

Integrated Management of Invasive Fishes in Some U.S. Ecosystems: Past, Present, and Possible Future Management (with Special Reference to Barriers)

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U.S. Fish and Wildlife Service



Presentation Outline

- Integrated Management of:
 - Sea Lamprey (includes barriers)
 - Asian Carps
 - Upper Mississippi River System (evaluation of barrier options)
 - Chicago Area Waterway System – electrical barriers
 - To Protect the Great Lakes
 - Technologies being developed & tested

Definitions

- Barrier = 100% effective at blocking passage of the subject species
- Deterrent = system that impedes passage of the subject species, but is not 100% effective at blocking passage

Integrated Management of Sea Lamprey in the Great Lakes

Great Lakes Fishery Commission

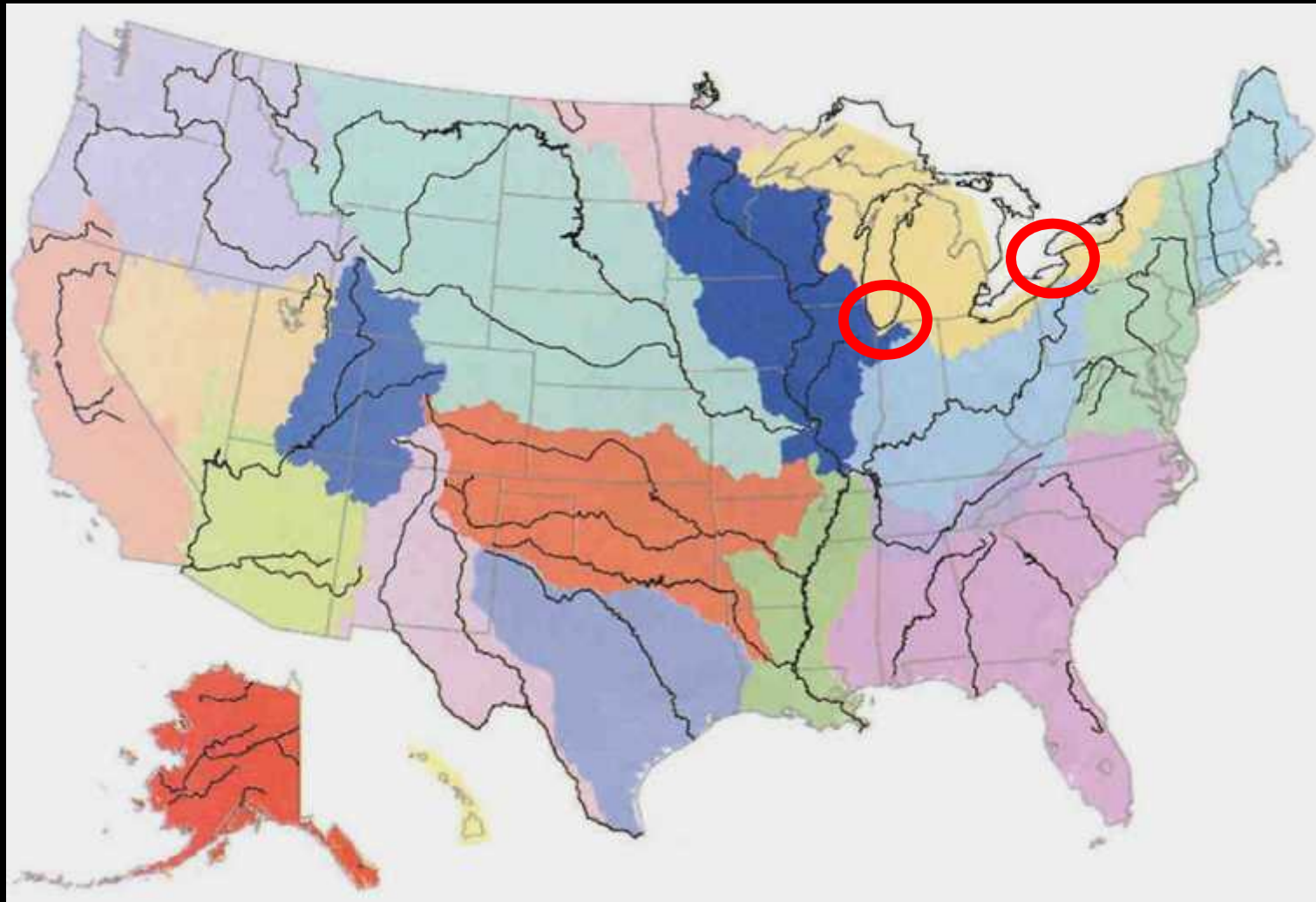




Integrated Management of Sea Lampreys in the Great Lakes

- Invasion of sea lampreys
- Establishment of control program
- Sea lamprey management today

Canals Connecting Naturally Unconnected Basins



Welland Canal



Spread of Sea Lamprey 1938

Superior

St. Lawrence Riv

Lake Huron

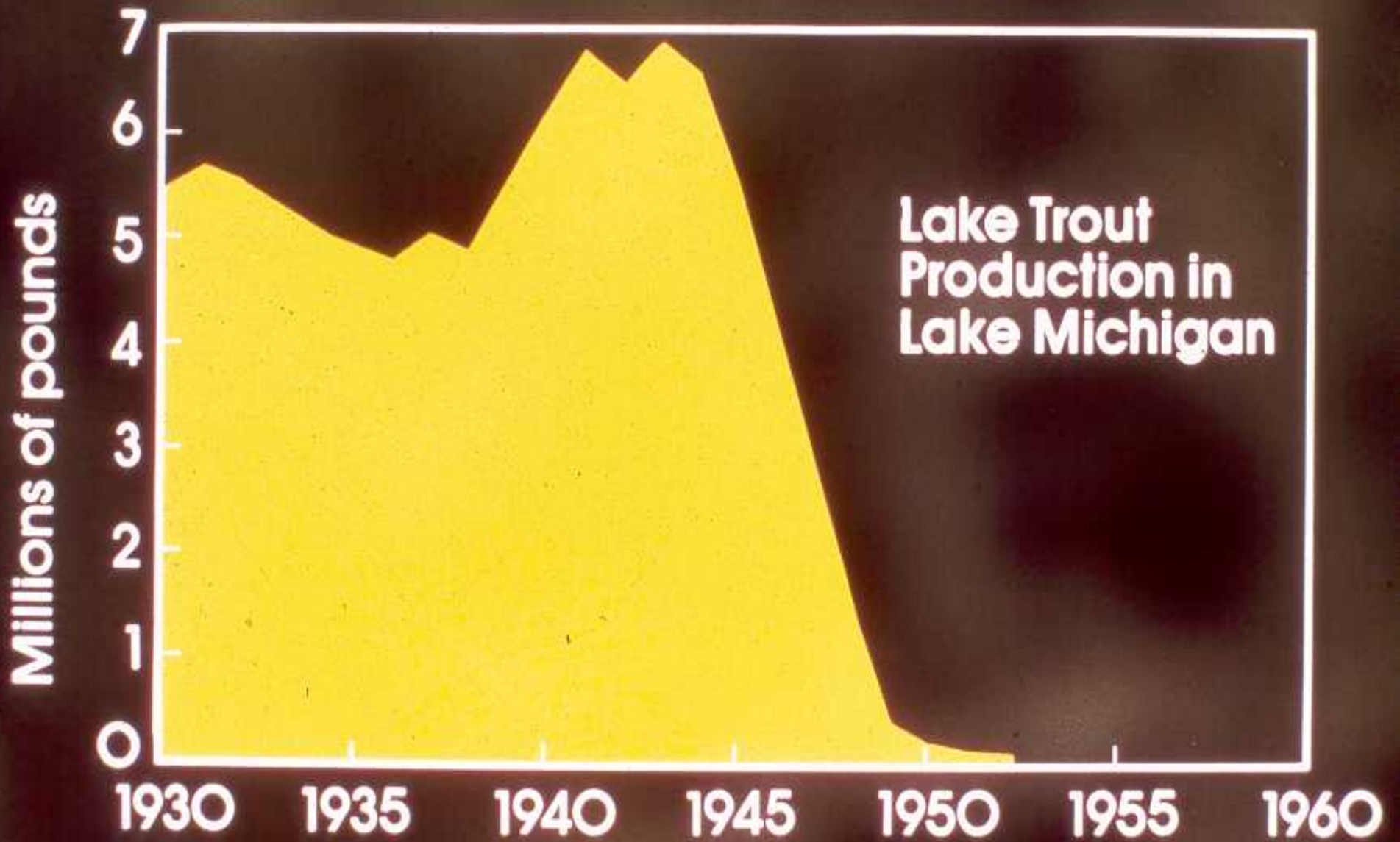
Lake Michigan

Lake Ontario

Lake Erie







Great Lakes Fishery Commission

- Established 1955 by Convention on Great Lakes Fisheries
- U.S. & Canada Contracting Parties
- 3 General Duties

