 hours
  - 10 days immediate drift
  - Or 5 days drift with interstitial hiding
- AT $T_{90}$, yolk plug expelled at 216 hours
  - 9 days intermediate drift
  - Or 4 days drift with interstitial hiding

$Q_{50}$ Ft. Peck

\[\text{Concentration} \quad \text{Ft. Peck Dam} \quad 12h \quad 24h \quad 36h \quad 48h/168h \quad 72h/192h \quad \text{Yellowstone Confluence} \quad \text{High Sak} \quad 96h/216h \quad 120h/240h \quad \text{Low Sak} \quad \text{River Kilometer} \]
For every complex problem there is an answer that is clear, simple, and wrong.

- H. L. Mencken (1917)
Synthesis: Best Available Science Based on Lines of Evidence and Model Projections

- Evidence from:
  - Focused research
  - Past implementation of management actions
  - Natural flow events
  - Evidence from similar systems

- Model predictions
  - General effects
  - Results for defined cases
## Criteria for advancing sturgeon actions

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

### Criteria for Level 3 implementation

1 - A "Yes" to all five questions triggers Level 3 implementation

2 - A "Yes" to four of five, with an "Uncertain" for either #1 or #2 triggers a two-year clock to either reject the hypothesis or implement at Level 3
Generic AM cycle

Step 5a: Complete
Step 5b: Adjust
Step 5c: Continue
Step 1: Plan / Design
Step 2: Implement
Step 3: Monitor
Step 4: Evaluate

Reformulate/Analyze Tradeoffs
Select Adaptive Actions in AM Plan
Deciding what to build and where
Working within opportunities and constraints
Implementation—contracting and construction
Monitoring habitat and birds
Research
Assessment and evaluation of habitat and bird status and trends
Evaluation—current status and need to act

- How much ESH acres and birds are out there now?
  - Monitoring results
  - Model projections
  - Field observations
  - Anything unusual?

- Comparison to targets
Evaluation—using learning

► How much habitat is needed? Where?

Learning: effects of flow on erosion, nesting success of birds, etc.

► What are the constraints? Are there enough resources?

Learning: efficiency of construction, ways to improve habitat quality

► How do different management options compare?

Learning: effects of construction methods, methods to improve quality and longevity of habitat, improved models to compare options
Types of Decisions

- Same actions, same extent
- Same actions, different extent
- Different actions within current set
- Add or remove actions from current set
- Change targets and/or objectives

Governance/Engagement

Adjust
Continue
Decision examples

- Have enough budget to build everything needed: build 200 acres in Gavins Point Reach and 150 acres in Garrison

- Don’t have enough money: build 120 acres in Gavins

- Do nothing this year, but need to construct next year
Implement and Monitor (and research)

Implementation:
- contracts and construction

Monitoring and research
- Designed specifically to meet evaluation needs and address information gaps
Programmatic evaluation

- Revisiting actions, objectives, targets
- Triggered by learning over time that current management is not working as expected or constraints preclude success
- OR that management is working better than expected and can be adjusted

Change targets and/or objectives
Add or remove actions from current set
Different actions within current set
Same actions, different extent
Same actions, same extent

5/19/2015

Acres

Year
Problem Context
- What is the problem that needed to be addressed?
- Why does addressing the problem matter (to decision makers, scientists, and/or stakeholders)?
- What is the history of development for Adaptive Management / overview of the program (status, key issues, scientific uncertainties, key participants, etc.)?
- What is the regulatory context / drivers for AM development and ongoing management?

Solutions
- How is the problem being addressed? What was done (related to developing objectives, funding, monitoring/assessment, triggers/thresholds, governance, transparency/inclusion, stakeholder engagement and buy-in)?
- How were Adaptive Management steps, AM tools, or AM principles used to address the challenge?
- What were some of the challenges that were encountered and how were they overcome?

Results
- What were the outcomes from applying these solutions?
- What were some of the benefits / costs of applying AM?
- How has AM held up over time?

Lessons Learned
- What are some transferable lessons for others (i.e., do’s and don’ts of applying AM)? Why?