Evaluating effects of actions across a range of uncertainty: approaches to evidence assessment in the Missouri River Recovery Program

KATE E. BUENAU¹, ROBERT B. JACOBSON², RONALD M. THOM¹

¹Pacific Northwest National Laboratory, Sequim, WA, USA
²U.S. Geological Survey, Columbia, MO, USA

Conference on Ecological and Ecosystem Restoration
New Orleans, LA
Missouri River Recovery Program

Three ESA listed species:
- Least tern, interior population listed as endangered in 1985
- Piping plover, listed as threatened in 1986
- Pallid sturgeon, listed as endangered in 1990

Biological Opinion in 2000, revised 2003, on operation of the mainstem dams and reservoirs by the U.S. Army Corps of Engineers
- Sakakawea
- Fort Peck
- Oahe
- Sharpe
- Francis Case
- Lewis & Clark

- Six Corps reservoirs
- Mainstem storage: 91 km$^3$
- Dams: 10 GWh peak generating capacity
- Other storage: 40 km$^3$

(National Map, 2006)
Missouri River Recovery Program

Management focused on:
- constructing habitat for all three species
- pallid sturgeon propagation
- protection of nesting birds from predators, people, and inundation

Adaptive management strategies started in 2008

Effects Analysis: key questions

- What needs to be done to avoid *Jeopardy* to the three species?
  - Are current actions effective?
  - If so, how should they be applied?
  - If not, what other actions are needed?

- Where are the critical uncertainties?

- What research and monitoring is needed for successful adaptive management?
Effects Analysis: general approach
Effects Analysis: general approach

Phase 1

- CEMs, concepts
- Information Evaluation
  - Hypotheses Evaluation
  - Working Population Effects Model
  - Population Effects Report

Phase 2

- Research
  - Design Monitoring, Assessment, Research
  - Adaptive Management Design Report

Phase 3

- Implement
  - Monitor
  - Assess
  - Documents, Reporting

Key

- CEM, Hypothesis Processes
- USACE, PDT Action
- Information Gathering
- Modeling Process
- Document, Deliverable
- AM Design Process
- Hypothesis Reserve

September 17, 2014
Tern and plover background

- Least terns and piping plovers nest on emergent sandbars and reservoir shorelines
- River management has limited the amount of habitat available
- Habitat created during high flow in 1997 and 2011 flood
- Need a plan to support a resilient population in a highly variable environment
The pallid sturgeon (*Scaphirhynchus albus*) is a very rare fish in a very large, muddy river

Listed in 1990 as endangered

No discernible recruitment in upper or lower Missouri River

Population: several thousand, highly uncertain

Life-stage processes mostly unobservable

Demographic rates are highly uncertain

Limiting habitats unknown
## Action Effectiveness Factors and Relative Uncertainty

<table>
<thead>
<tr>
<th>Factors in determining action effectiveness</th>
<th>Piping Plover</th>
<th>Least Tern</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural uncertainty (what is limiting the population?)</strong></td>
<td>Low</td>
<td>Low – Medium</td>
</tr>
<tr>
<td><strong>Information about demographics</strong></td>
<td>Moderate to good data from Missouri River</td>
<td>Limited data from Missouri River, limited data from other areas</td>
</tr>
<tr>
<td><strong>Observability of cause and effect:</strong></td>
<td>High, with sufficient monitoring</td>
<td>High, with sufficient monitoring</td>
</tr>
<tr>
<td>Action → species response</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Time lag of population response to habitat change</strong></td>
<td>1-3 years</td>
<td>3-6 years</td>
</tr>
<tr>
<td><strong>Habitat complexity</strong></td>
<td>Low</td>
<td>Low-Medium</td>
</tr>
<tr>
<td><strong>Spatial complexity</strong></td>
<td>Low</td>
<td>Low</td>
</tr>
</tbody>
</table>
### Action Effectiveness Factors and Relative Uncertainty

<table>
<thead>
<tr>
<th>Factors in determining action effectiveness</th>
<th>Piping Plover</th>
<th>Least Tern</th>
<th>Pallid Sturgeon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural uncertainty (what is limiting the population?)</td>
<td>Low</td>
<td>Low – Medium</td>
<td>High</td>
</tr>
<tr>
<td>Information about demographics</td>
<td>Moderate to good data from Missouri River</td>
<td>Limited data from Missouri River, limited data from other areas</td>
<td>Some data but high uncertainty range; largely unobservable</td>
</tr>
<tr>
<td>Observability of cause and effect: Action → species response</td>
<td>High, with sufficient monitoring</td>
<td>High, with sufficient monitoring</td>
<td>Low to very low</td>
</tr>
<tr>
<td>Time lag of population response to habitat change</td>
<td>1-3 years</td>
<td>3-6 years</td>
<td>Multiple decades</td>
</tr>
<tr>
<td>Habitat complexity</td>
<td>Low</td>
<td>Low-Medium</td>
<td>High</td>
</tr>
<tr>
<td>Spatial complexity</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Conceptual Ecological Models: Plovers
Effects Analysis Process: State of Science