Great Lakes Fishery Commission: Responsibilities

- Conduct Sea Lamprey Control
- Coordinate Fisheries Research
- Coordinate Fisheries Management

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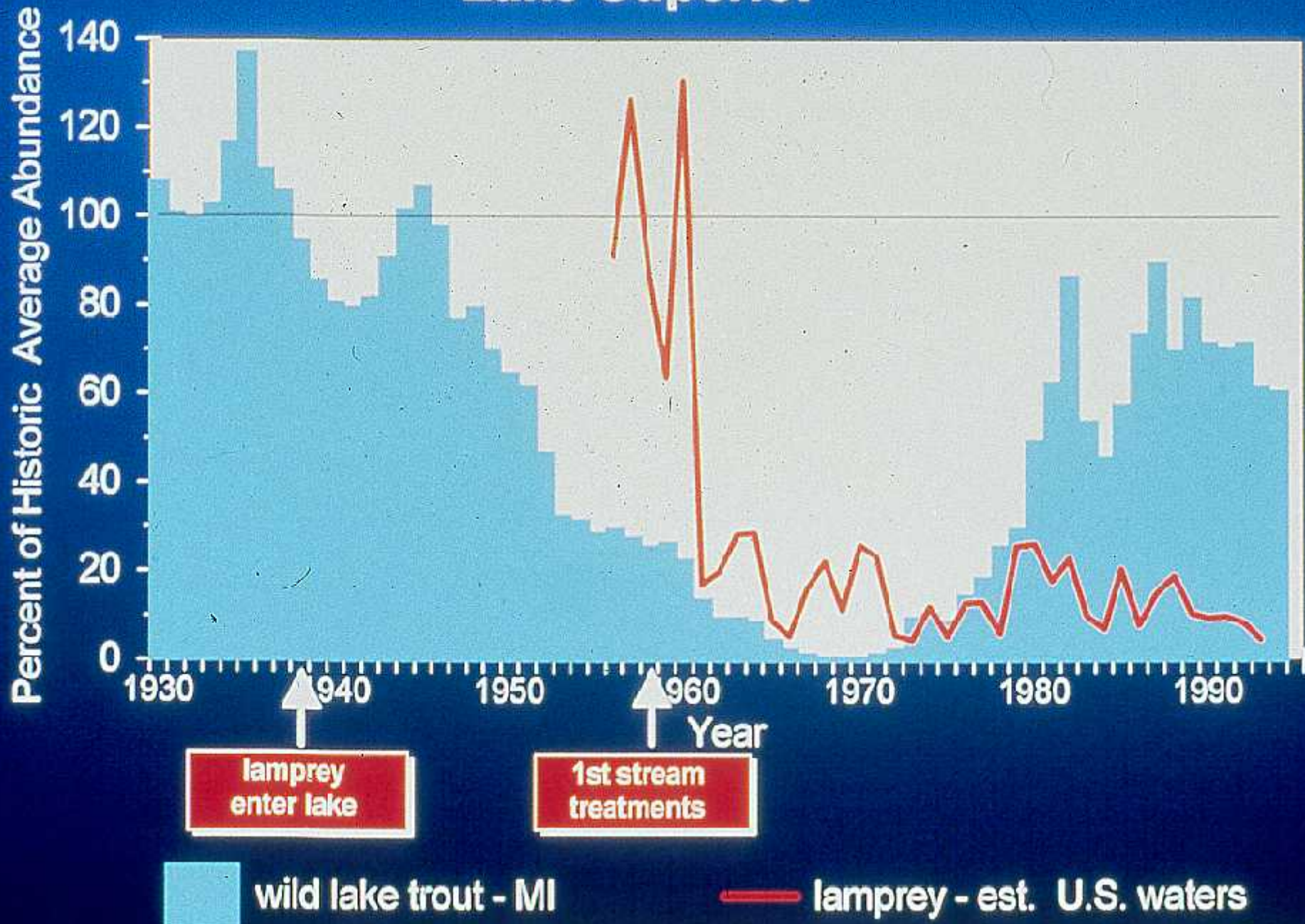


Chemical Control





Lake Superior



Integrated Management of Sea Lamprey in the Great Lakes

- Invasion of sea lampreys
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MAJOR SEA LAMPREY CONTROL METHODS

In the Great Lakes



Lampricide
(TFM)



