



# Lessons from Carp

## Sorensen Lab

*April 14, 2016*

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# This Talk

- Carp!
- “Common” carp
  - The “invasion”
  - Biology
  - Control
  - Lessons?
- “Asian” carp
  - Their invasion
  - Biology
  - Control!
- Questions?

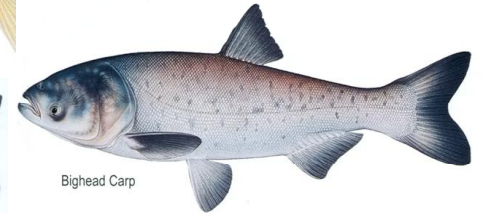
# Carp

=Large minnows that live in rivers  
(*Carpa*, *Karpe*, *Capre*, *Carp*)

“Eurasia”



“Asia”

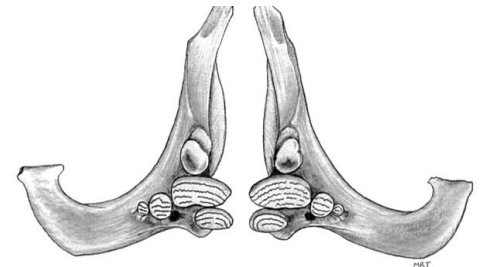


India



# Common Carp

*Cyprinus carpio*



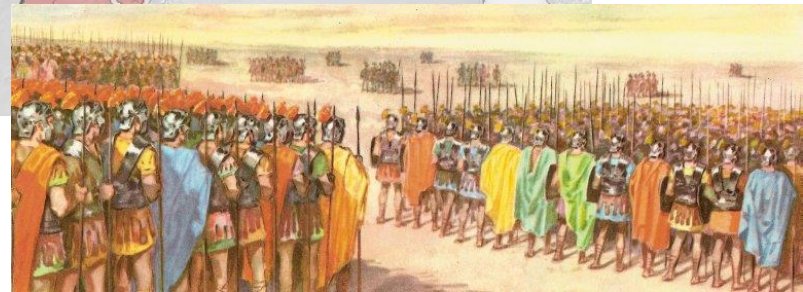


# Native habitat of Common Carp: the Volga

- Large: Delta 160 km across; 3,200 km<sup>2</sup>
- Complex: Braided channels with interconnected wetlands
- Harsh and Variable: Icy in winter, Hot & dry in summer

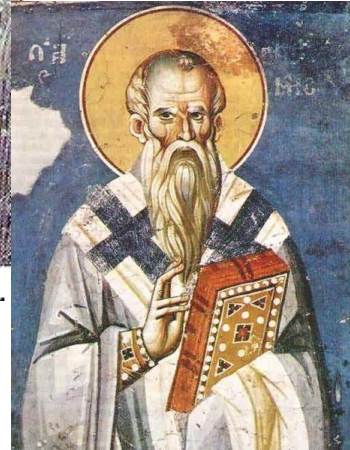


# Initial spread - The Roman Empire

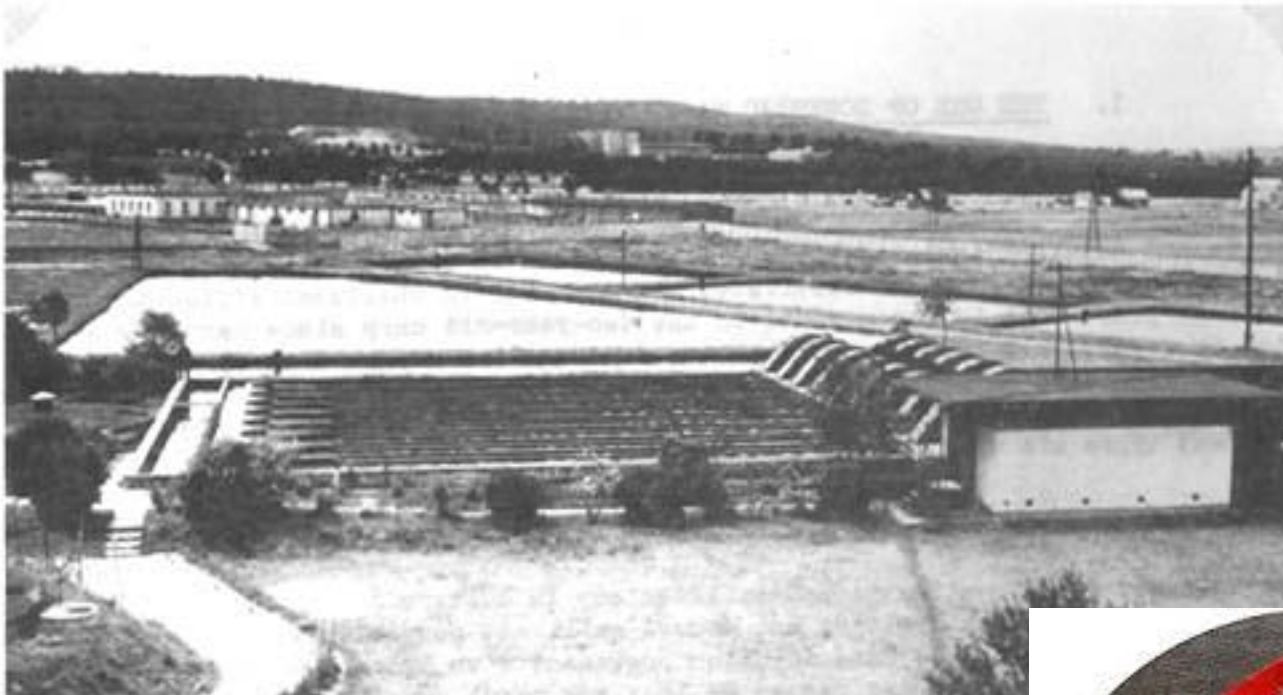




# Subsequent Spread - Catholic Church



# Perpetuation – Culturing (Eastern Europeans)



THE CHRISTMAS CARP



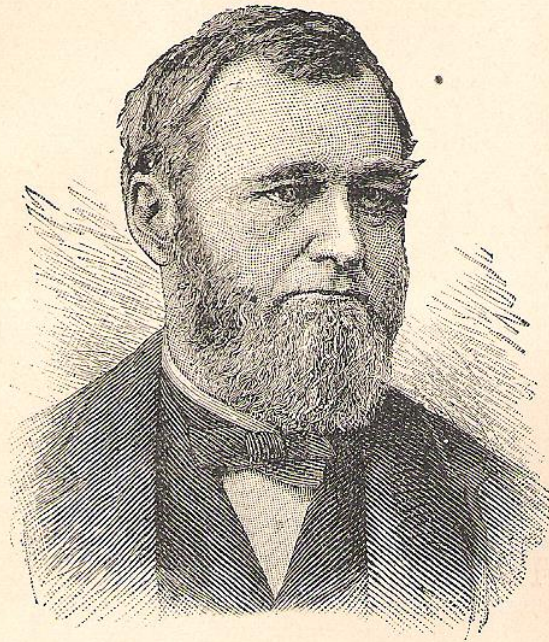
# Integration- Stocked game fish (British)



#1 gamefish in the UK

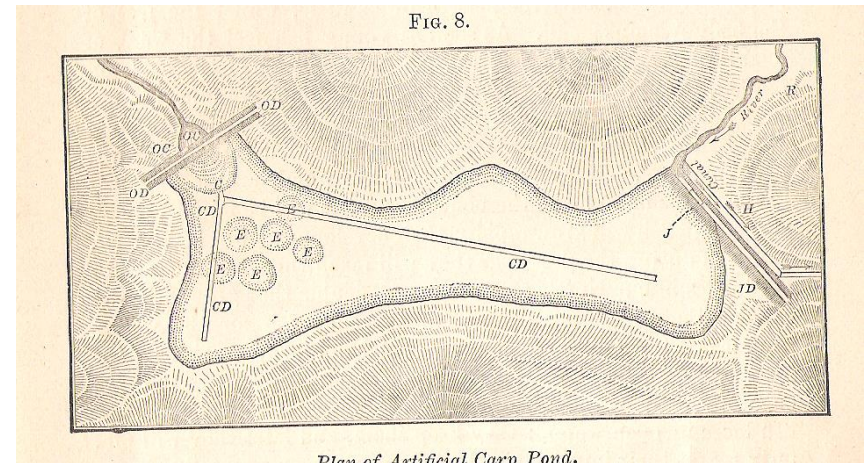
# The Rest of the World Acclimatization Societies:

## 1877: U.S. Fish Commission



PROF. SPENCER F. BAIRD,

U. S. COMMISSIONER OF FISH AND FISHERIES.



Plan of Artificial Carp Pond.

*'... for some years a resident of Minnesota, I am acquainted with its grand opportunities for carp culture... in a few short years there will be millions of surplus carp' Pierce 1883*



# Officially introduced to USA in 1877

- 345 adult carp brought from Germany
- Propagated in reflecting pools for 2 years
- 1879 - 1895 entire country stocked



# Carp in Minnesota

Oct 21, 1880: “ A good thing has come”  
-15 carp immediately stocked in 12 lakes

1884: 9,000 young carp

1885: 3105 young carp

1888: 522

1889: 1,385

1897: PROGRAM STOPPED



John Wesley Speelman of Verndale, one of many carp enthusiasts who tried to improve on the state's natural species of fish



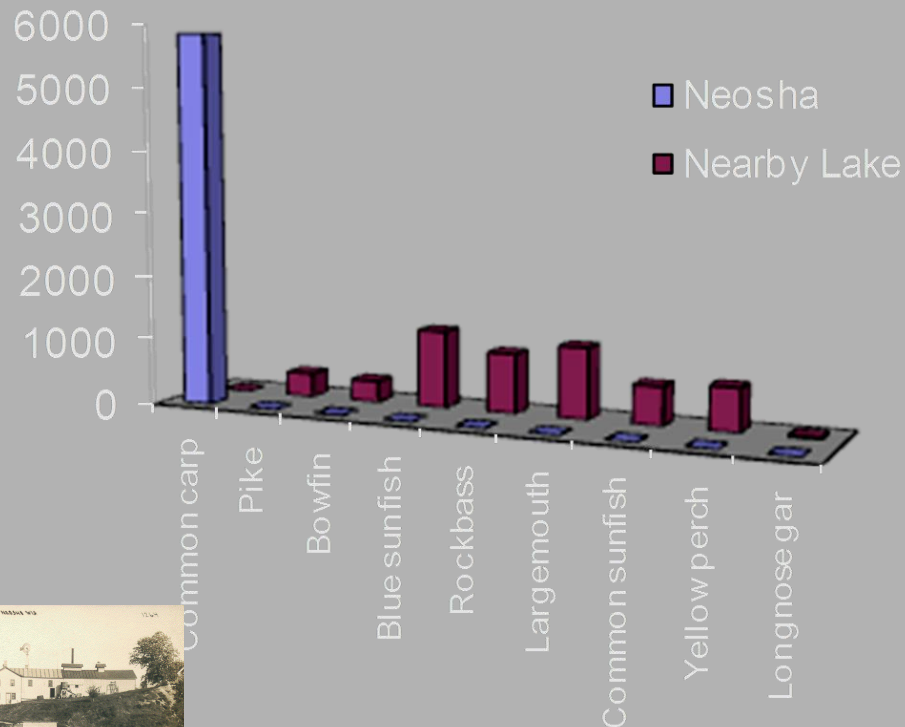
With the catch-and-release concept many years away, a Minnesota “boatman” (at left) and three sport fishermen from Louisville, Chicago, and Detroit display their day’s cane-pole catch of about three-dozen hefty smallmouth bass from Detroit Lake, 1884



# Mysterious Loss in plants and game-fish!

ex. Cahn 1929

- “there was no vegetation in the lake – not a single plant...”
- “ I regret exceedingly that I have no pre-carp data...”



# Eating our way to the solution?!



PLEASE POST CONSPICUOUSLY

DEPARTMENT OF COMMERCE  
U. S. BUREAU OF FISHERIES  
WASHINGTON

## EAT THE CARP!

The carp discovered America in 1877.

He found the land to his liking. He multiplied and filled the waters with his kind.

He is now big, abundant, useful. He converts useless vegetation and small animals into meat.

This meat is wholesome and nutritious. It contains as much protein as sirloin steak.

It is easily digestible.

It can be cooked in such a way as to remove the muddy taste. It can be boiled, baked, made into croquettes, or fish loaf. Carp jelly, an ancient Swedish dish, is delicious.

There are millions of carp in the United States. The last census shows that 43,000,000 pounds were marketed in one year. Nearly all this came from a few states in the Middle West.

Somebody ate those 43,000,000 pounds of carp.

Therefore the carp must be good to eat.

The carp is good to eat. Carp has not only been eaten, but has been cultivated in Europe for centuries. Europeans know how to cook it.

Catch the carp; buy the carp; cook the carp properly and eat it. Eat the roe; can the roe. Make carp jelly. Can the fish. Smoke it, too.

For information and recipes write to

UNITED STATES BUREAU OF FISHERIES  
DIVISION F, WASHINGTON, D. C.

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11-6176



# Fishing our way to the solution?

- Government-run "rough fish" removal programs

## Fighting carp at Fish Camp County Park



In a new place, non-native invasive species cause trouble. Ever since Europe's common carp was stocked in Wisconsin lakes in the 1830s, it has been a problem fish. To respond, the state operated fish camps to contain the exploding carp population. Here at McFarland, from 1932 to 1969, crews at Fish Camp caught and sold millions of pounds of carp and other non-sport fish.

**BAD FOR NATIVE FISH**  
The goal of the fish camps was to improve habitat for sport fish such as bass and walleye. So quickly did common carp become pests in Wisconsin waters—especially Dane County's four Yahara lakes—that by 1895, anglers called for their removal. The bottom-feeding carp stirred up lakes, and cloudy water blocked light and plant growth. That meant less food and cover for other fish.

**SEEKING FOR FOOD**  
Year after year, crews at Fish Camp set mile-long seine nets to catch carp. In winter, they seined under the ice at lakes around the state. The crews placed live carp in holding ponds, then shipped them by truck and railroad. Live carp were sold throughout the country to restaurants and fishing

ponds. Small carp were packed in ice and canned for animal feed—usually for mink and fox ranches—or used as fertilizer.

**FISH CAMP IN McFARLAND**  
Fish Camp started in the 1930s with a holding pond, corn storage and equipment warehouse. The headquarters of the camp stood a few miles up the Yahara River. In 1954, all operations moved to this site. The camp closed in 1969 when the market for carp faded and running state fish camps was no longer economical. The carp remain.

**CARP TEACH A LESSON**  
Blaming carp as the single enemy of Wisconsin waters goes too far. Pollution and sedimentation cause most harm to lakes and rivers. As the Wisconsin Conservation Department put the matter in 1952, "In some cases, carp take over for the simple reason that most species cannot live in the water."



**KNOW MORE**  
Wisconsin's fish camps

Starting in the 1930s, the Wisconsin Conservation Department built fish camps to harvest non-sport fish, especially carp.