- Literature and model review
- Assessment of data availability and potential for analysis
- 101 plover references, 60 tern references, summarized in tables
- Opportunity for new data analysis to address bird-habitat relationships

Sturgeon: more challenging
- Large literature
- Large data sets
- Significant data gaps between habitat and population

Cumulative number of scientific titles related to pallid sturgeon
### Hypothesis complexity

<table>
<thead>
<tr>
<th>Effects Analysis elements</th>
<th>Piping Plover</th>
<th>Least Tern</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of conceptual models</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Number of global hypotheses</td>
<td>Tens</td>
<td>Tens</td>
</tr>
<tr>
<td>Number of dominant hypotheses</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Number of potential management actions</td>
<td>18</td>
<td>17</td>
</tr>
<tr>
<td>Number of management actions initially considered</td>
<td>15</td>
<td>14</td>
</tr>
</tbody>
</table>
## Hypothesis complexity

<table>
<thead>
<tr>
<th>Effects Analysis elements</th>
<th>Piping Plover</th>
<th>Least Tern</th>
<th>Pallid Sturgeon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of conceptual models</td>
<td>1</td>
<td>1</td>
<td>10 (5 life stages x 2 regions)</td>
</tr>
<tr>
<td>Number of global hypotheses</td>
<td>Tens</td>
<td>Tens</td>
<td>Thousands</td>
</tr>
<tr>
<td>Number of dominant hypotheses</td>
<td>12</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>Number of potential management actions</td>
<td>18</td>
<td>17</td>
<td>53</td>
</tr>
<tr>
<td>Number of management actions initially considered</td>
<td>15</td>
<td>14</td>
<td>21</td>
</tr>
</tbody>
</table>
EA process: Bird models

EA process: Sturgeon models

Model Management to Functional Habitats

Model Population Sensitivity

Reasonably robust models

Upper basin Pallid Sturgeon CEM
Conservation & Developing Embryos
Lines of Evidence – Pull all of the above together with other evidence... synthesis step

• Lines of evidence include:
  • **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

• Information and understanding should be:
  • **Realistic** – does it make sense?
  • **Sensitive** to actions or changes in drivers – does it measure a change?
  • **Predictive** – does it provide for useful prediction of future or independent observations?
Summary

► Plovers and terns: relatively high knowledge in a variable environment
  ■ Important relationships understood
  ■ Models link habitat to population
  ■ Focus on refining ability to design optimum restoration actions
  ■ AM will help determine how and when to act

► Sturgeon: significant data gaps in complex system
  ■ Model management effects on habitat
  ■ Model population sensitivity
  ■ Plan around key uncertainties (i.e., structured decision making process)
  ■ AM critically important for experimentation and learning

► Complex science in a short time frame
  ■ Stakeholder communication and engagement
  ■ Balancing need for prompt decisions with complexity of system
Potential Applications to other Systems and Programs

- Missouri River Effects Analysis provides a robust example of application of state of the science to structured decision making on a large river.

- The EA is going to provide an example of evaluating trade-offs between management strategies for different species, as well as trade-offs with human considerations.

- Approaches for dealing with a range of uncertainty in the same system and through the same process demonstrates tools for:
  - Identifying key interactions and hypotheses from a large universe of relationships
  - Adapting the scientific process to meet both short and long term decision making needs
  - Carrying out a transparent process with frequent management, stakeholder, and advisory panel interaction and feedback
Thank you!

Bird Effects Analysis
Kate Buenau, PNNL
kate.buenau@pnnl.gov
Chris Vernon, PNNL
Val Cullinan, PNNL
Coral Huber, USACE
Carol Aron, USFWS
Jane Ledwin, USFWS
Carol Smith, USFWS
Todd Swannack, USACE-ERDC
Dan Catlin, Virginia Tech
Jim Fraser, Virginia Tech

Sturgeon Effects Analysis
Robert Jacobson, USGS
rjacobson@usgs.gov
Michael Parsley, USGS
Michael Colvin, Oregon State
Mandy Annis, USGS
Tim Welker, USACE
Dan James, USFWS

Craig Fischenich, USACE-ERDC; USACE: Craig Fleming, Aaron Quinn, Joe Bonneau, Mark Harberg