Sea Lamprey
Barriers and
Trapping

Asian Carp: Risk to the Upper Mississippi River System and Great Lakes



Asian Carp Invaders

Bighead carp



Photo: D. Riecks

Silver carp



Photo: L. Lovshin

Black carp

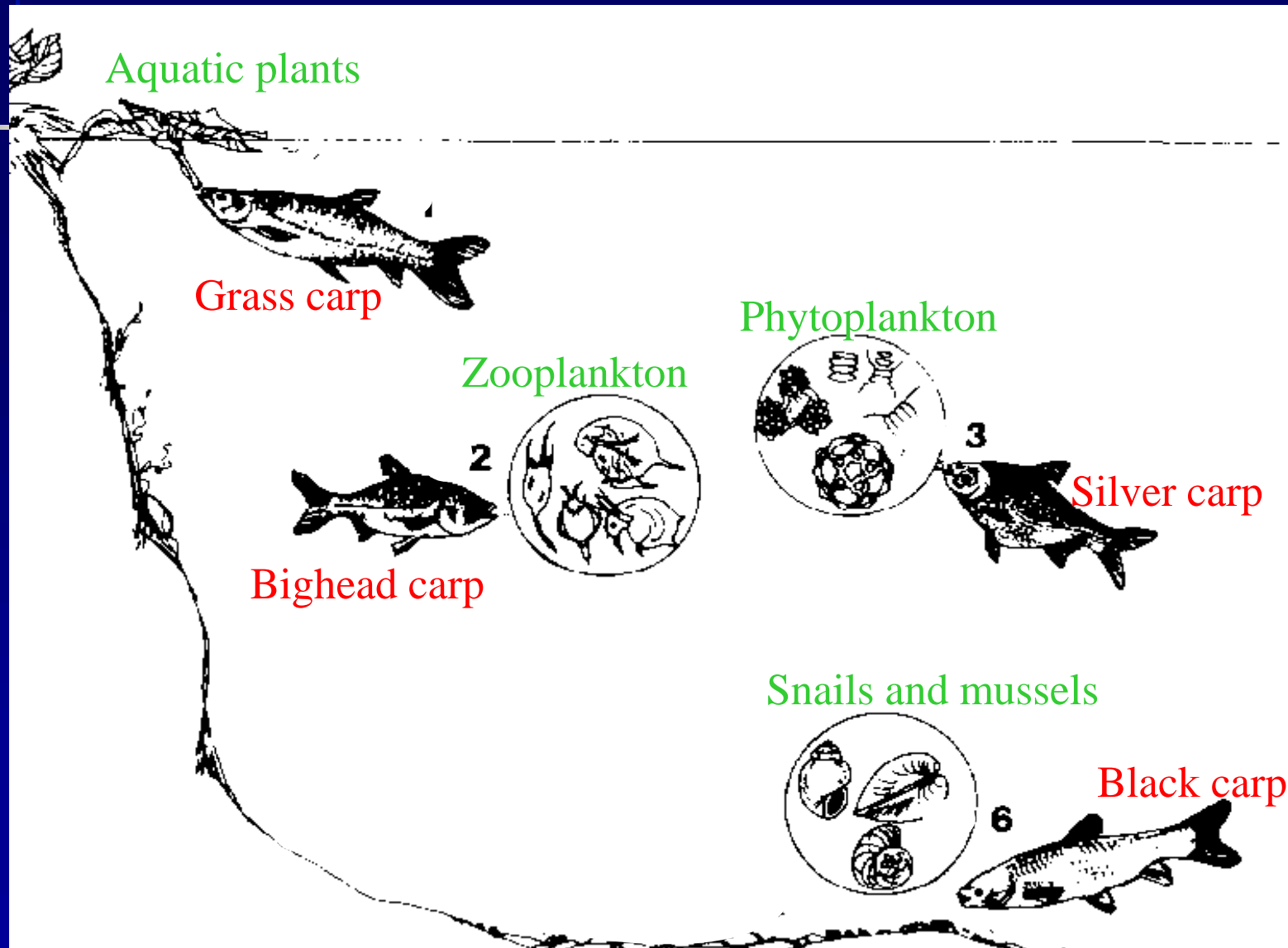


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Grass carp



Feeding niches of grass, bighead, silver, and black carp. All four species will cause food-web disruption. (from Bardach et al.)



Feasibility Study to Limit the Invasion of Asian Carp into the Upper Mississippi River Basin

(Final Report – March 15, 2004)

Prepared for the Minnesota DNR in cooperation with
the Wisconsin DNR and the U.S. Fish and Wildlife Service (Region 3)



Prepared By:



With Assistance From:



Feasibility Study Purpose

Evaluate feasibility of limiting the spread of Asian carp into the Upper Mississippi River Basin

Feasibility Study Supporters

- Funding provided by
 - Minnesota Department of Natural Resources
 - Wisconsin Department of Natural Resources
 - U.S. Fish and Wildlife Service
- Cooperation and technical support by many agencies

Feasibility Study Scope of Work

- Evaluate potential and available technologies that may be effective in limiting or stopping the northward movement of Asian carps into the Upper Mississippi River

Feasibility Study Recommendations

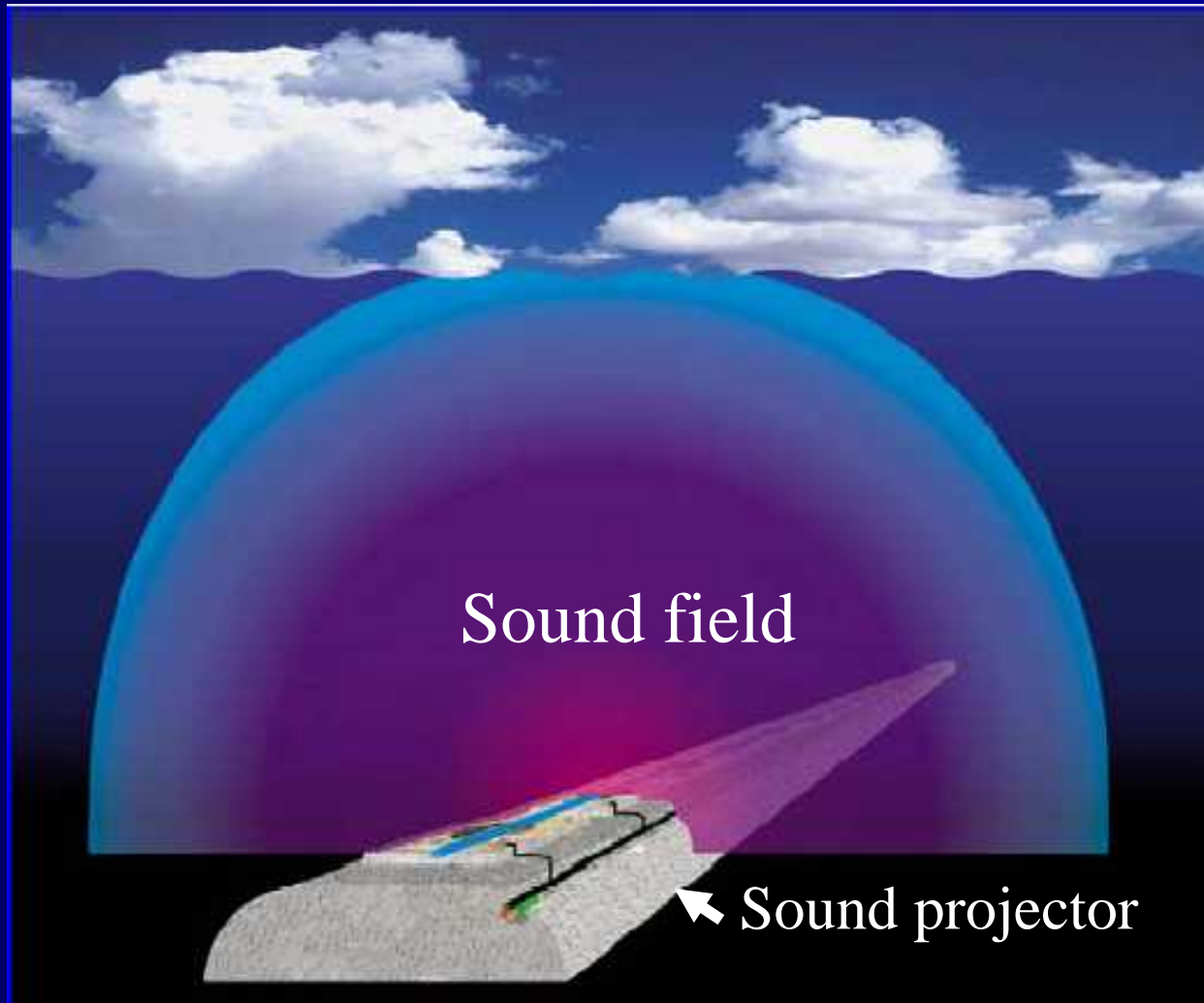
- Recommendations include strategies relating to
 - Education
 - Research and Monitoring
 - Regulation and Enforcement
 - Management
 - Develop and implement a National Management and Control Plan
 - Ecological Risk Assessment
 - Complete
- Install Barriers and/or Deterrents