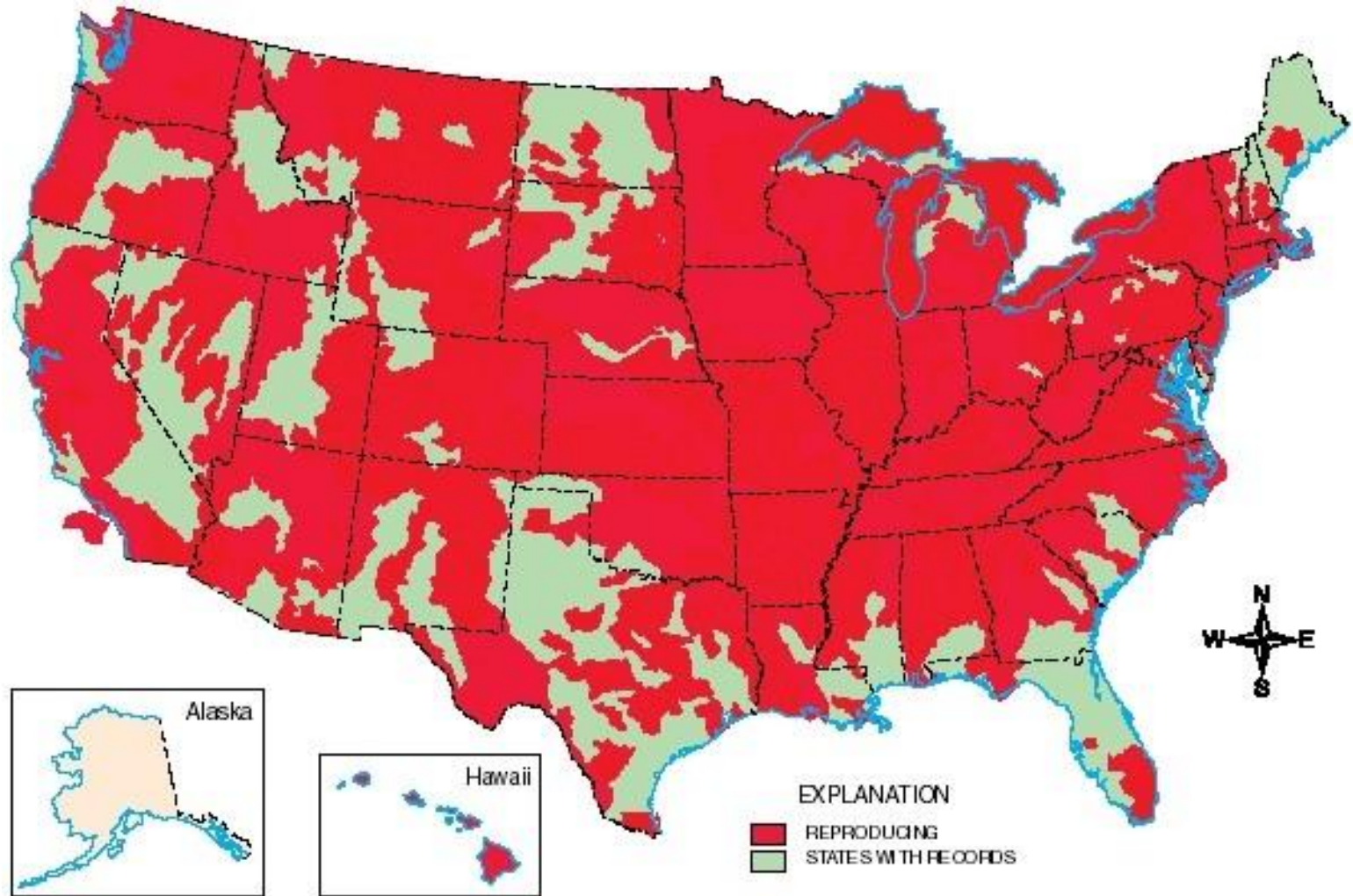
**IN THEIR WORDS**  
tough day seining

"I remember one time, we had about 5,000 feet of net laid out on Kegonsa, and it got too late in the day, because it was too hard to land things, so we were over there by the (state) park trying to land in that area, and the wind shifted on us overnight and sunk our towing barge. Flood it up with water, sunk it right on the shoreline, rolled the net. Then we come out the next morning and the net is full of ice, all rolled up, full of ice and carp, the barges are sunk. Here we've got to pump out those damn barges, refloat them. It was a bear that day."



Barge pulling in seine on Lake Kegonsa in 1932. Exhibit image credit: photo courtesy of Wisconsin Department of Natural Resources.

# Success/Failure: Common Carp Today





# A few facts about life history of carp:

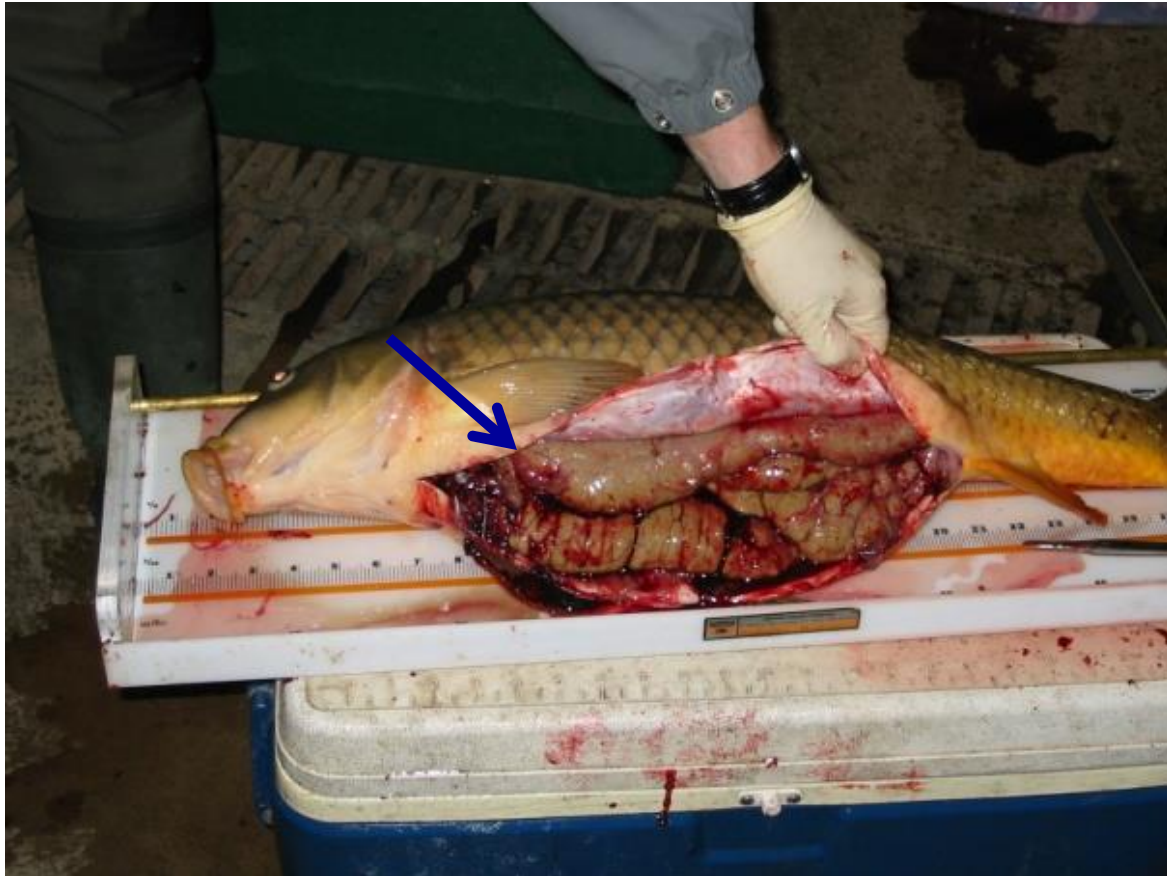
*(Why these strategies did not have work)*

## 1. Spawning

- Adults migrate to shallows to spawn, compete for mates, releasing millions of eggs
- Fate of eggs and larvae unknown



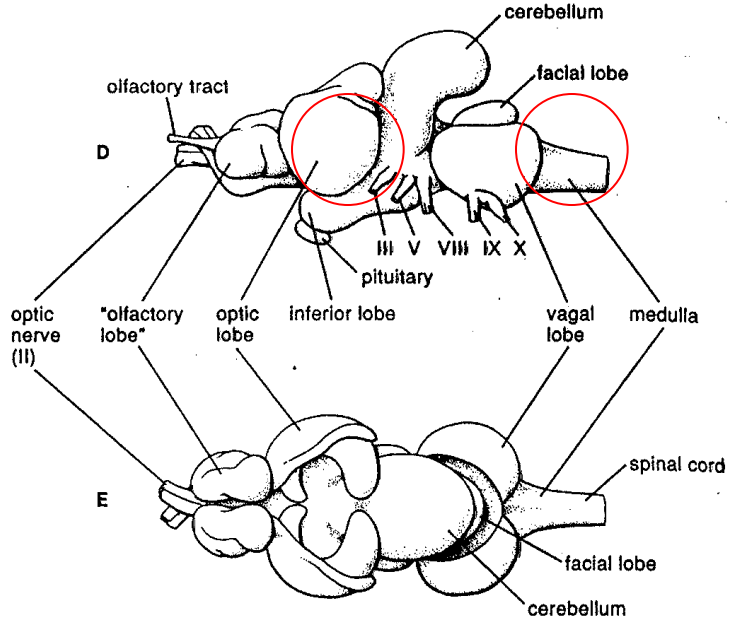
## 2. Fecund



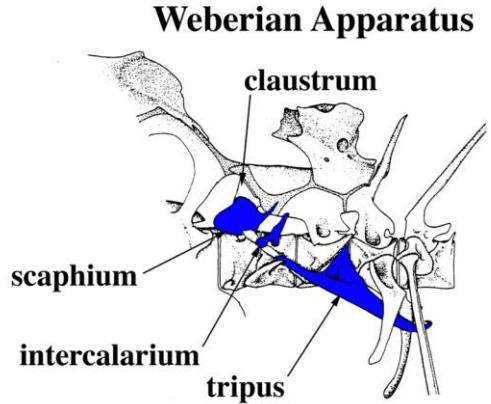
1-3 million eggs/ female/year for 50 years!

# 3. Well developed brains and sensory systems

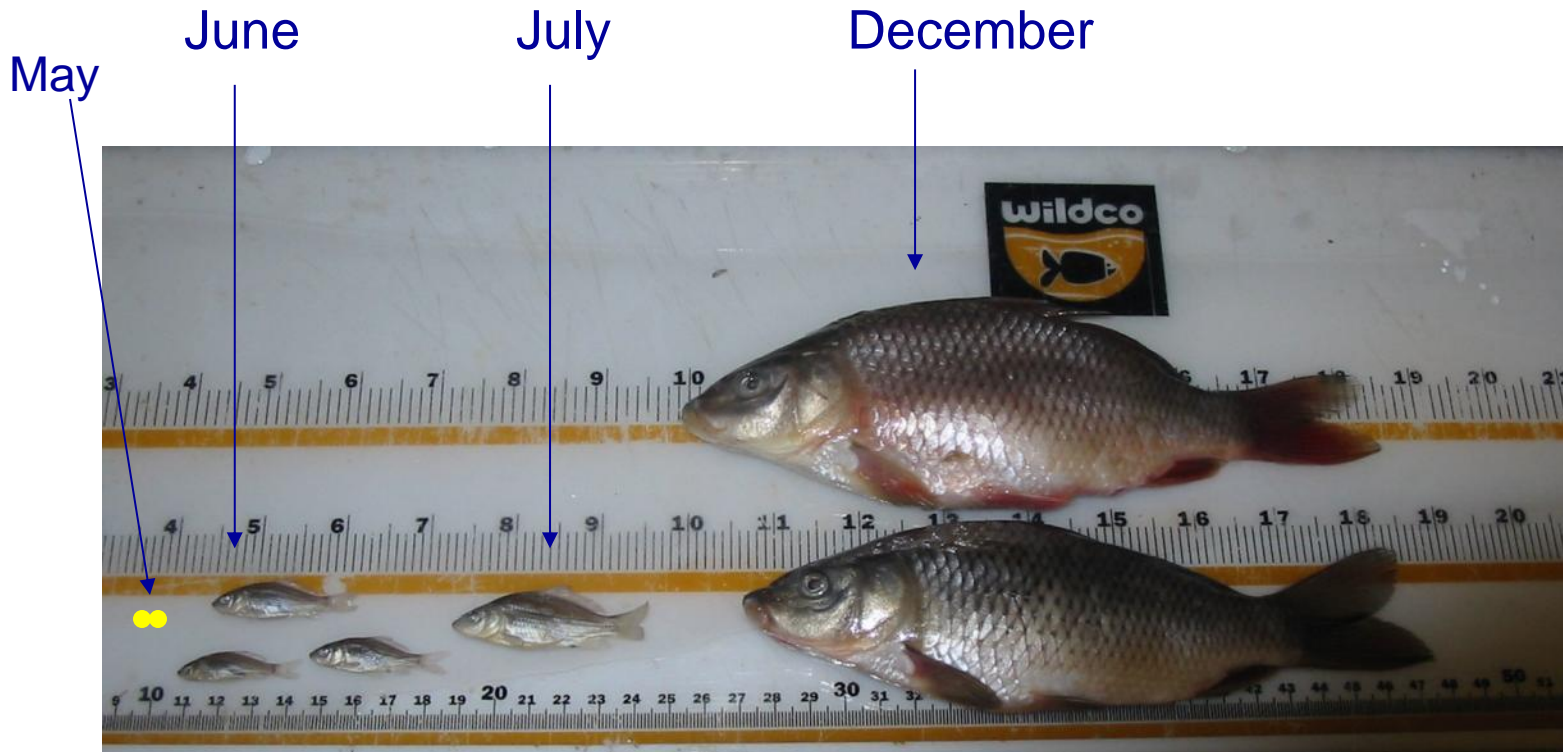
Learn and remember for weeks  
 Acute senses  
 hearing  
 taste (feeding)  
 smell (pheromones)



**FIGURE 17-1** Brains of D, carp (*Cyprinus*), lateral view; E, carp, dorsal view.  
 (Continued)



# 4. Rapid Growth and survival



- Young grow very quickly

6 inches



# 5. Feed on most everything in the bottom

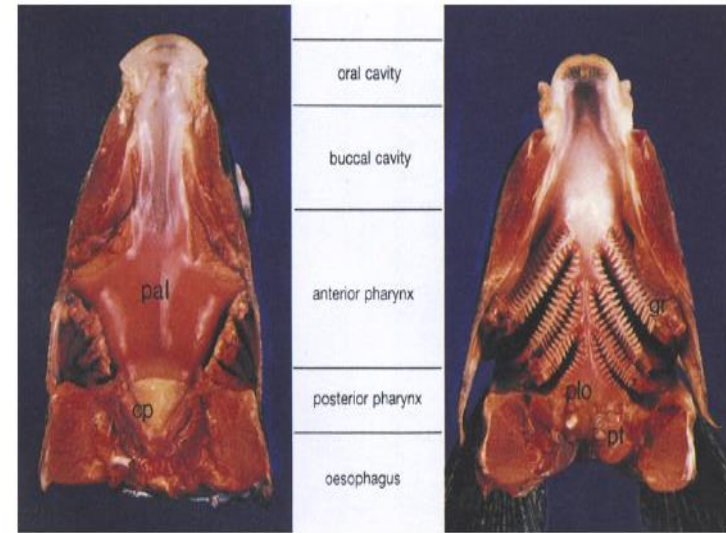
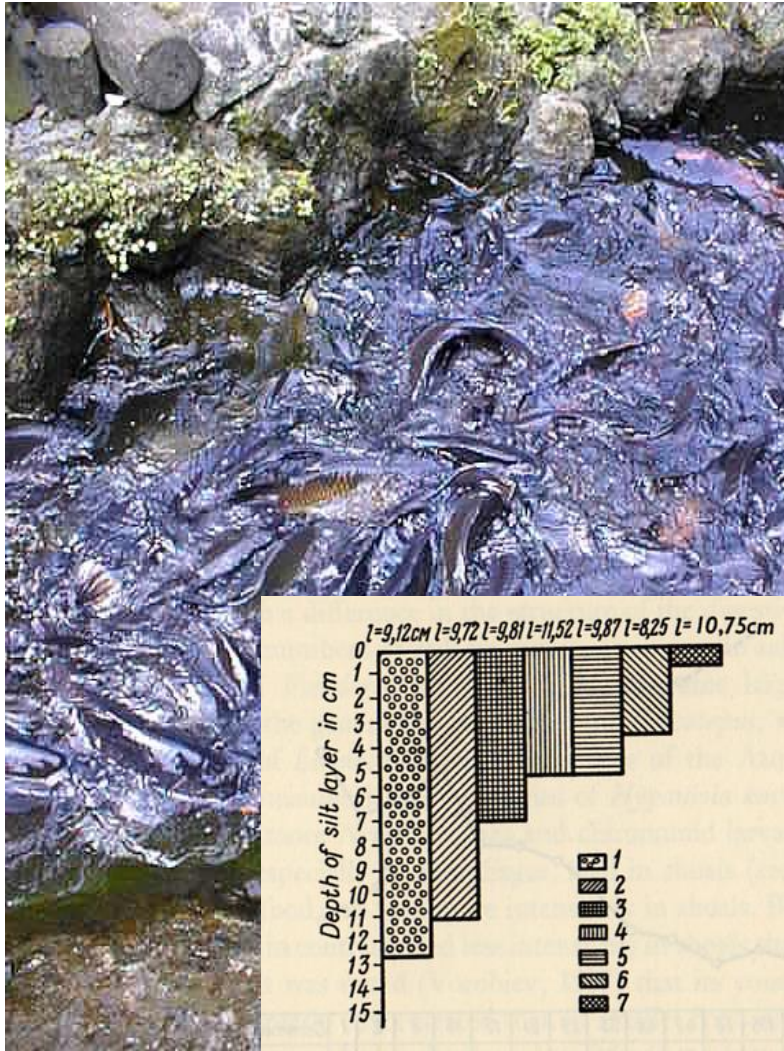


Fig. 2. Oropharyngeal structure of the carp. Note the lack of oral teeth, the presence of the fleshy palatal organ (pal) and the chewing pad (cp) in the roof (left) and the fleshy postlingual organ (plo) and pharyngeal teeth (pt) in the floor (right). The branchial floor is composed of gill arches and their gill rakers (gr). Subdivision of the oropharyngeal cavity is indicated.