Evaluation of Barrier Alternatives

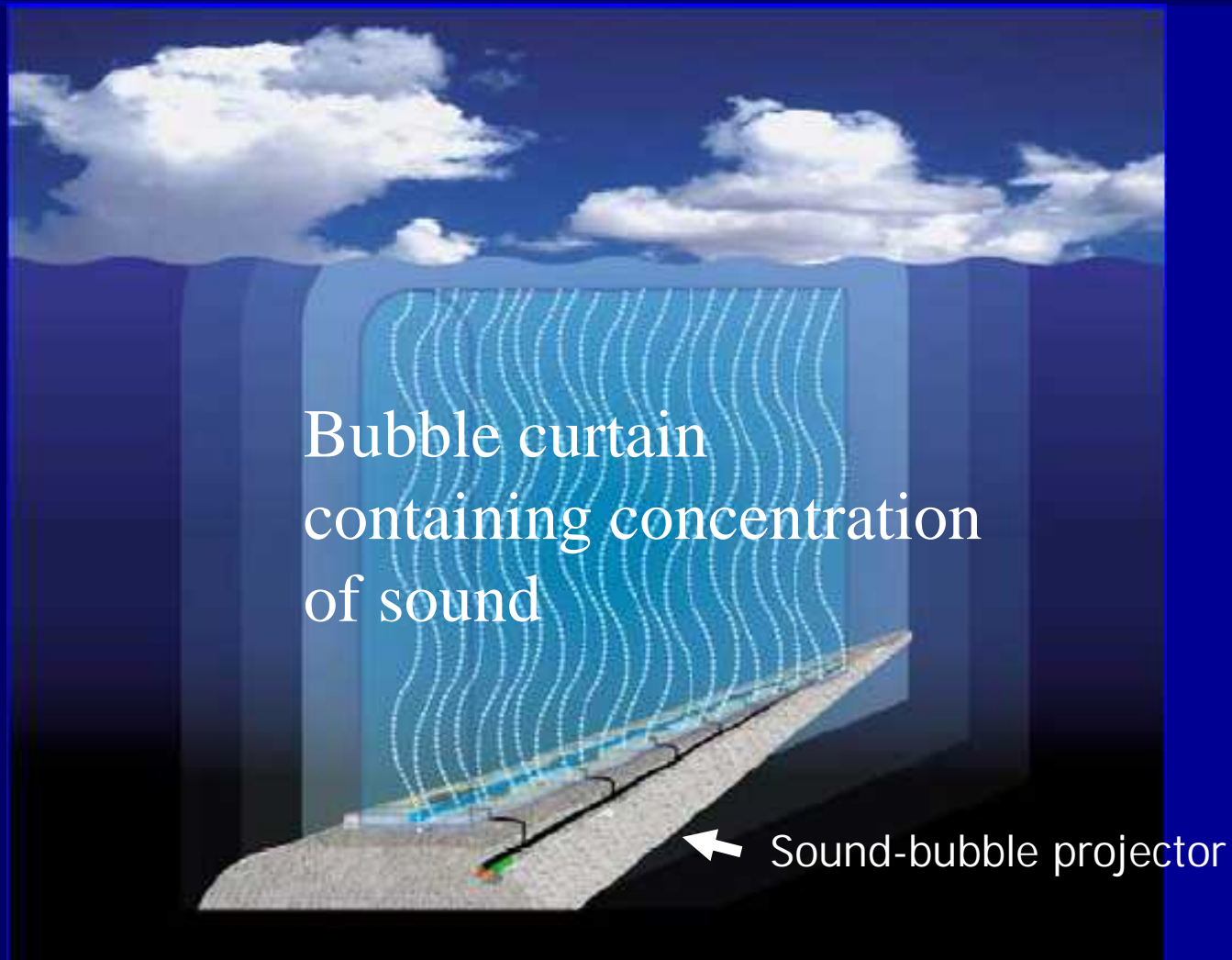
- Barriers and Deterrents

- 16 types considered
- Alternatives were evaluated in relation to:
 - Barrier Efficiency (from literature)
 - Probable Risk of Failure of technology
 - Navigation impact
 - Construction and implementation complexity
 - Operation and maintenance issues
 - Safety concerns
 - Cost

Sound Projector Array (SPA) showing multidirectional transmission



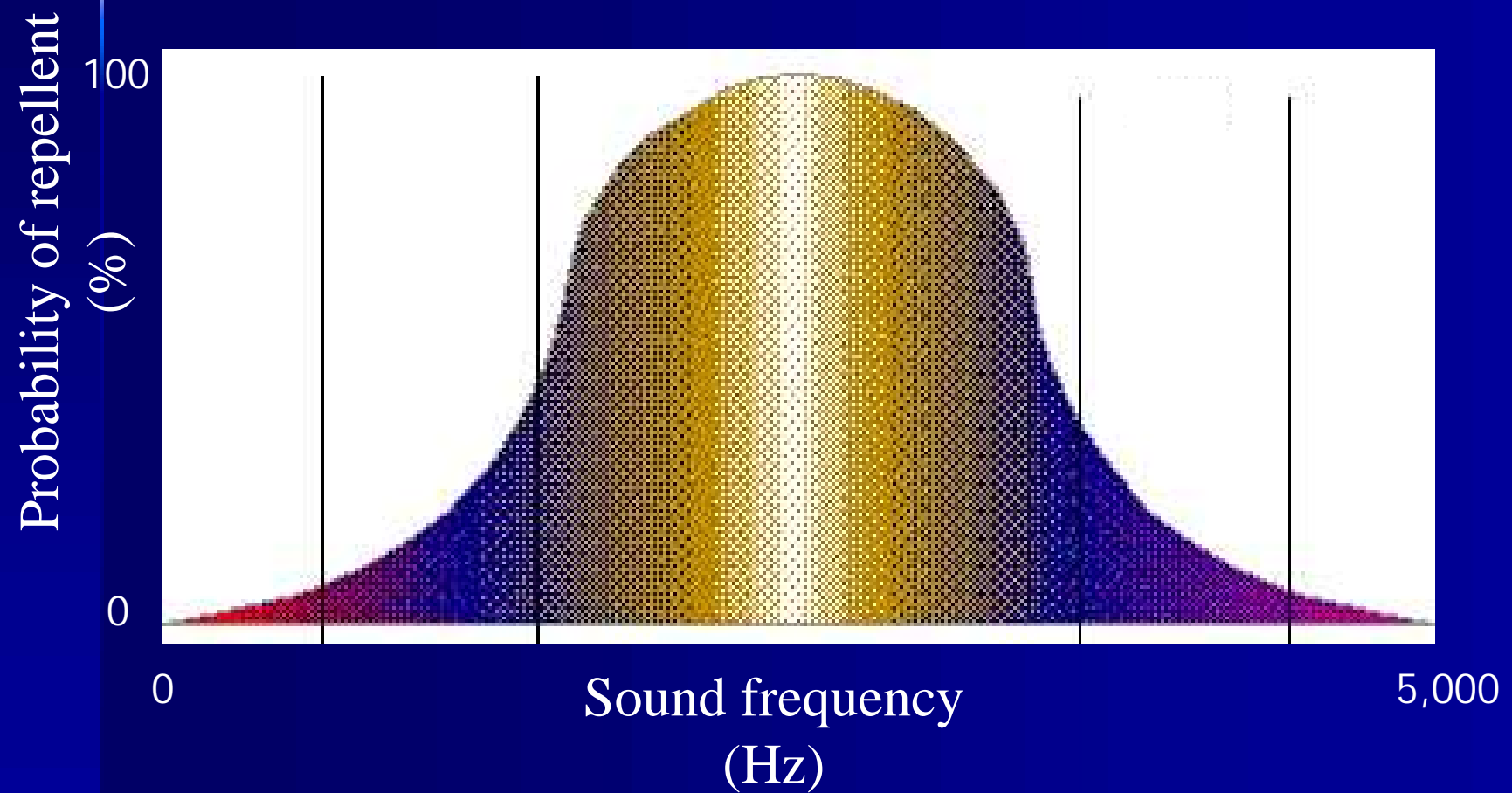
Bioacoustic Fish Fence (BAFF)



Recommended: Hybrid Bubble-Acoustic system

- Fish Guidance Systems (UK)
 - Developed a Sound Projector Array (SPA)-based Bioacoustic Fish Fence (BAFF)
 - **Combines**
 - Selection of sound frequency in an SPA
 - Concentrated sound field of a BAFF system
 - System differs from the conventional BAFF in that **Array projectors can be calibrated to produce a sound signal that matches a particular fish deterrent audiogram**

Theoretical audiogram for efficiency of repelling fish



Testing differences in hearing among species of concern: Invasive (Bighead/silver carp) vs. Native (Paddlefish and Lake Sturgeon)

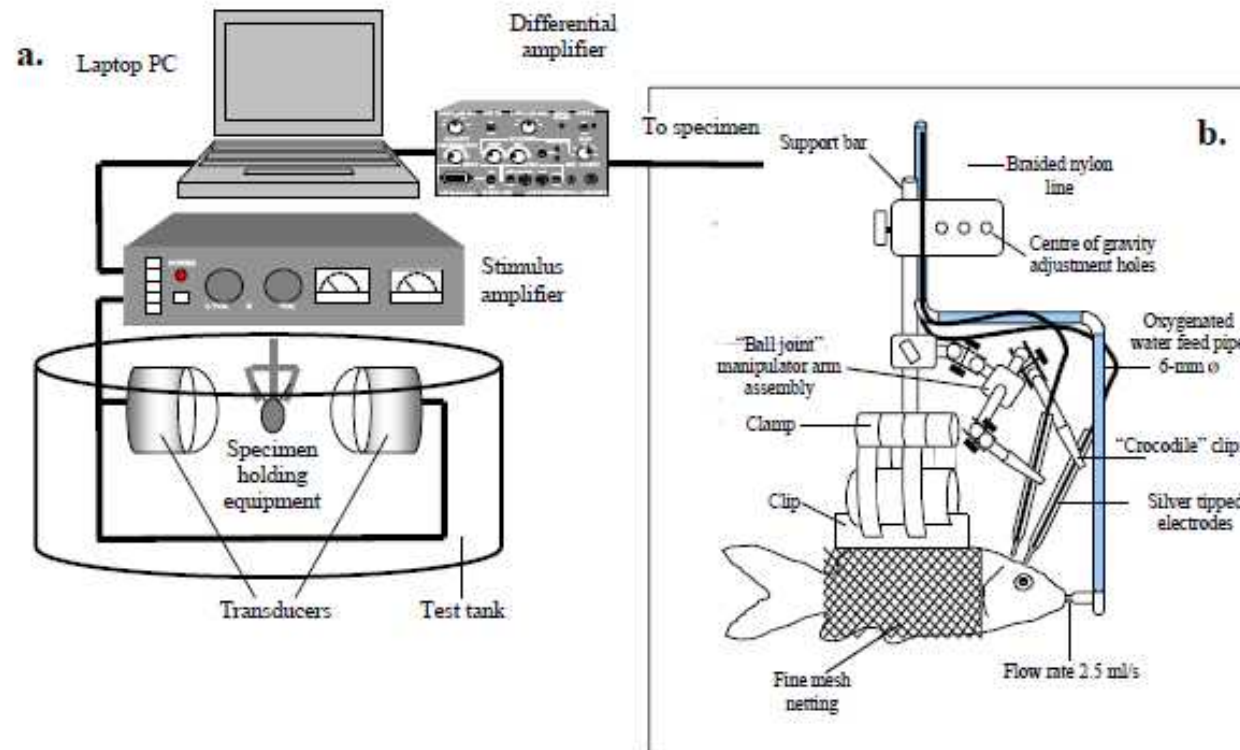
The hearing abilities of the silver carp (*Hypophthalmichthys molitrix*)
and bighead carp (*Aristichthys nobilis*)

J.M. Lovell ^{a,*}, M.M. Findlay ^a, J.R. Nedwell ^b, M.A. Pegg ^c

Comparative Biochemistry and Physiology, Part A 143 (2006) 286 – 291

Testing differences in hearing among species of concern: Invasive (Bighead/silver carp) vs. Native (Paddlefish and Lake Sturgeon)

J.M. Lovell et al. / Comparative Biochemistry and Physiology, Part A 143 (2006) 286–291



1. (a) Schematic of the ABR audiometry system and (b) schematic of the clamp assembly used to hold *H. molitrix* and position the electrodes.

Results of hearing testing among species of concern: Invasive (Bighead/silver carp) vs. Native (Paddlefish and Lake Sturgeon)

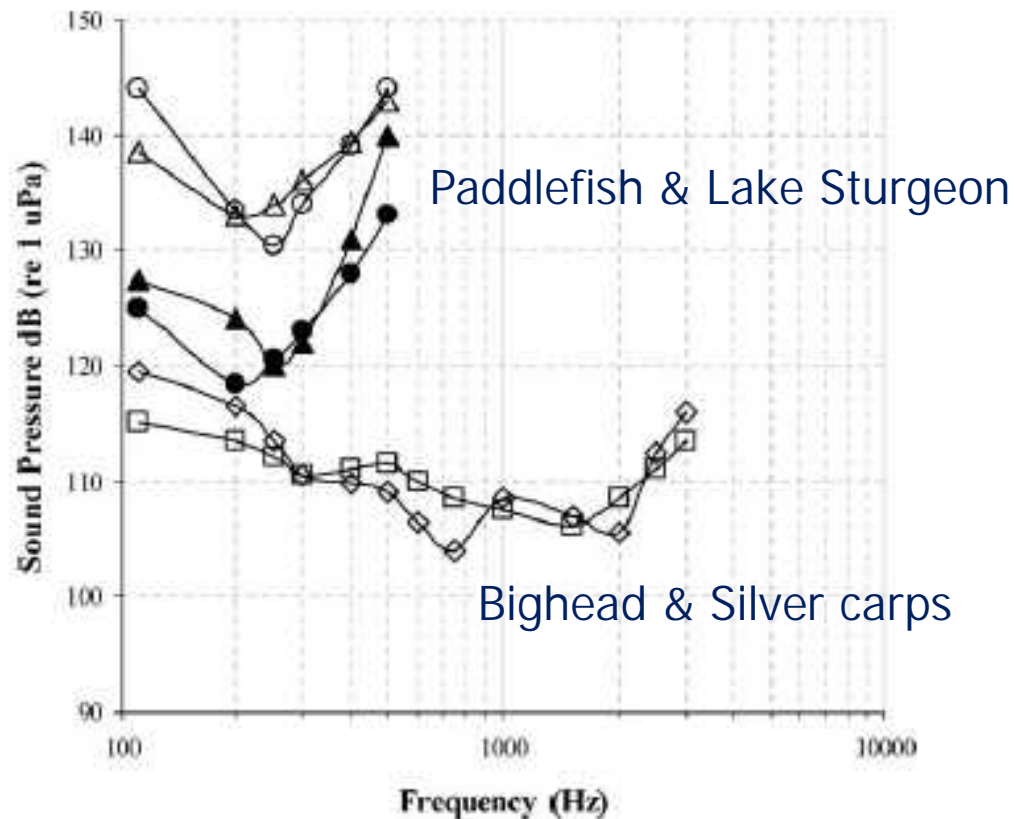


Fig. 4. Comparison of the audiograms for *A. fulvescens* (closed circles=maximum sound pressure; open circles=maximum particle motion), and *P. spathula* (closed triangles=maximum sound pressure; open triangles=maximum particle motion) (from Lovell et al., 2005a,b D), and for *H. molitrix* (diamonds) and *A. nobilis* (squares).

“Result show [Bighead & Silver Carps] are sensitive to a wider range of frequencies at lower intensities than [Paddlefish and Lake Sturgeon]”

Testing SPA-Based BAFF



Aquatic Invasions (2012) Volume 7, Issue 1: **in press**

doi: 10.3391/ai.2012.7.01

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Proceedings of the 17th International Conference on Aquatic Invasive Species (29 August-2 September 2010, San Diego, USA)

Research Article CORRECTED PROOF

***In-situ* tests of sound-bubble-strobe light barrier technologies to prevent range expansions of Asian carp**

Blake C. Ruebush^{1*}, Greg G. Sass¹, John H. Chick² and Joshua D. Stafford³

Testing SPA-Based BAFF

- Passed upstream through the barrier
 - 2 of 575 marked silver carp
 - 0 of 101 marked bighead
- “technologies could be used as a deterrent system to repel Asian carp, but should not be used as an absolute barrier to prevent range expansions.