Highly specialized feeding apparatus

Probe/ dig very deeply

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# 6. Long-lived

Easily 25,  
Sometimes 70!



## Benson

Benson, England's best-loved fish, died on July 29th, aged about 25

PETERBOROUGH, in the English Midlands, is a red-brick town, best known as the midway point on the line between King's Cross and York. But from the bottom of Kingfisher Lake, just outside it, urban toil seems far away. There, all is most delightful silt and slime. A push of your probing nose sends up puffs and clouds of fine mud through the water. A riff of bubbles rises, silvery, towards the surface. The green reeds quiver, and sunlight ripples down almost to the depths where you are lurking, plump and still.

Such was mostly the life, and such was the address, of Benson, England's most famous fish. Her actual place of birth, as a wriggling, transparent fry prey to every frog, pike and heron, was never known. But at ten, when she was stocked in Kingfisher, she was already a bruiser. And there, among the willow-shaded banks, she grew. And grew. At her peak weight, in 2006, she was 64lb 2oz (29kg), and was almost circular, like a puffed-up plaice. Bigger carp have been seen in Thailand and in France; but she still amounted to a lot of gelatinous fish.

In her glory days she reminded some of Marilyn Monroe, others of Raquel Welch. She was lithe than either as she cruised through the water-weed, a lazy twist of gold. Her gleaming scales, said one fan,

were as perfect as if they had been painted on. Some wag had named her after a small black hole in her dorsal fin which looked, to him, like a cigarette burn. It was as beautiful and distinctive as a mole on an 18th-century belle. Her lips were full, sultry or sulking, her expression unblinking; she seldom smiled. Yet the reeds held fond memories of her friend Hedges, her companion in slinky swimming until she, or he, was carried away in 1998 by the waters of the River Nene.

Abandoned, she ate more. She devoured everything. Worms, plankton, crayfish, lily roots, disappeared down her toothed, capacious throat. She was a one-fish Hoover, motoring through the food-packed sludge and through rich layers of sedimentary smells. But she was offered daintier and more exotic fare. Cubes of cheese, scraps of luncheon meat, bread crusts, Peperami, dog biscuits and tutti-frutti balls all came down invitingly through the water. She sampled most of them.

Of course, she was not fool enough to think they came from heaven. Carp are cunning, a very fox of the river, as Izaak Walton said. She could see the lines, and at the end of them the trembling shadows of Bert, or Mike, or Stan, spending an idle Sunday away from the wife with a broly

and a can of beer. Often she continued to lurk, roiling the mud to conceal herself, basking in her own scaled beauty, as she will. On hot days she would rise to the surface, glowing and tantalising, with a leaf shading her like a parasol. She played hard-to-get, or the One That Got Away, nudging the line before drifting down towards the dark serene. But then, just for a moment, she would take the bait.

The first hookings hurt like hell, the whole weight of her body tearing her skin like a razor blade. But over the years she got used to it, and her leathery mouth would seize the bait as a prize. Haunted by the limelight, she was admirably unphased. This was, after all, the home beauty she was owed. She would submit to the scales and then pose for the photographer, unmoving, holding her breath. She had her picture taken with Tony, owner of her lake, who confessed to the *Wall Street Journal* that he had "quite a rapport" with her; with Ray, who caught her at two in the morning, disturbing her beauty sleep; with Matt, of the shy smile and the woolly hair; with bearded Kyle, for whom she looked especially dark and pouting; and with Steve, who ungallantly told *Peterborough Today* that she felt like "a sack of potatoes" and was "available to everyone". She was not, but at least 50 others held her, gripped her, for a moment or so. Unconcerningly, she nestled in their arms before she was lowered to her element again.

These men had a knowledgeable respect about them. They might have been a sect, a society, meeting at odd hours in hidden nooks around the lake. Each had his specialities for anoracked meditation. When they spoke, it was of wagglers and clips, spots and backbiters, size 14s and number 8 elastics. Dates and weights were banded about, an arcane code. For a while, Benson imbibed the philosophy of a gaudier and a more complex sphere, heard the tinny music of their radios and stared into the dazzle of the day. There was much that she herself might have imparted, of the mystery of the flected and inverted things. But her angle needed to get home to the football and their tea.

### The fatal nut

Greed probably undid her in the end. She was said to have taken a bait of uncooked tiger nuts, which swelled inside her until she floated upwards. Telltale empty paper bags were found on the bank of the river. Or she may have been pregnant, with 300,000 eggs causing complications, stressed after so much catching and releasing, those constant brushes with extinction. On the line between life and death at Kingfisher Lake, she breathed the fatal air and did not sink again. And there she lay like Wisdom drawn up from the deep: golden, and as quiet. ■



# CARP FEEDING: Environmental Engineers

Feeding in the Bottom (a lot)

**Uprooting plants (cover)**

Taking food from birds and fish

Releasing nutrients from sediments

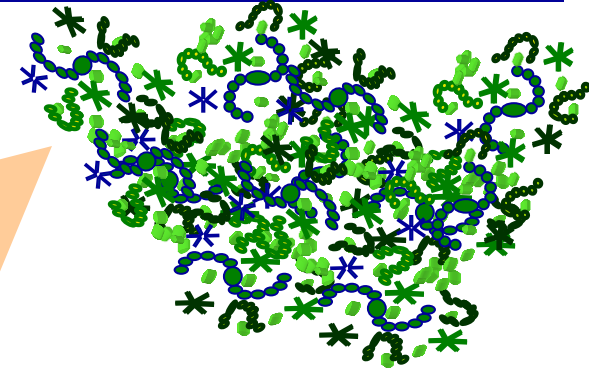
Growing

releasing nutrients

'Biological pump'

Nutrients (N, P)

**Algae bloom**

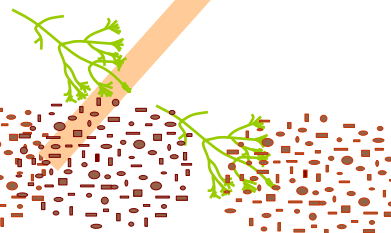
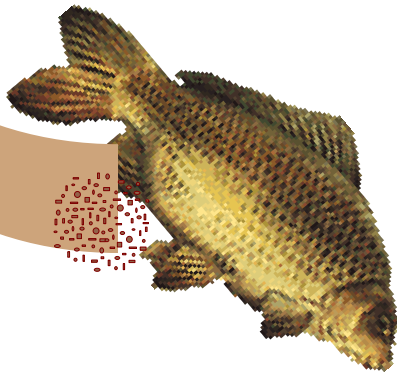


**X**  
Shading

**Plants decline**



**Uprooting**



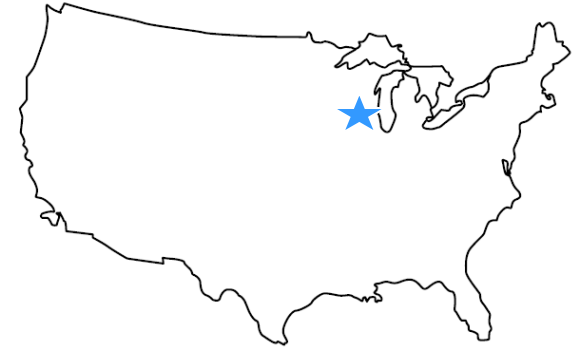
# Carp Damage: Loss in water clarity + quality



Lake Wingra, WI



# The Hennepin and Hopper Lakes



- Shallow, 1,000 acre lake in the Illinois River Valley
- Historically a waterfowl habitat
- In 1910 drained, converted to arable land
- Restored in 2001

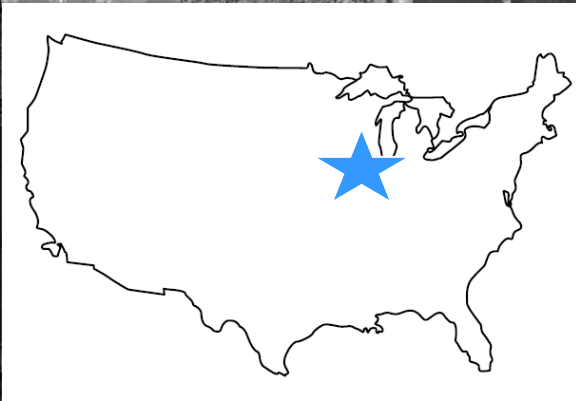




# CARP DAMAGE: Loss of submersed plants

The Hennepin and Hopper Lakes, Ill

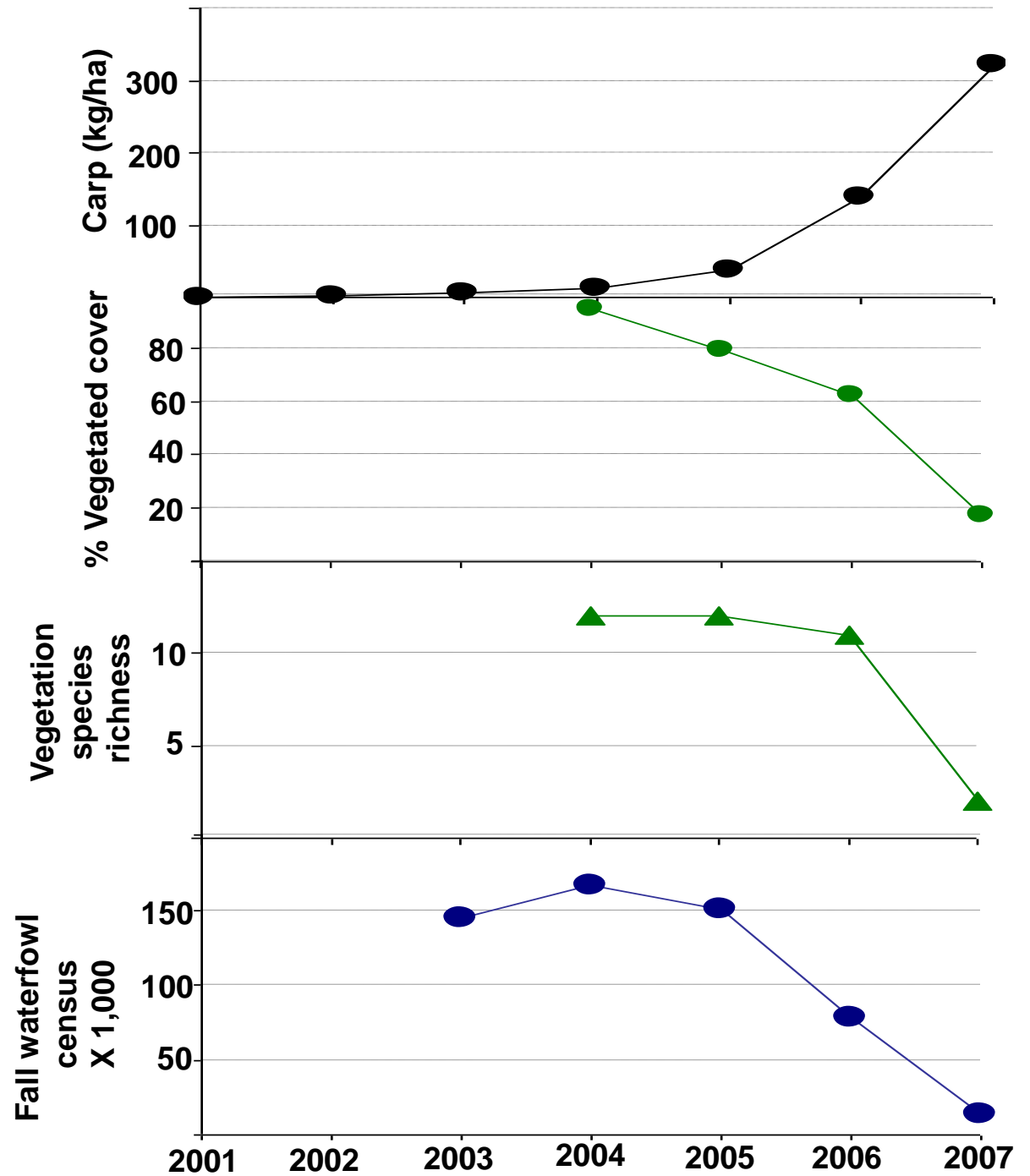
(invaded by carp in 1990s)



# Relationships between carp, vegetation and waterfowl



Bajer et al. 2009





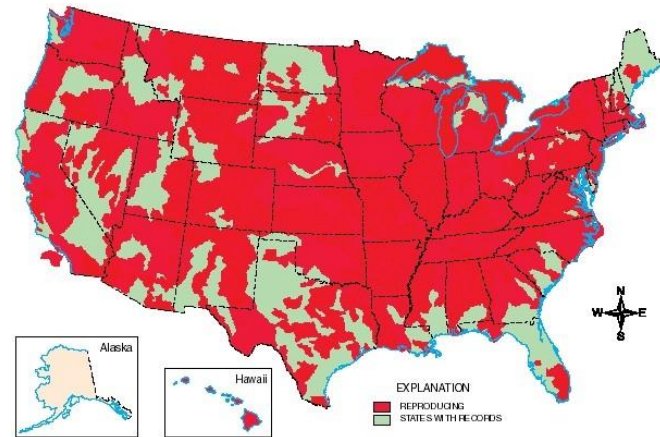
# What to do about carp?



Poison with rotenone



Commercial fishermen



Drawdowns



Something new and different?





# What have we done wrong?

1. Failure to get last adult female and male-
  - 1,000,000 eggs!/fish/year.
2. Failure to prevent new adult carp from entering system.
3. Inattention to the young.
4. **No new science (and too much politics)**

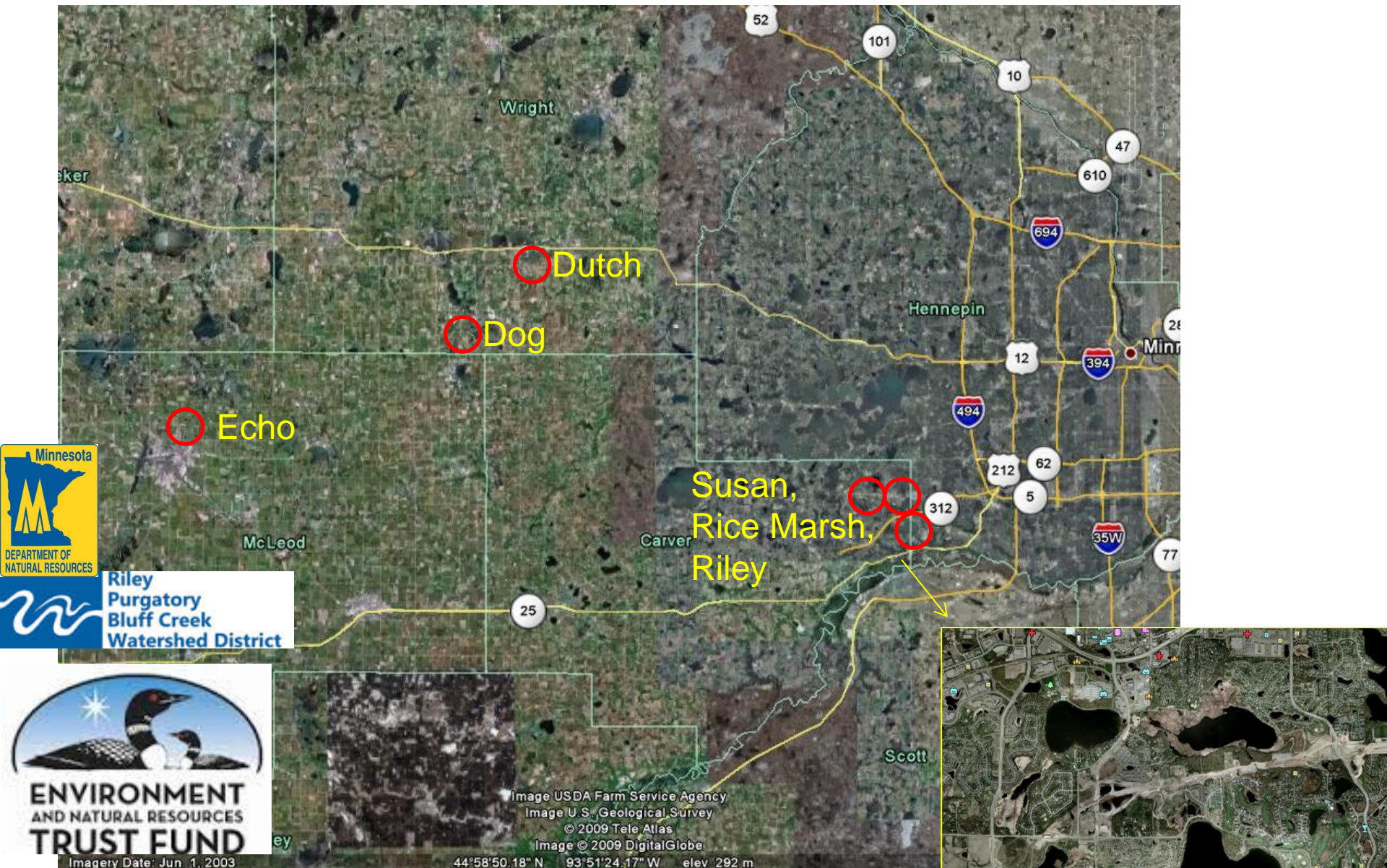
# Starting again - important unknowns: Minnesota research

- 1) How many carp are there in Midwestern lakes and why?
- 2) Exactly how much and what do carp do to water quality?
- 3) Knowing this – can we control them?