Testing SPA-Based BAFF

- 85 of 2,937 marked individuals of other fish species breached the barrier
- “Potential negative influences of this technology on non-target fishes must also be evaluated prior to implementation as a management tool”

Feasibility Study to Limit the Invasion of Asian Carp into the Upper Mississippi River Basin

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Prepared By:



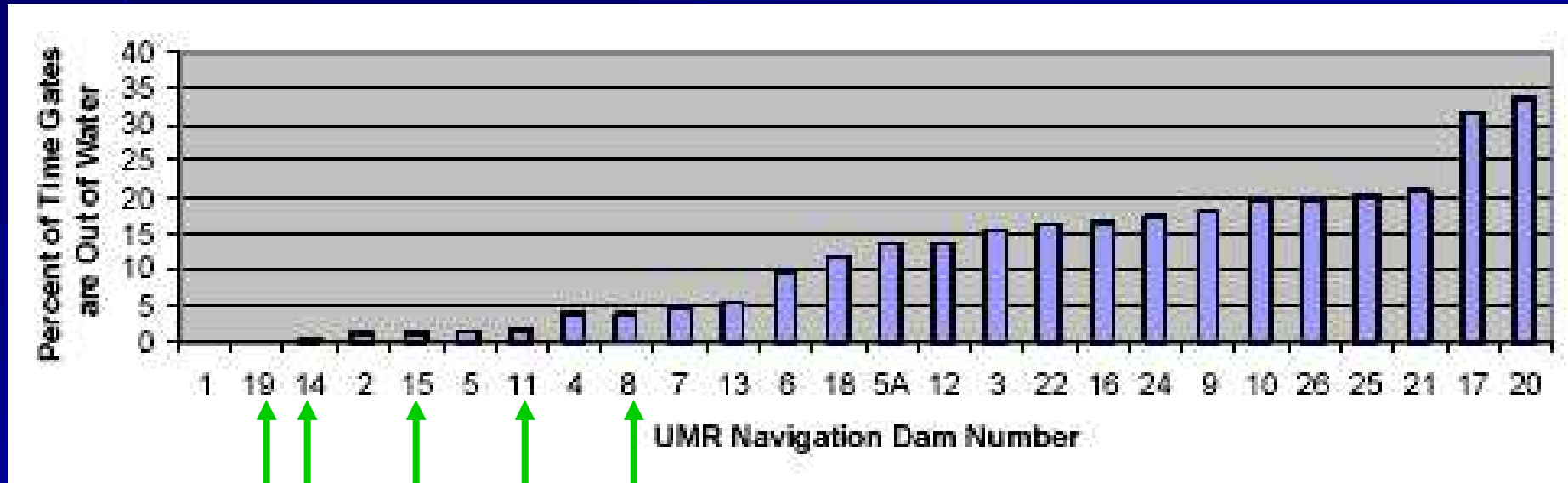
With Assistance From:



Recommendation: Location of barriers

- Either in, or downstream of, a Lock and Dam
- Criteria for selecting recommended locations
 - Physical features (e.g., dam height, % of time tainter gates out of water)
 - Known distribution of established populations of Asian carp
 - Estimated length of time required to implement barrier technologies

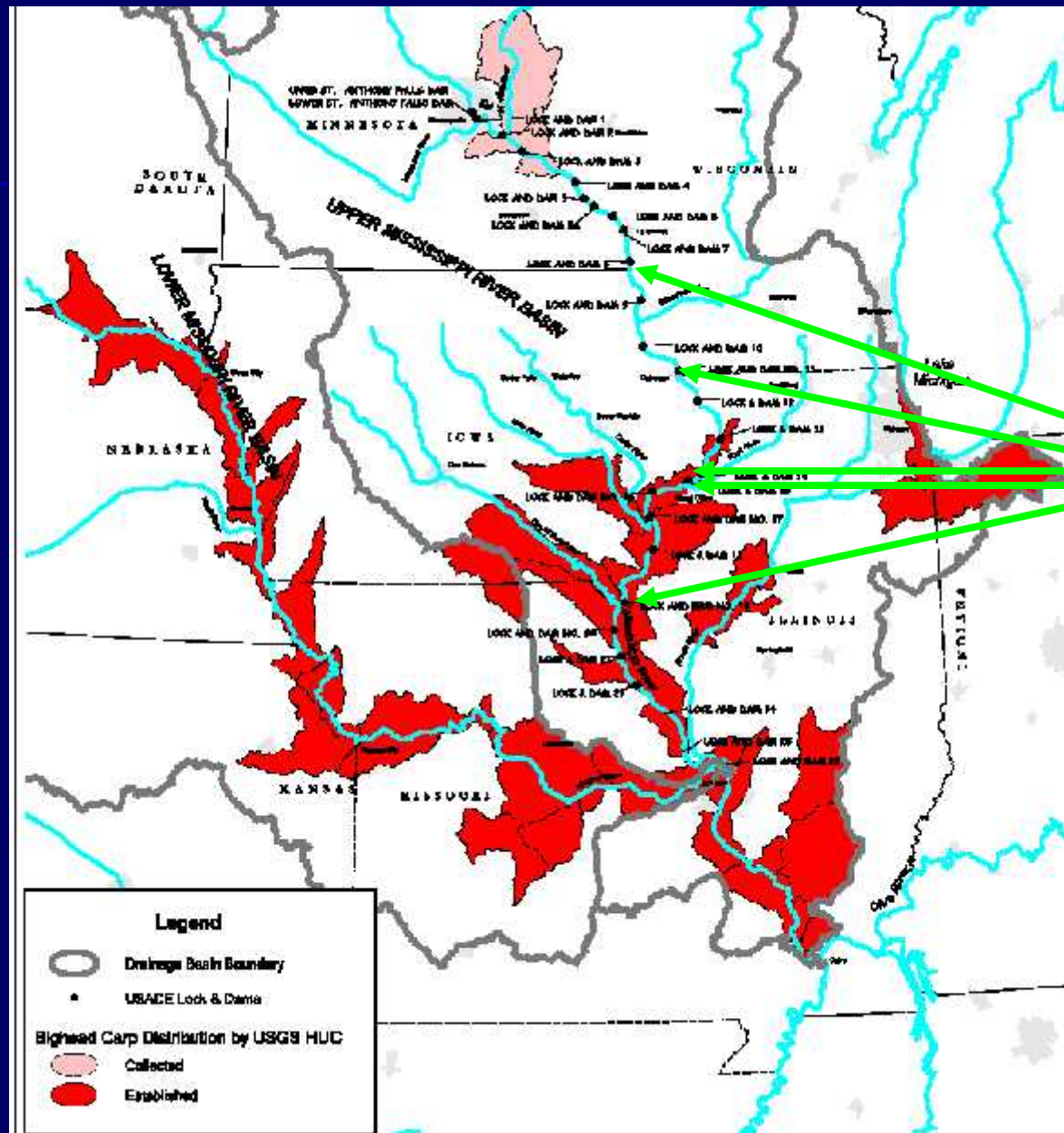
Percentage time Upper Mississippi River Dam Gates Open that could Allow Passage of Fishes Over Dam



Recommended locations for barriers.

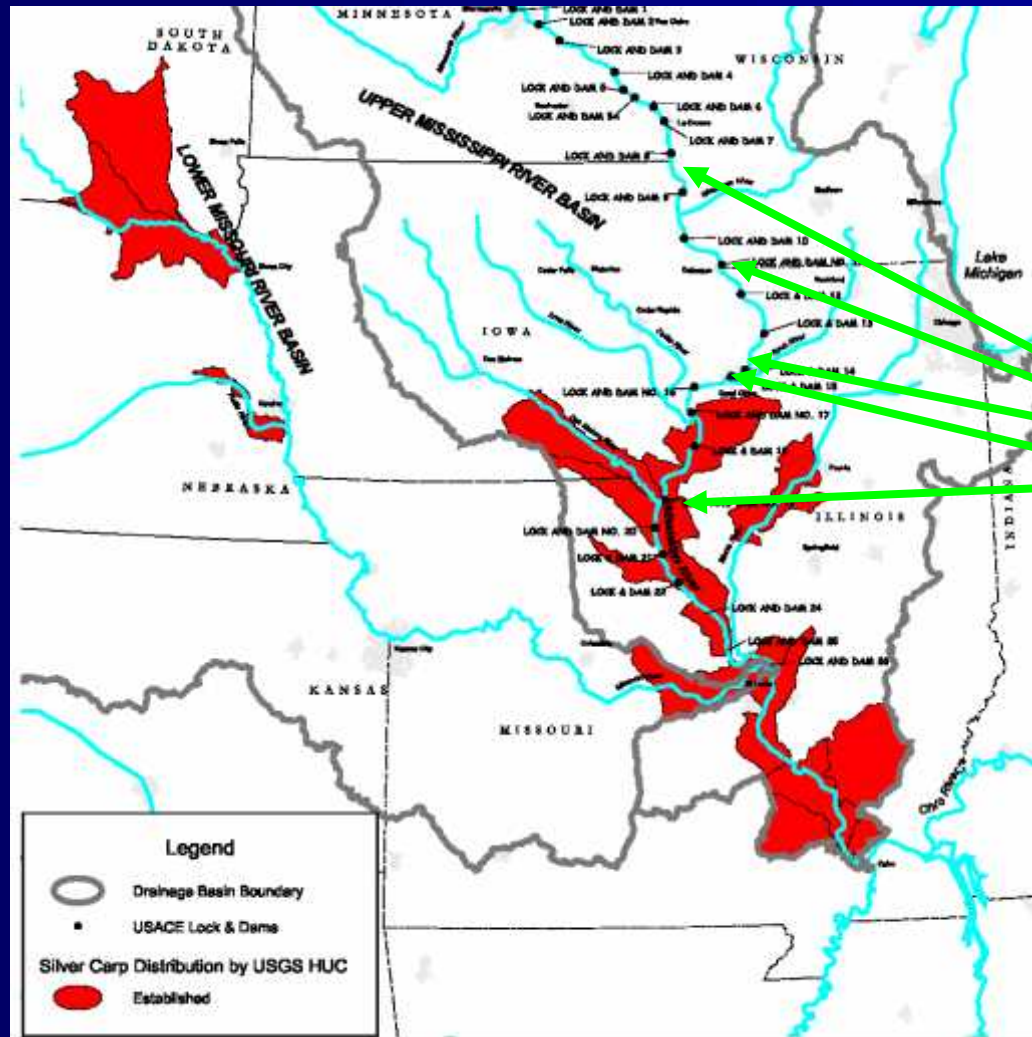
Graph courtesy of U.S. Army Corps of Engineers

Bighead carp distribution in the Upper Mississippi and tributaries.