# Western Metro Study lakes



about 4 million dollars, 3 postdocs, 2 technicians, 3 MS students, undergrads, 10 years



# How many carp?



# A lot of carp!

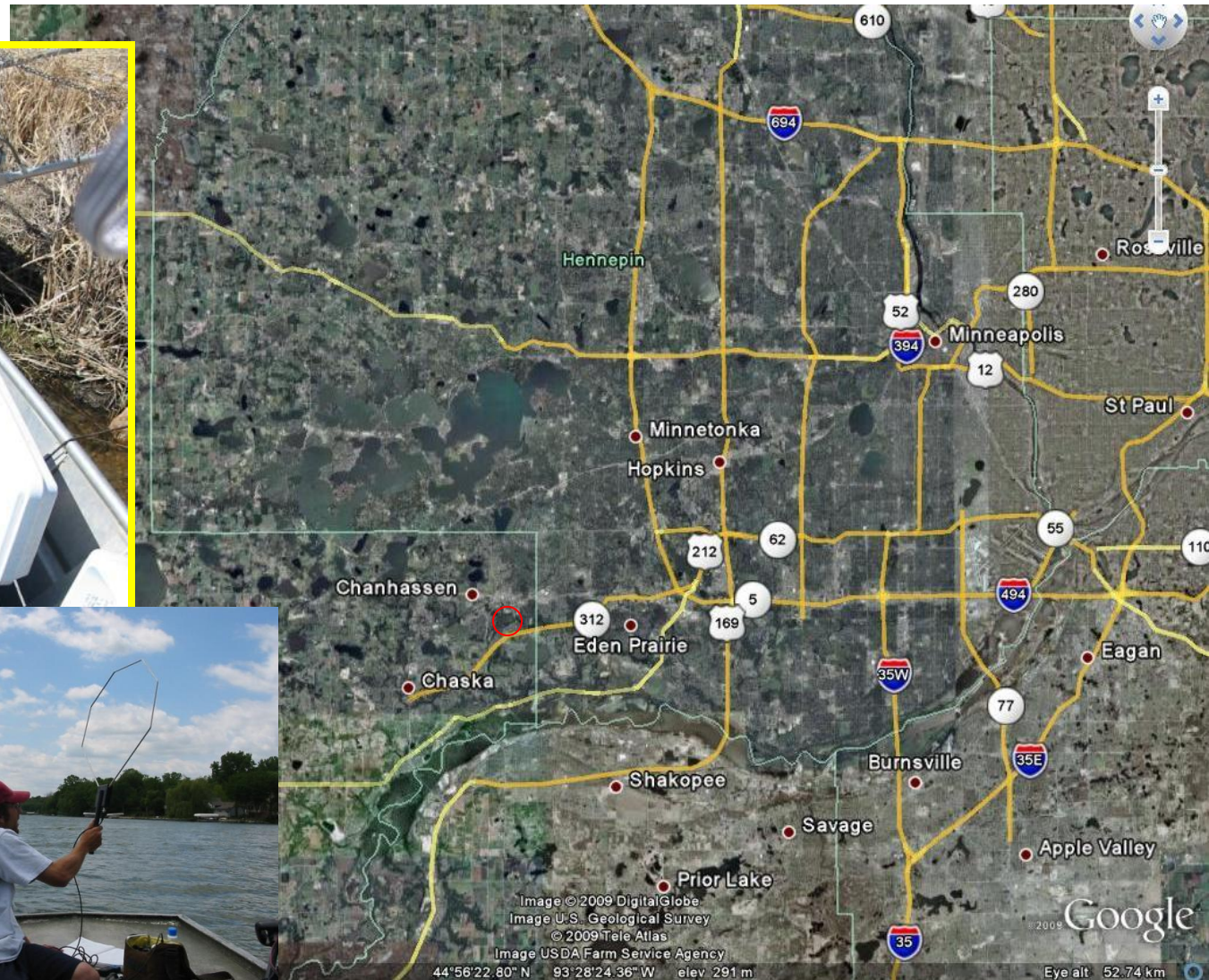
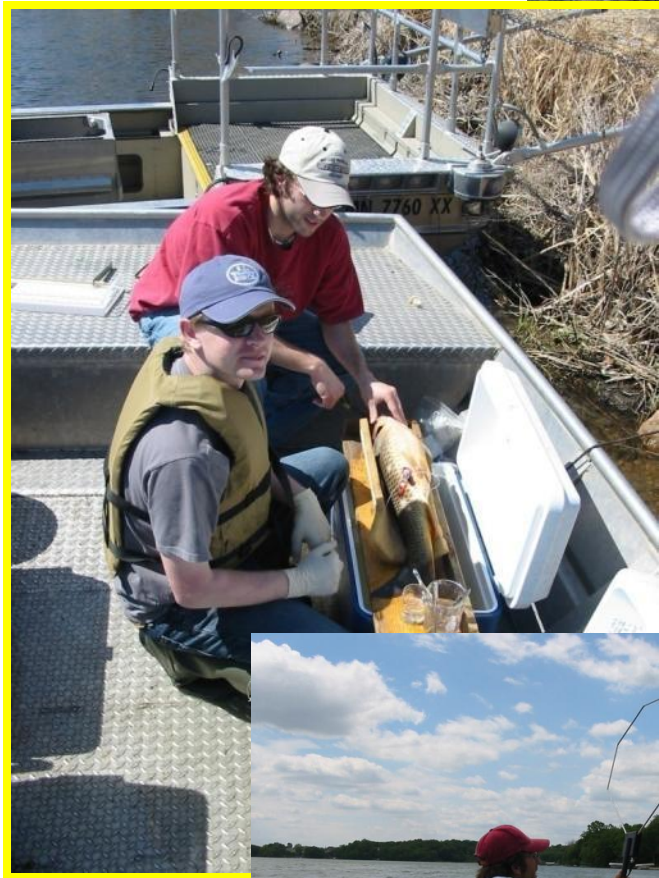
Lake	Sampling sessions	Marked	Recaps	Population Estimate (95% CI)	Biomass kg/ha (lbs/acre)
Dutch	11	2088	122	<b>13,312</b> (11,300 – 16,100)	402 (358)
Echo	13	929	72	<b>8,167</b> (6,244-11,866)	471 (419)
Susan	11	361	15	<b>4,459</b> (3,661-5,700)	338 (301)

• *The numbers of carp exceed those known to cause severe ecological damage (Bajer et al. 2008)*



# Where do they move & Spawn?

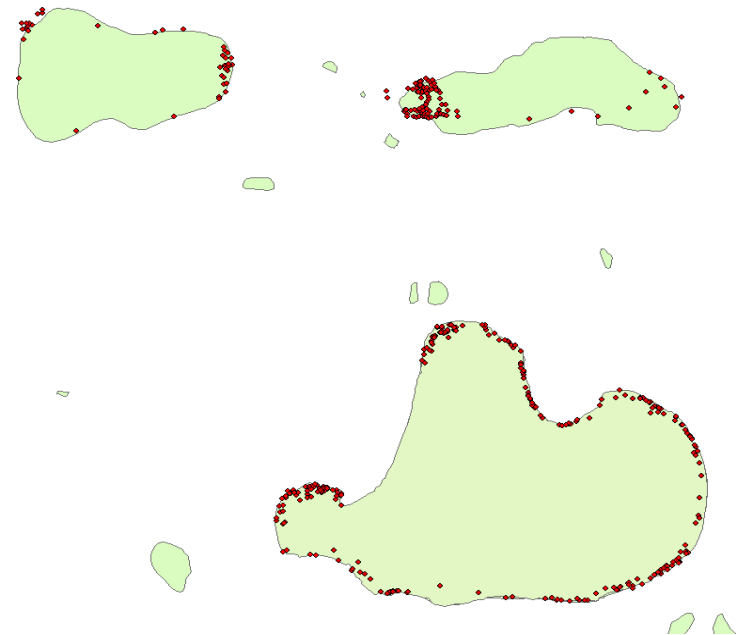
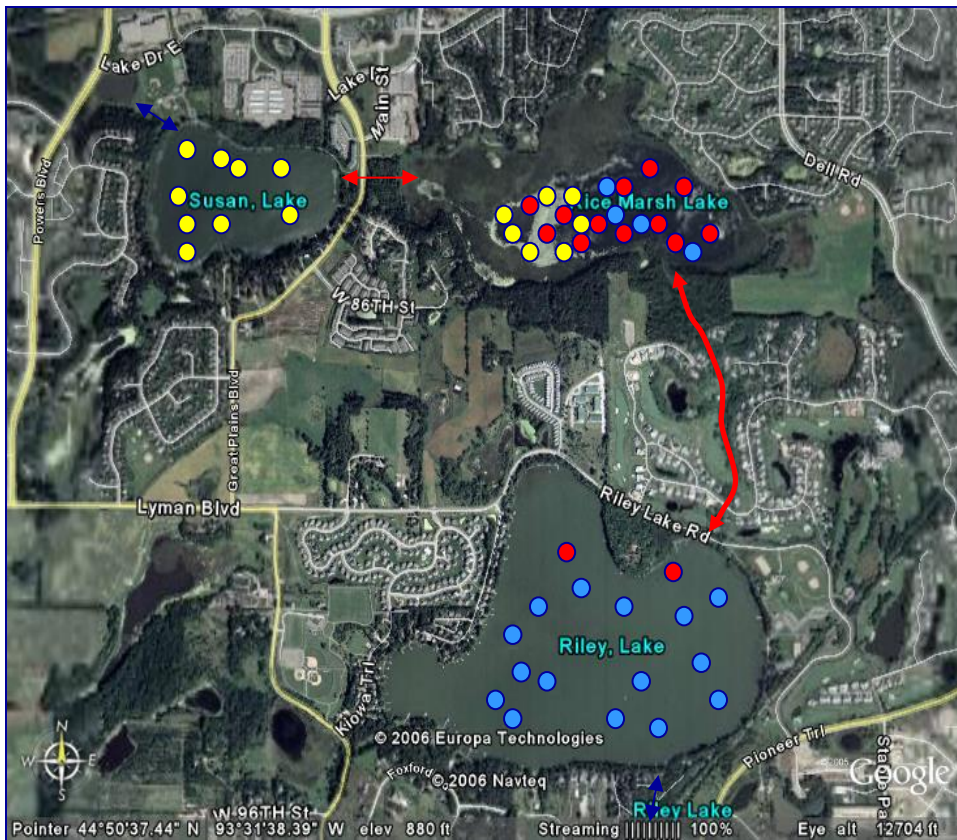
Year-round radio-tracking





# Key results

- NO immigration or emigration
- Approximately 1/3 of adult carp move in/out Rice Lake Marsh to spawn and then return (weakness?)
- But spawn everywhere!
- Winter aggregations of adults



# Rice Marsh Lake?



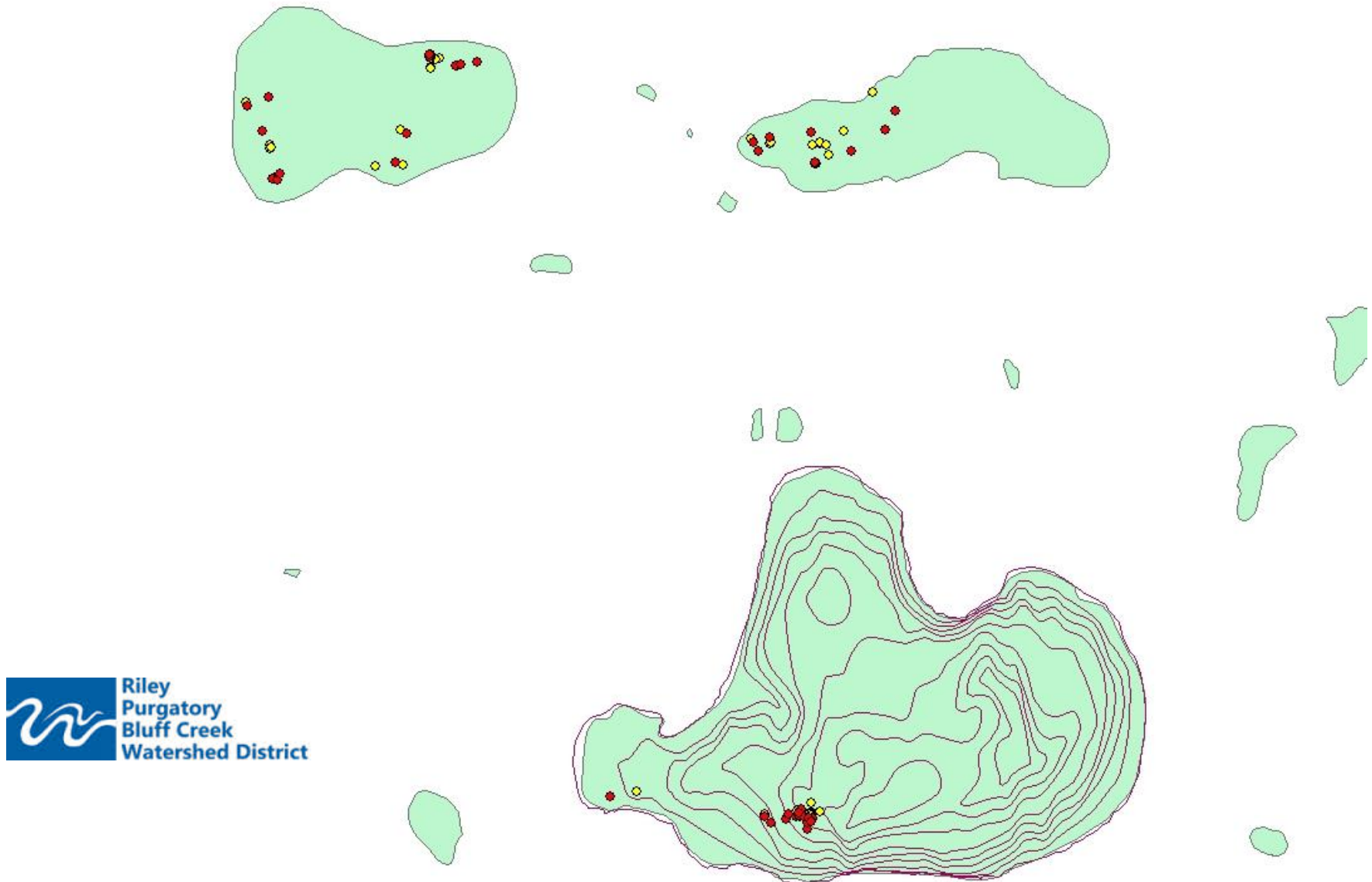
Ignored, Highly degraded because of Human impacts  
(Sewage Treatment plant location)

Winter kills – no fish!

**Lack of Biotic Resistance**



# Ex. Winter aggregations



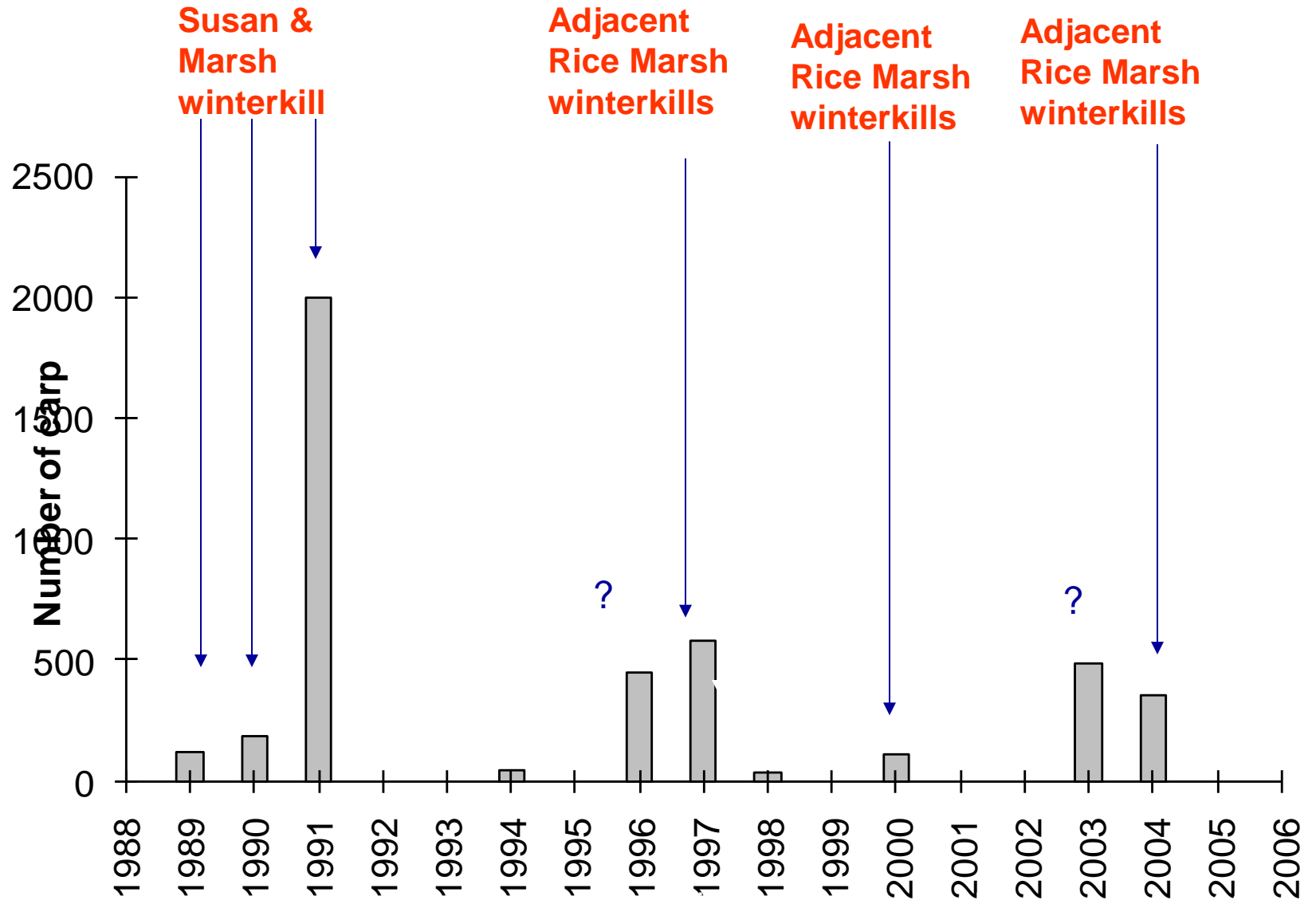
(Bajer et al. 2010 *Fisheries Management and Ecology*)

# How old (and why)?

- Otoliths collected from 100 carp from Susan and Echo
- Sectioned and aged following Brown et al. (2004)
- 3 independent readers, modal age used
- 1<sup>st</sup> and 2<sup>nd</sup> annulus verified using fish of known age



# Recruitment history in Lake Susan





# Why winterkill?

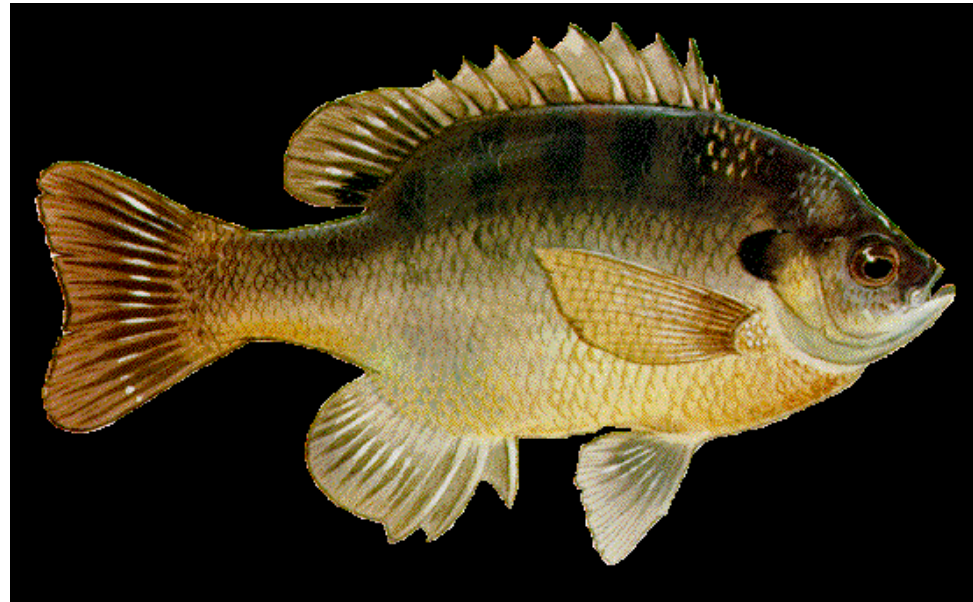
Lakes that winterkill have no predators to eat carp eggs and larvae





# Testing the role of bluegill sunfish and winterkill

1. Juvenile carp should only be found in lakes without bluegill sunfish
2. Bluegill sunfish will eat a lot of carp eggs



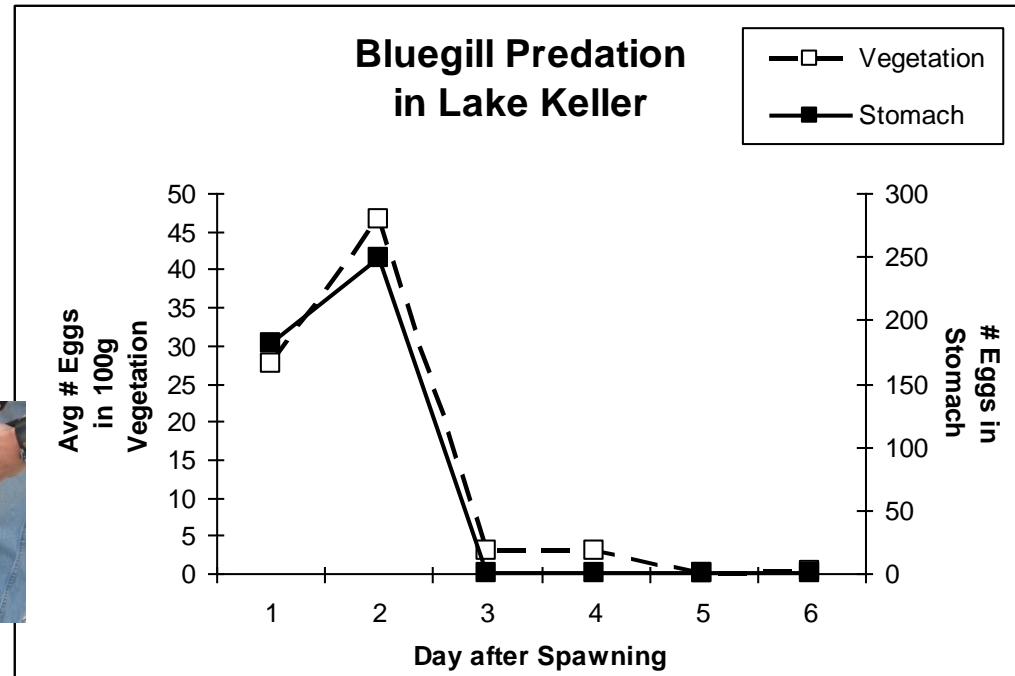
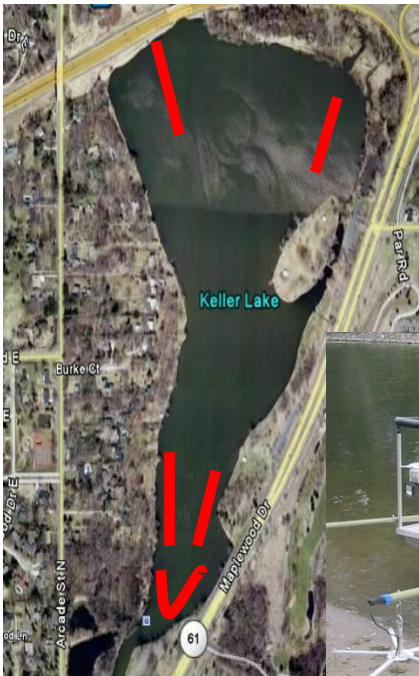
# Testing if bluegill sunfish control carp eggs

Silbernagel & Sorensen 2013

*Lake Keller surveyed for carp spawning and fish*

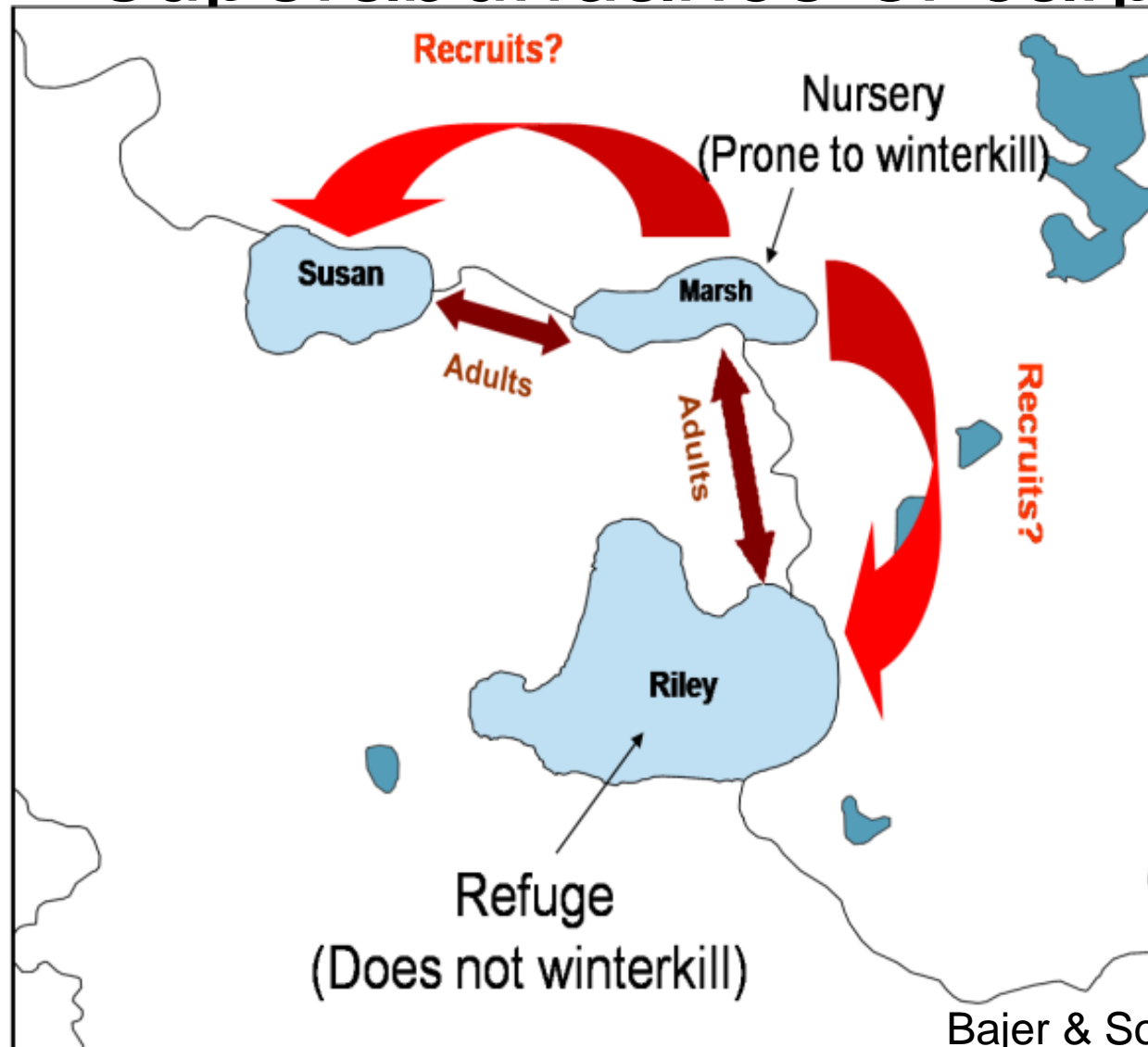
- eggs disappeared within 3 days, prior to hatch

-1000's of eggs found in bluegill sunfish stomachs





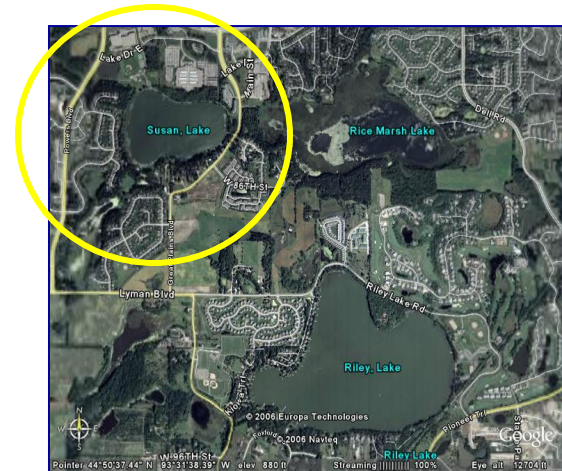
# An hypothesis to explain the superabundance of carp



Bajer & Sorensen (2010)  
Sorensen & Bajer (2011)

# Lake Susan Experiment: Hypotheses

1. Carp can be sustainably removed because:
  - The young come from a single location
  - Adults aggregate and can be targeted
  - Bluegill sunfish will eat eggs/ young in main lakes
  
2. Carp damage lakes, and their removal will:
  - Reduce suspended sediment
  - Allow aquatic plants to recover:
    - Increase water clarity
    - Provide habitat for native fish
    - Permit nutrient management