Recommended
Barrier
Locations

Silver carp distribution in the Upper Mississippi River and tributaries



Recommended
Barrier
Locations

Lock and Dam 19 with proposed alternative locations

Dam Width = 1,408 M

Lock Width = 34 M

Dam Height = ~12 M

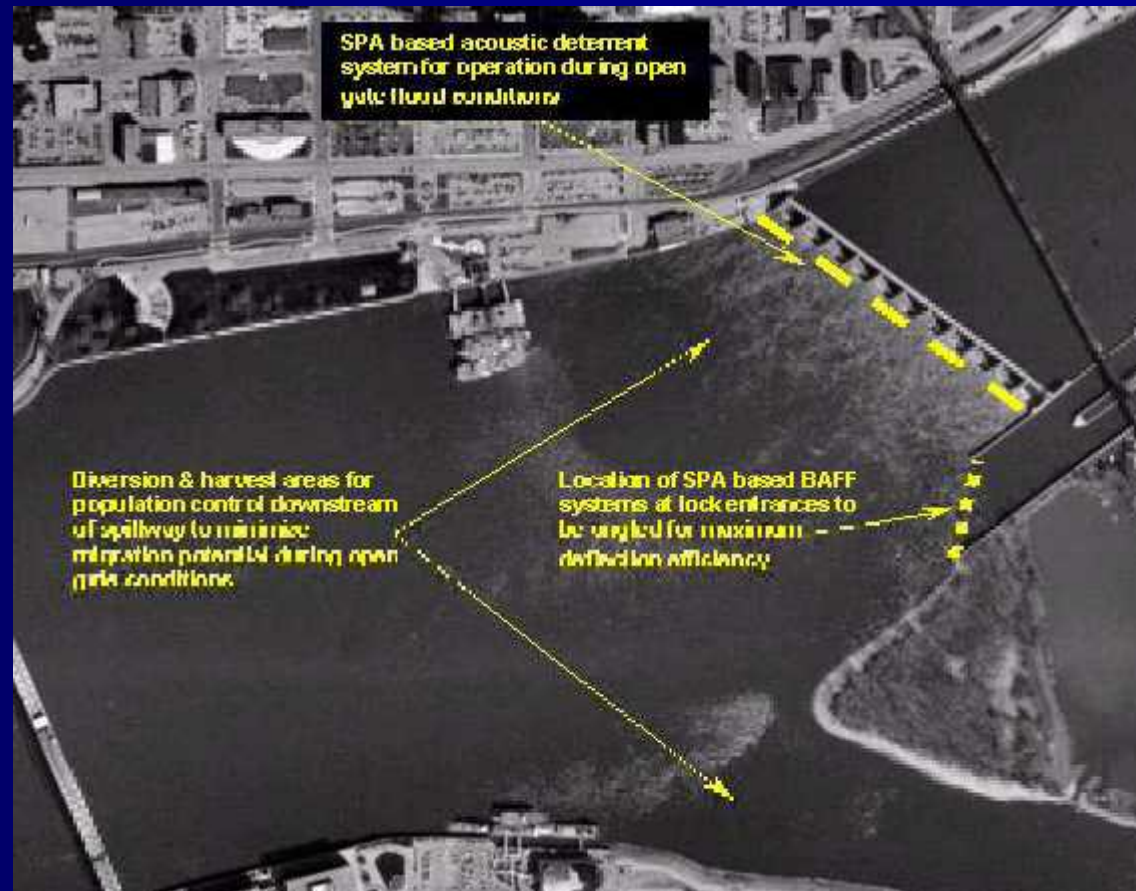


Lock and Dam 15 with proposed alternative locations

Dam Width = 367 M

Lock Width = 34 M

Dam Height = ~5 M



Lock and Dam 14 with proposed alternative locations

Dam Width = 409 M

Lock Width = 34 M

Dam Height = ~3 M



Lock and Dam 11 with proposed alternative locations

Dam Width = 451 M

Lock Width = 34 M

Dam Height = ~3.5 M

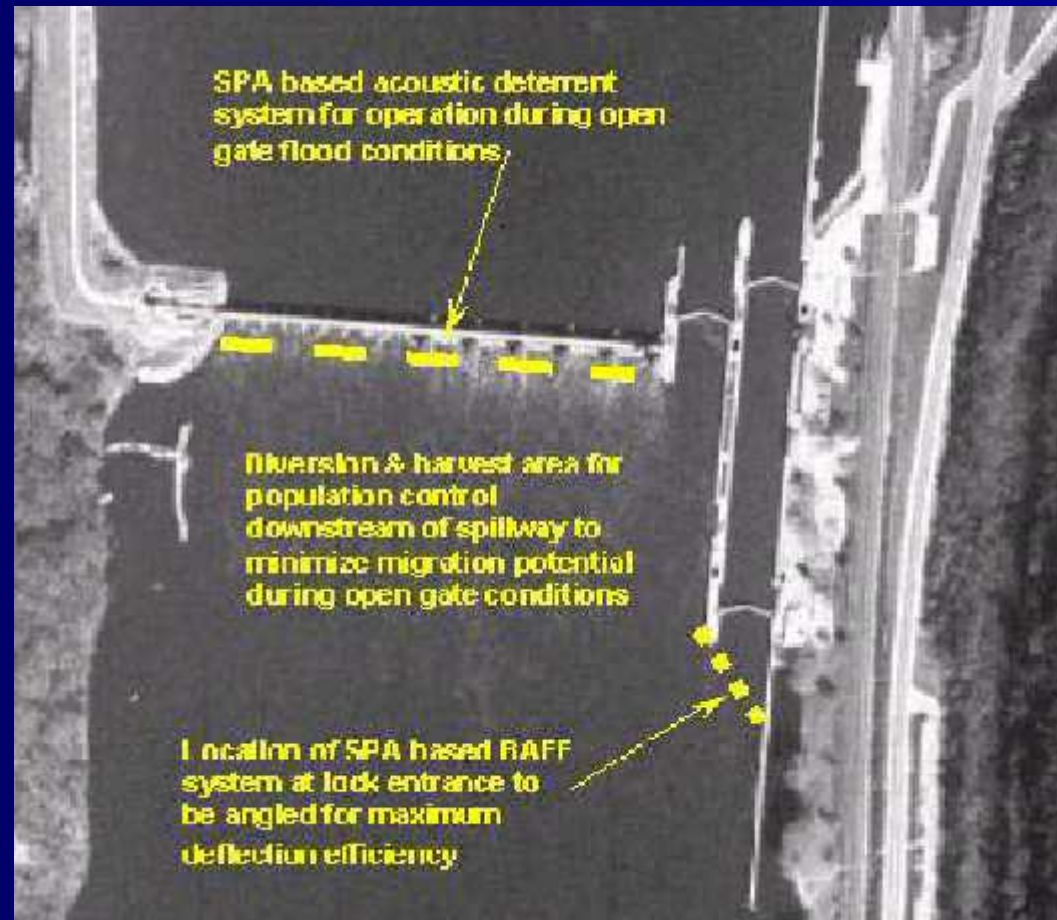


Lock and Dam 8 with proposed alternative locations

Dam Width = 451 M

Lock Width = 34 M

Dam Height = ~3 M

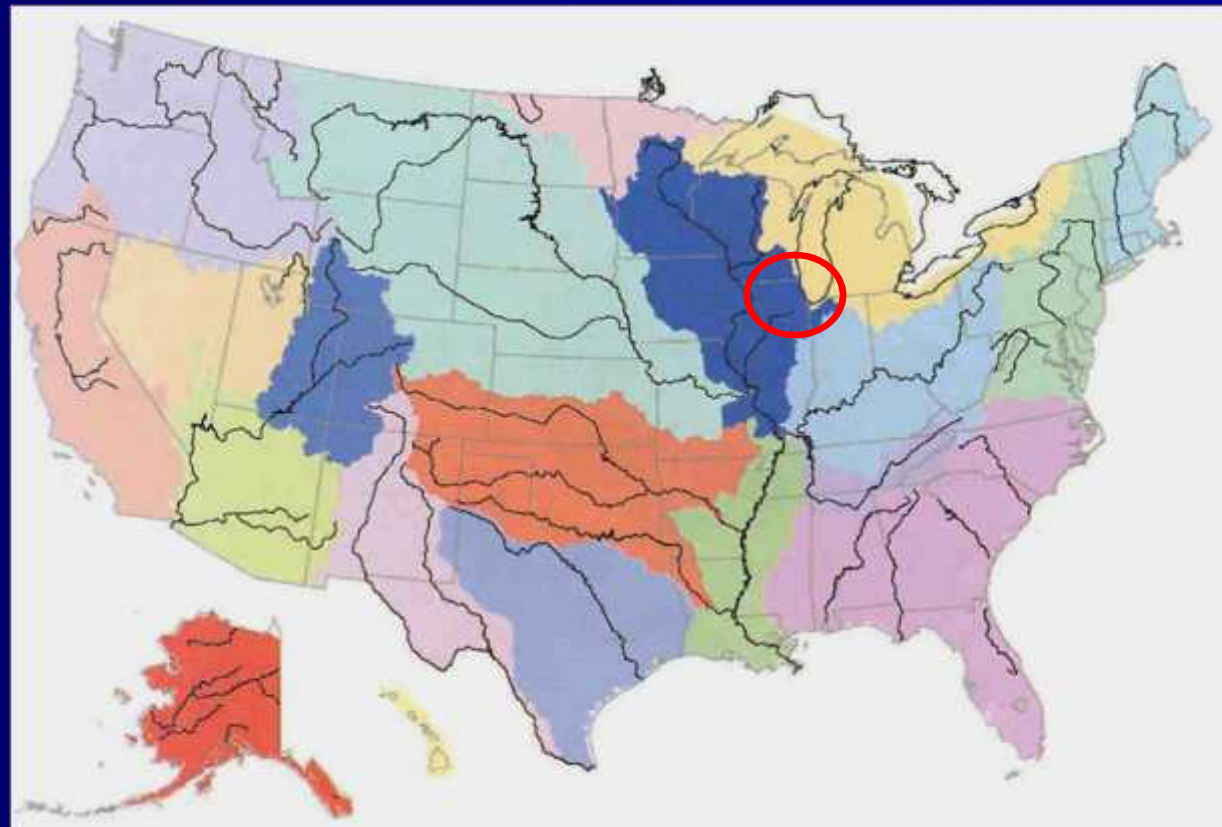


Cost Estimates - 2004

- Integrated management - ~\$10.0-15.0 M/Lock and Dam
 - Barrier
 - Sound Projector Array-based acoustic bubble curtain (SPA-BAFF)
 - At a lock entrance - \$1.2-1.6 M
 - Downstream of a Dam spillway - \$8.5-10.5 M
 - Habitat-attractant staging area downstream of a spillway - \$0.5-3.0 M
 - Fish harvest - \$??

Electrical Barriers: Chicago Area Waterway System

- Goal: Protect the Great Lakes from establishment of self-sustaining populations of Bighead and Silver Carps



Electrical Barriers Deployed to Stop Asian Carps



Electrical Barriers Deployed to Stop Asian Carps



CO₂ Injection: Possible Future Deterrent System

- Deterrent –not 100% effective (i.e., not a “barrier”)

CO₂ Injection: Possible Future Deterrent System

- The targeted deadline for submission of application (by FWS) for registration (by EPA) of CO₂ as a deterrent system is late 2015
- Possible placement at a lock structure on the Illinois River
- Should not be considered a 100% effective barrier

CO₂ Injection: Possible Future Deterrent System

- Management Issue:
 - Decreased pH could cause harm to lock infrastructure, if placed **within** a lock in the Illinois River

Complex Sound: Possible Future Deterrent System

- Experiments continue on use of sound as a barrier or deterrent for Asian carps
- Complex sound (outboard motor recordings) played through underwater speakers show promise for “herding” Asian carps

Complex Sound: Possible Future Deterrent System

- Although the approach shows promise for Asian carps, application to other species will depend on the species, and their evolved auditory systems
 - Almost certainly to be of limited effectiveness for most species other than Asian carps

Summary and Synthesis

- A variety of barrier and deterrent technologies exist
 - Each is different in:
 - Known or projected effectiveness at blocking subject species
 - Impacts to native species and habitat
 - Cost
 - Safety to humans

Summary and Synthesis

- Based on technologies available now, & goal of 100% effectiveness, I recommend consideration of 2 alternatives:
 - Fixed dam
 - Electrical Barrier
- Of the 2, you may wish to explore electrical barriers in more detail
- I can connect you with a representative from Smith-Root (<http://www.smith-root.com/barriers/>)

Electrical Barriers

- Cost dependent on site
- Operation specifics will need to be designed
- Backup generator system needed
- May wish to consider alternative technology (e.g., sound, CO₂) to be added later
- Human safety an issue
- Depending in design, will be highly effective at blocking invasive and native species (upstream migration)

Questions and Discussion

Many eyes will be
watching our next steps