# Experimental Design

## 1. Monitor pre-removal conditions

-carp and fish abundance, water clarity, plants, nutrients

## 2. Remove a known number of adult carp

## 3. Block recruitment from / in a winterkill nursery

## 4. Monitor for improvement

-carp and fish abundance, water clarity, plants

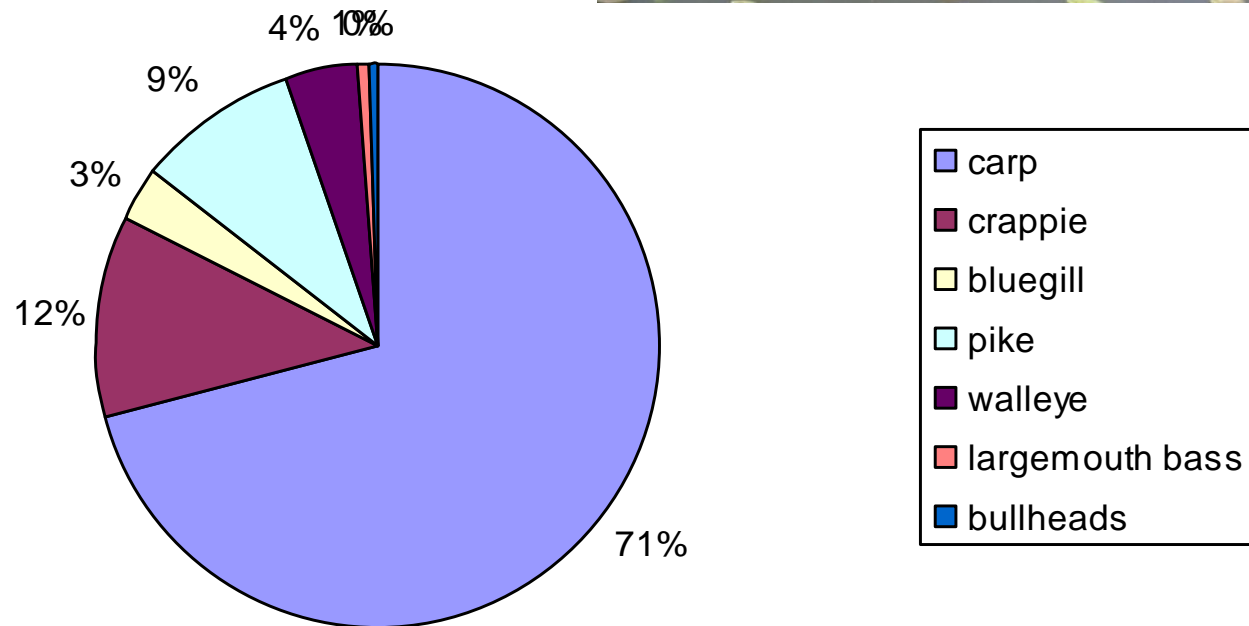
## 5. Develop a strategy forward





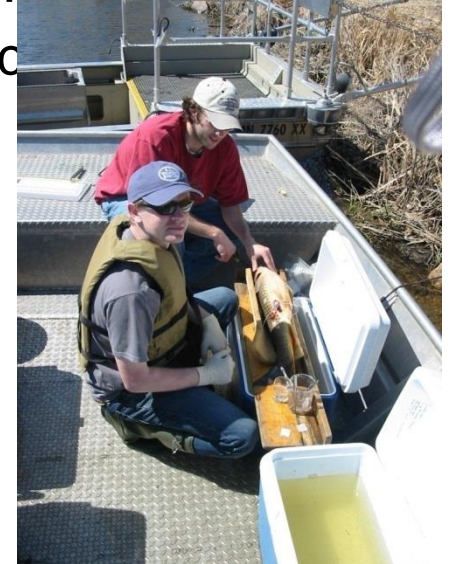
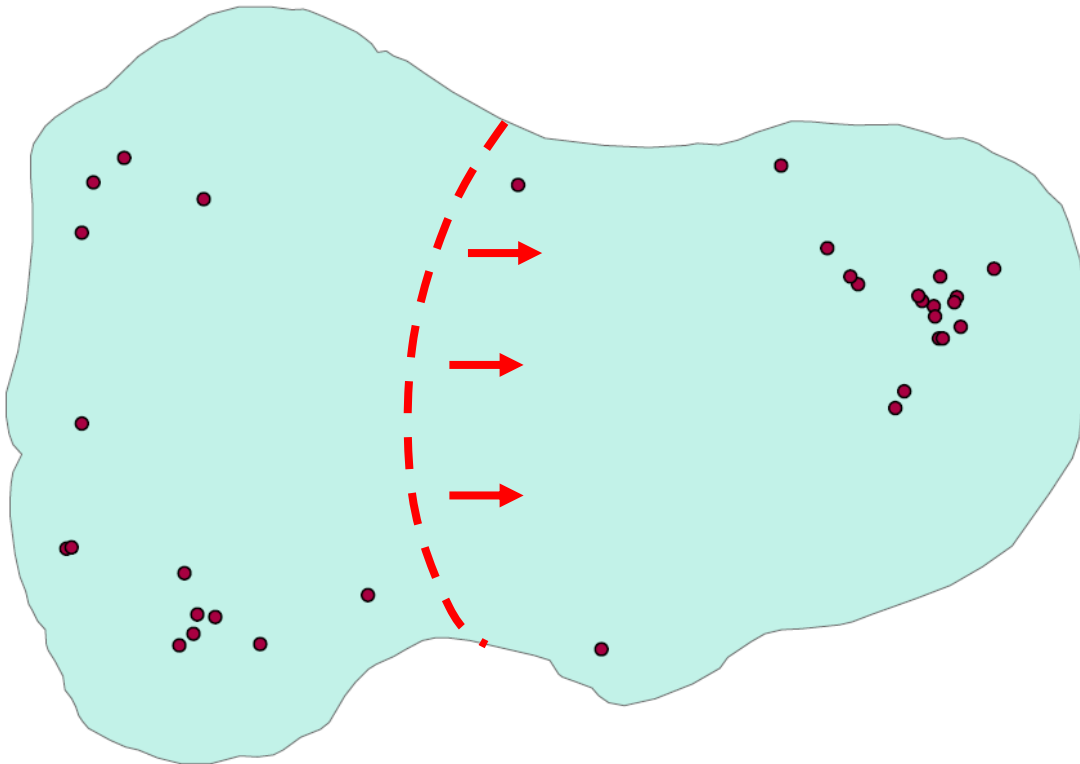
# Lake Susan: pre-removal 2008

- Carp are 70% of fish biomass
- Little vegetation
  - Only a few of the most resilient species
- Water clarity very poor
- Phosphorous high



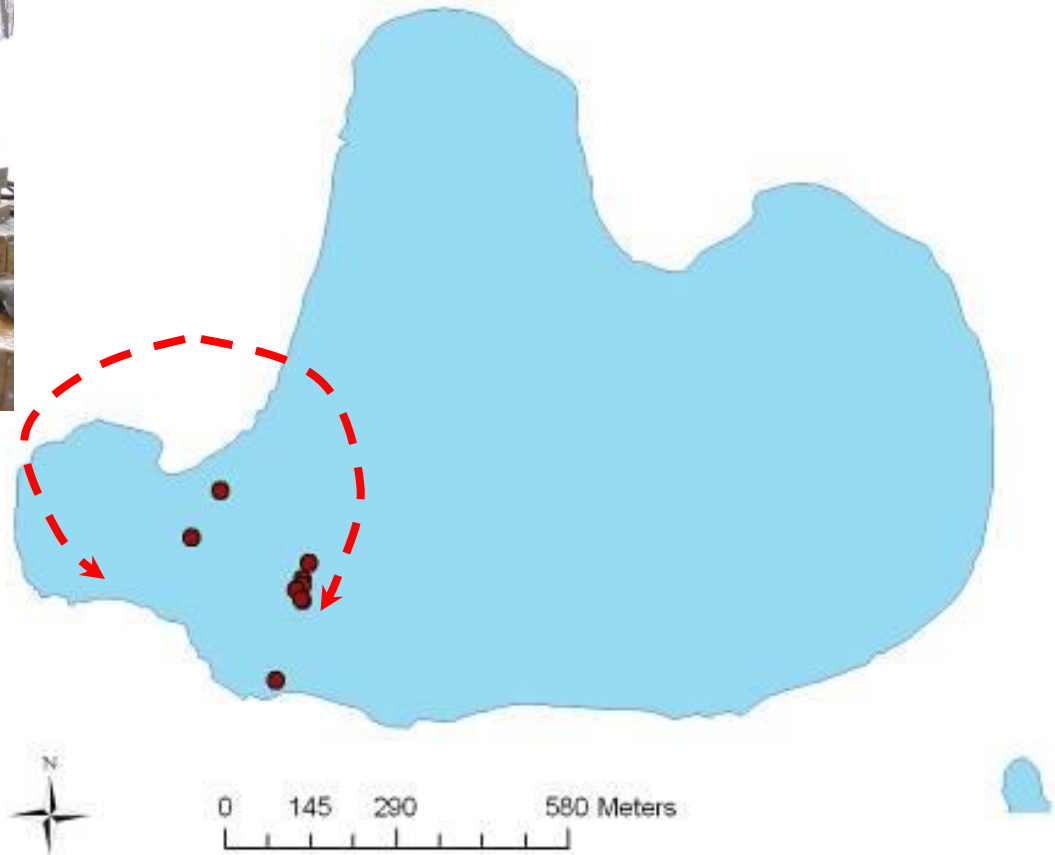
# January 2009: Carp removal

- Carp aggregation located under ice using radio-telemetry
- 3278 adult removed (78% of the population)
  - Biomass reduced from 307 lbs/acre to 90 lbs/acre



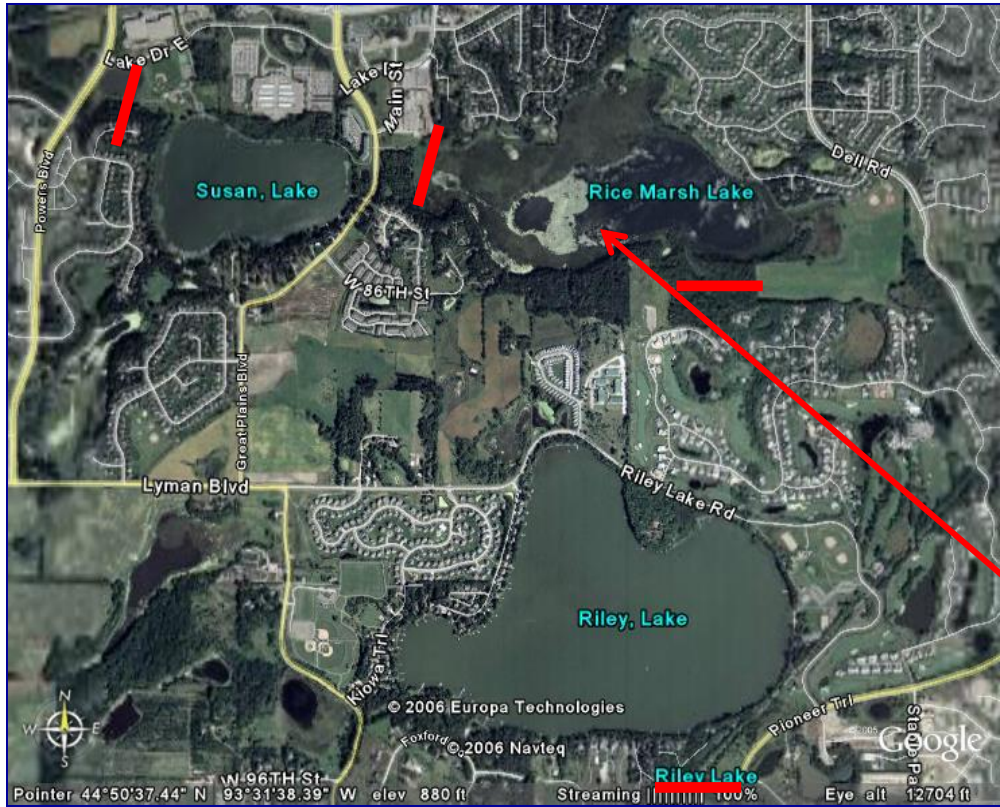
# Removal of carp in Lake Riley

- 94% population removed using Judas fish on 3/5/10



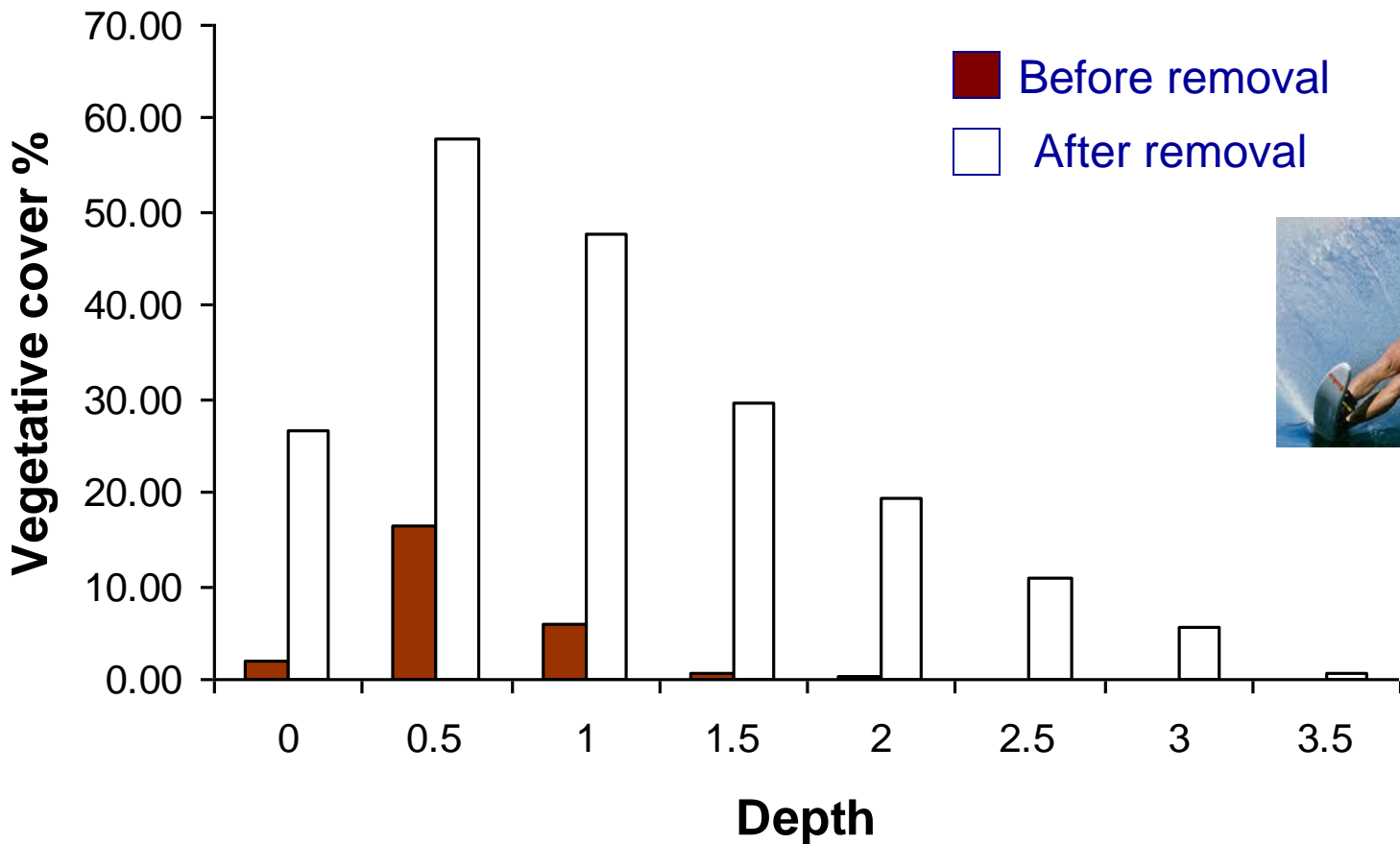


# April 2009: Carp screens and aeration installed to prevent carp recruitment



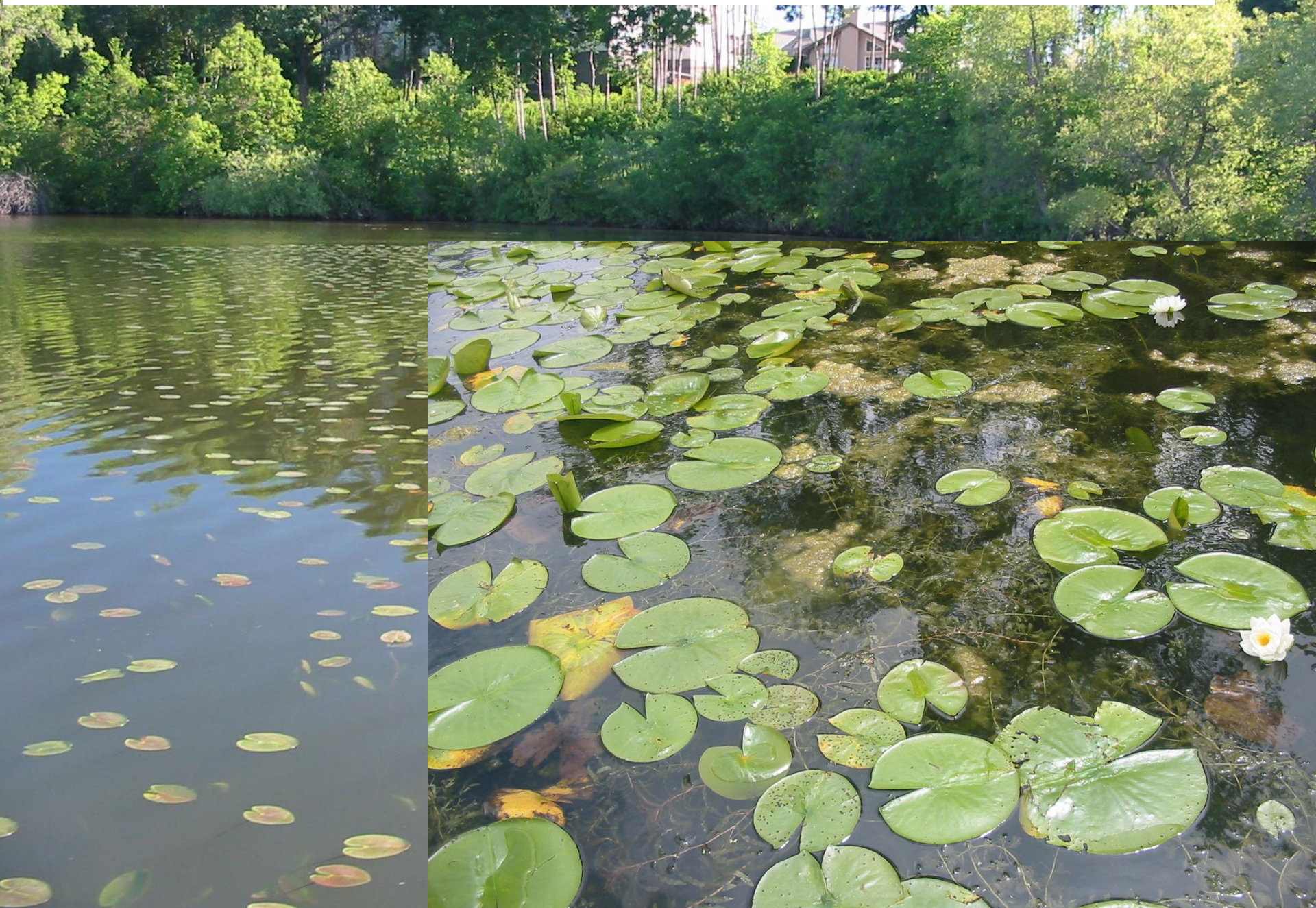
# LAKE SUSAN: RESULTS

## Vegetation increase following carp removal





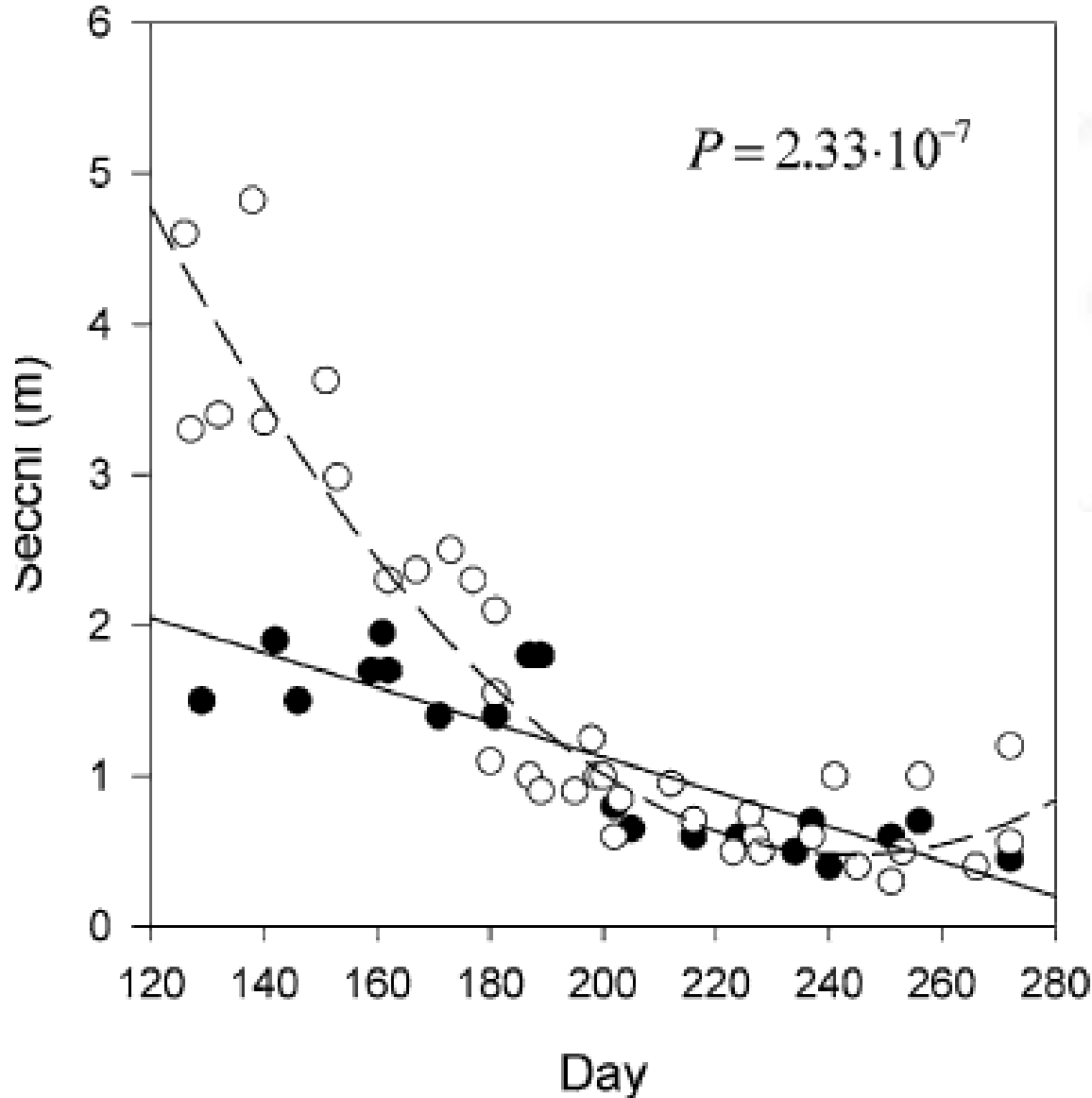
# Water quality in Susan increases in spring





# Water clarity in Susan deteriorates in summer

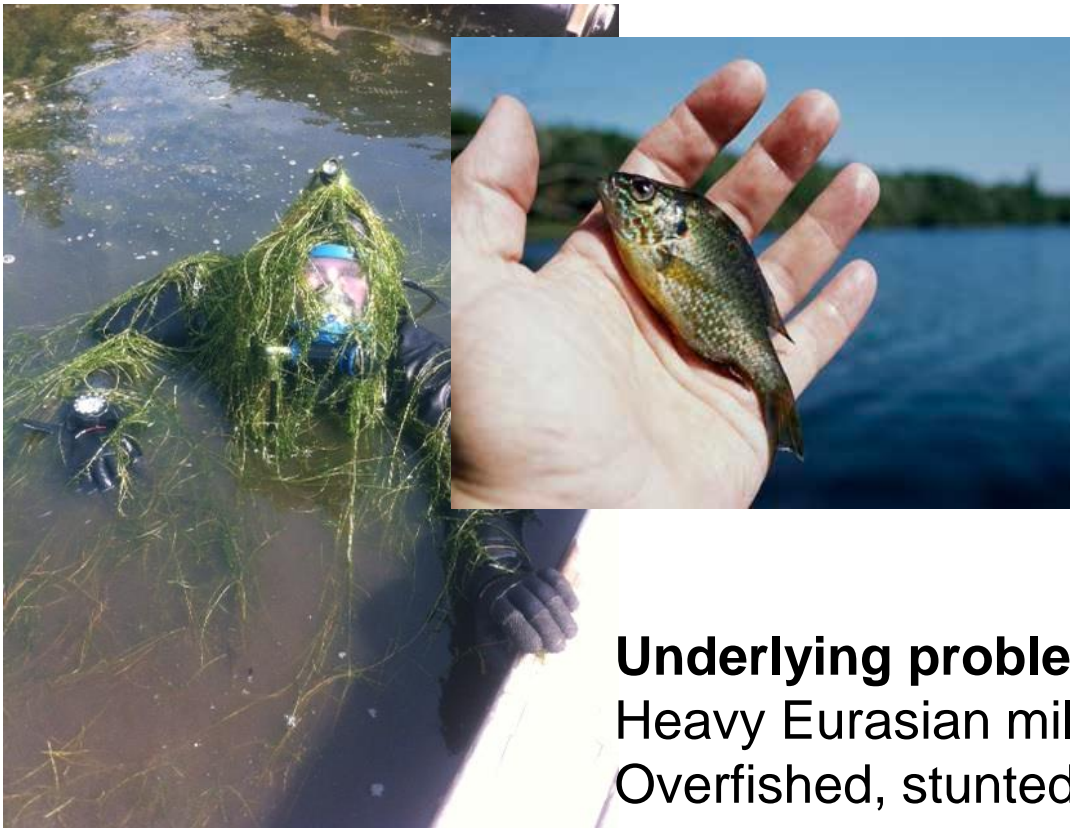
*(Real Problem- TP comes out of sediment)*



# Water quality in Riley does not change



# Lake Riley vs Susan?



## **Underlying problem**

Heavy Eurasian milfoil, few submersed plant

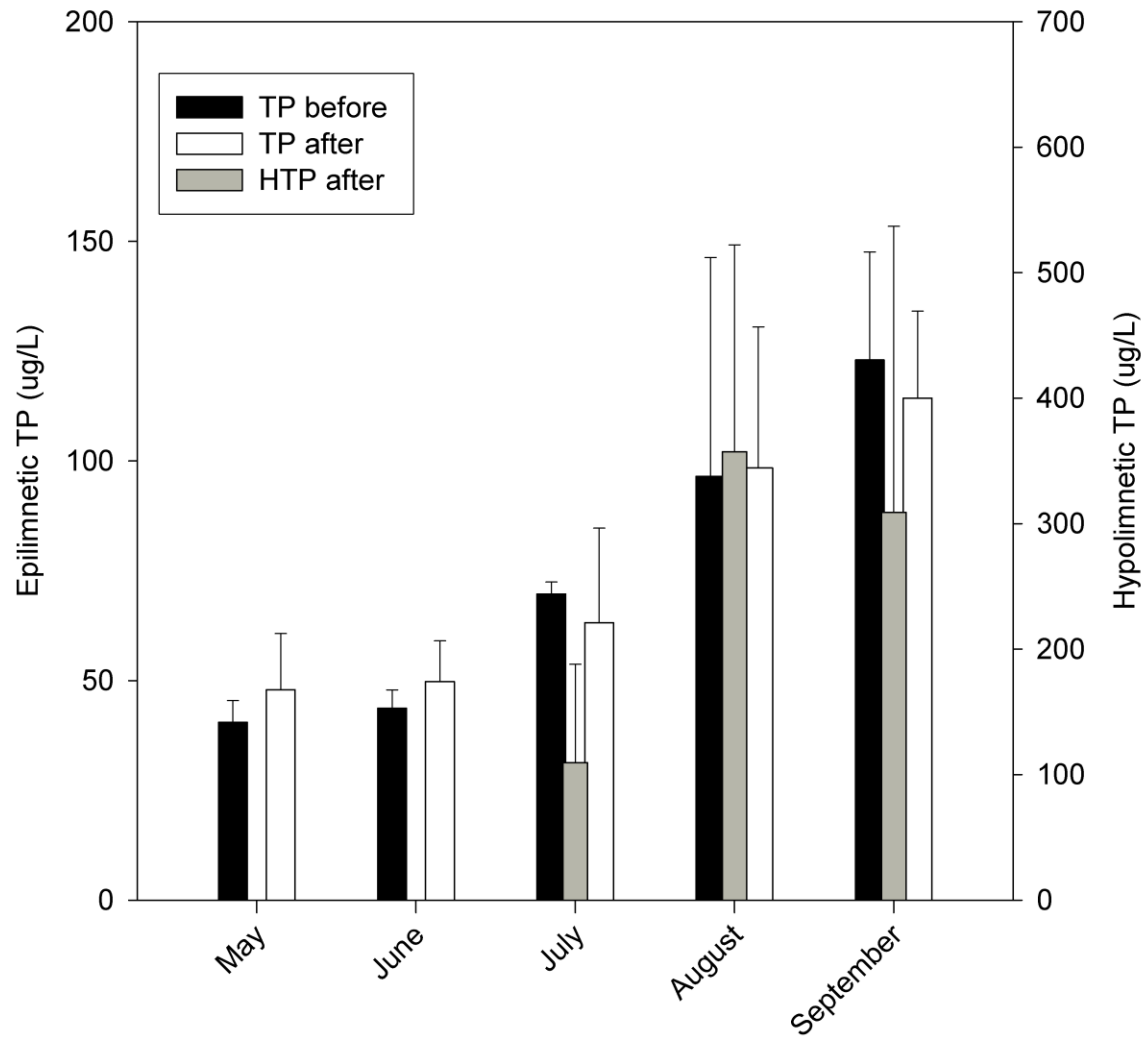
Overfished, stunted bluegills

High bottom nutrients

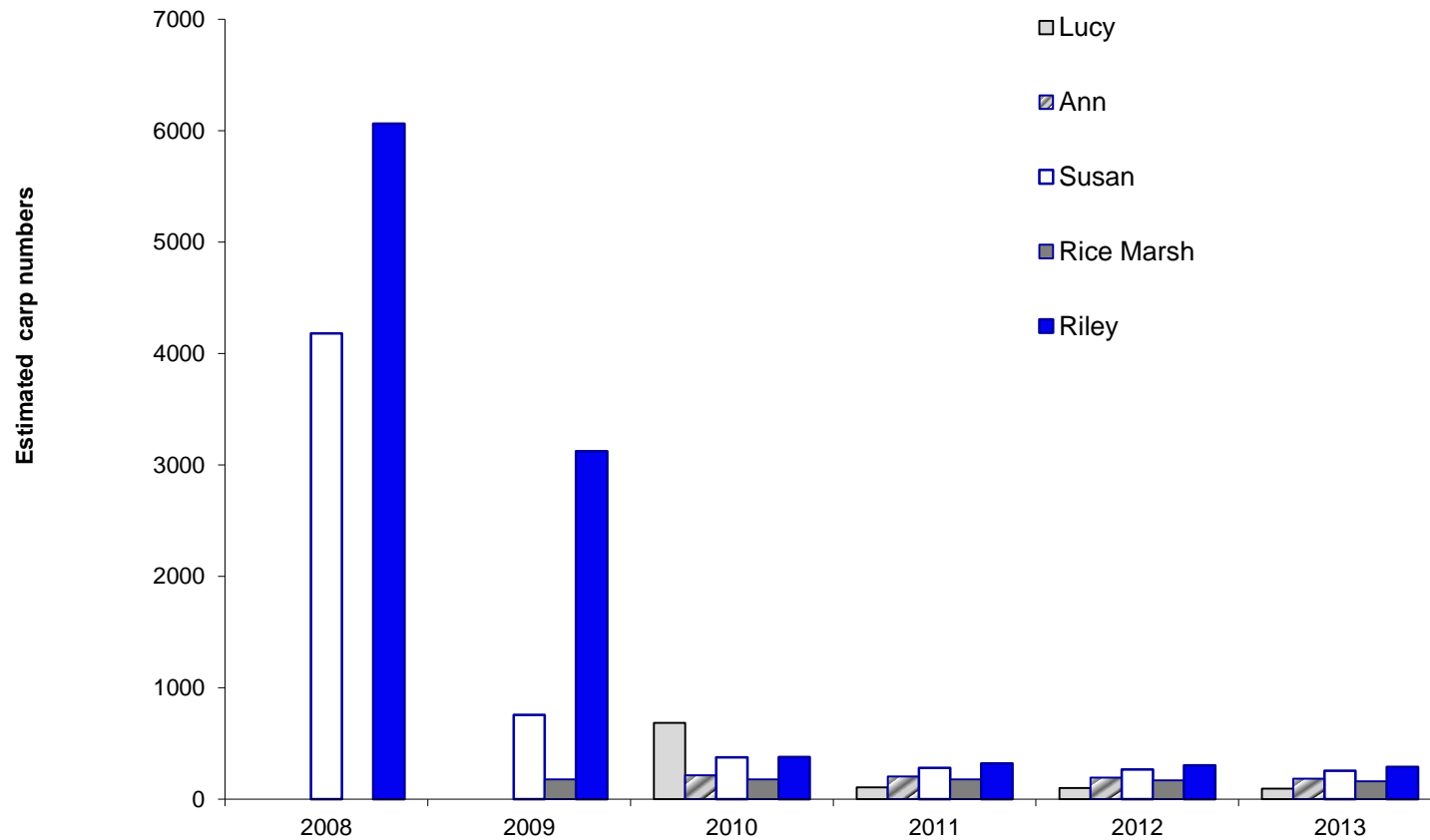
(Lake is in another ecological state)



# Nutrients do not improve...



# Carp biomass stays low

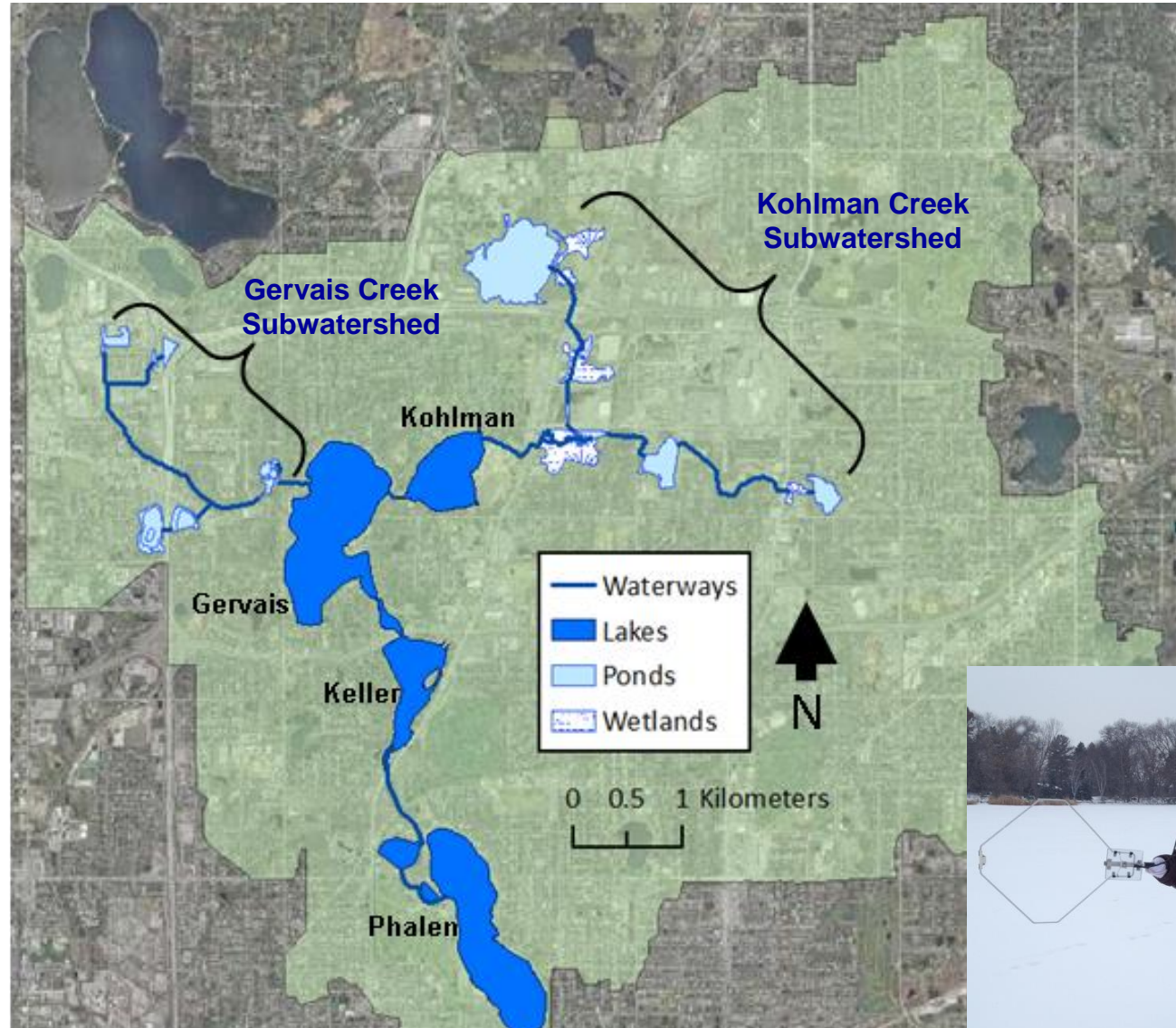


# Mini Summary

- - 4 years
- - 1.5 million\$ (these 2 100ha lakes)
- - Problem was degraded wetlands
- - 1 lake experiences sustainable increases in clarity, 1 does not.
- - plants do well (including invasives)



# Phalen Chain Watershed

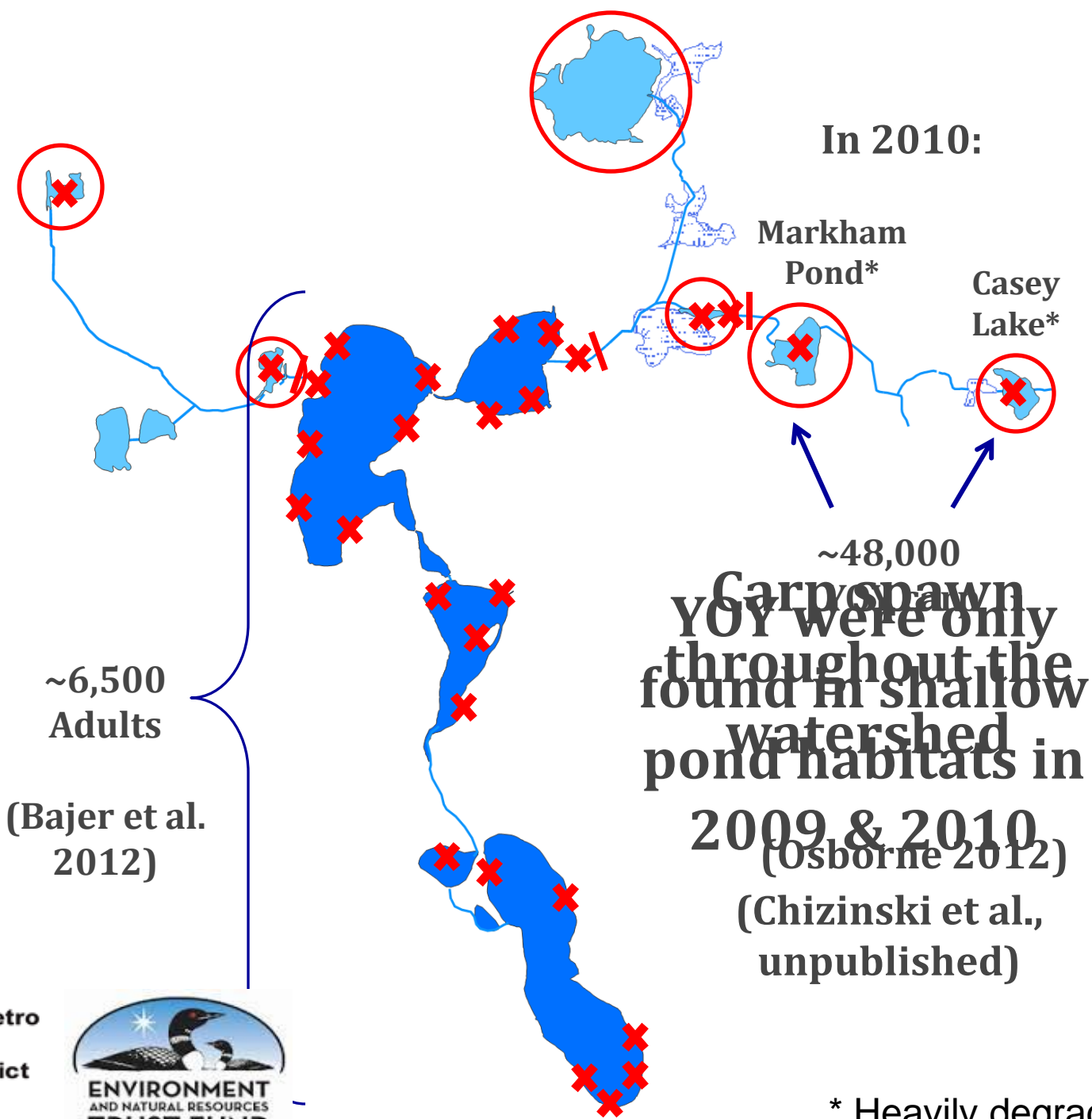


Ramsey-Washington Metro  
*Watershed* District

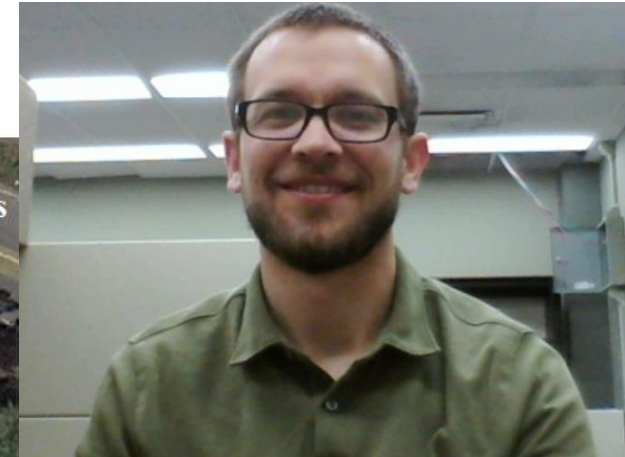
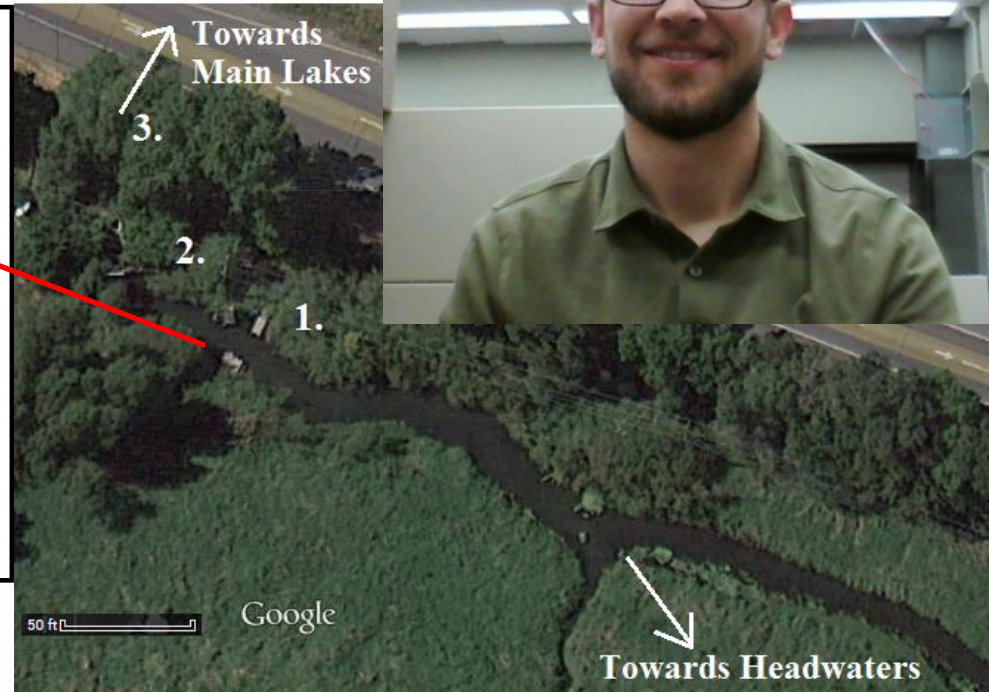
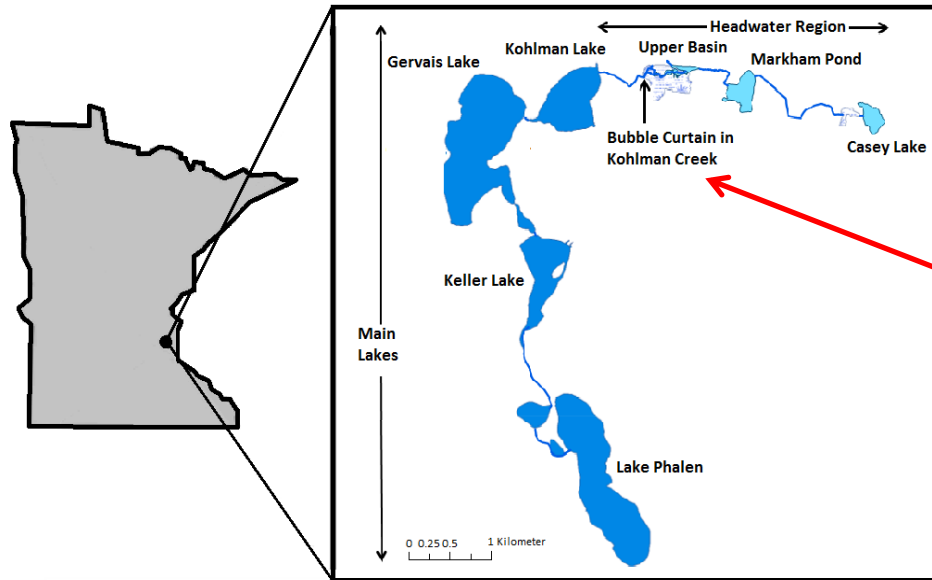


5 years , 1.2 million \$, 3 MS students, 1 postdoc, 1 tech

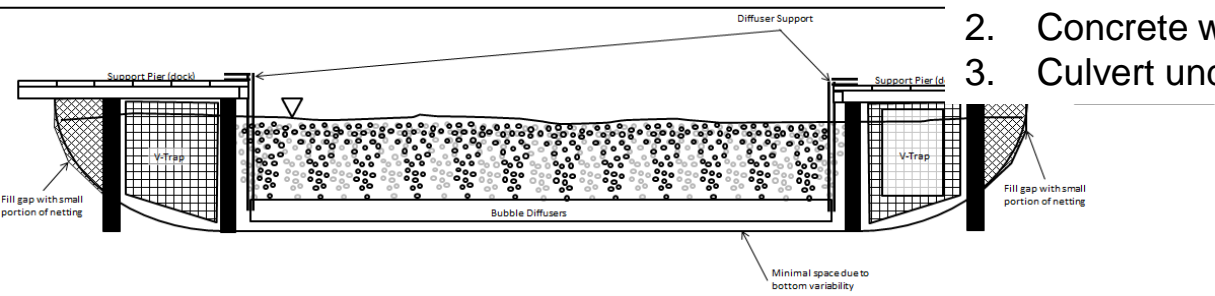
# Common carp in the Phalen Chain



# Spawning Block: Bubble curtain



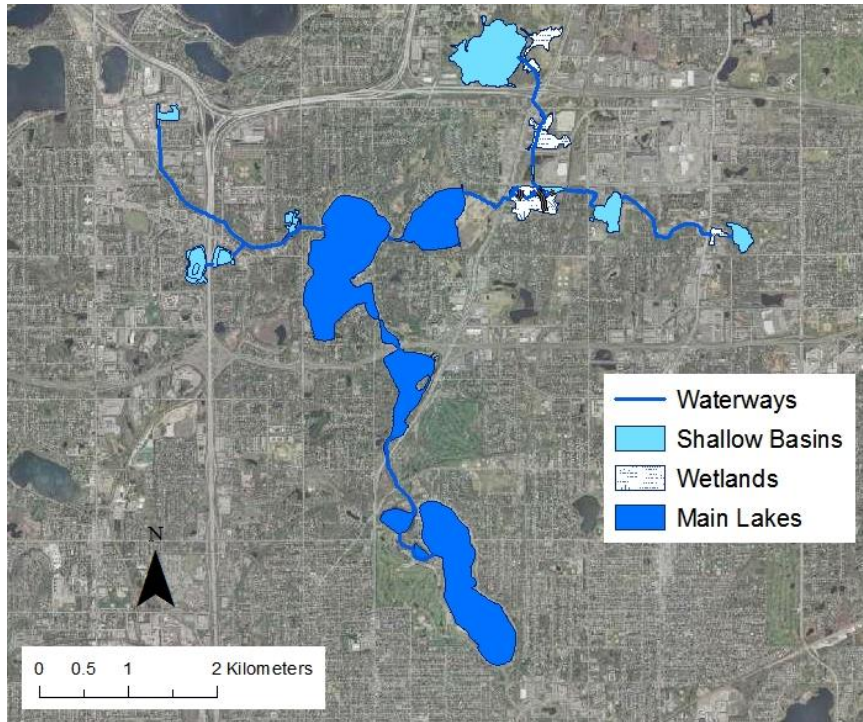
1. Bubble curtain
2. Concrete weir and temporary fish screen
3. Culvert under Hwy 61





# Recruitment Suppression: Headwaters

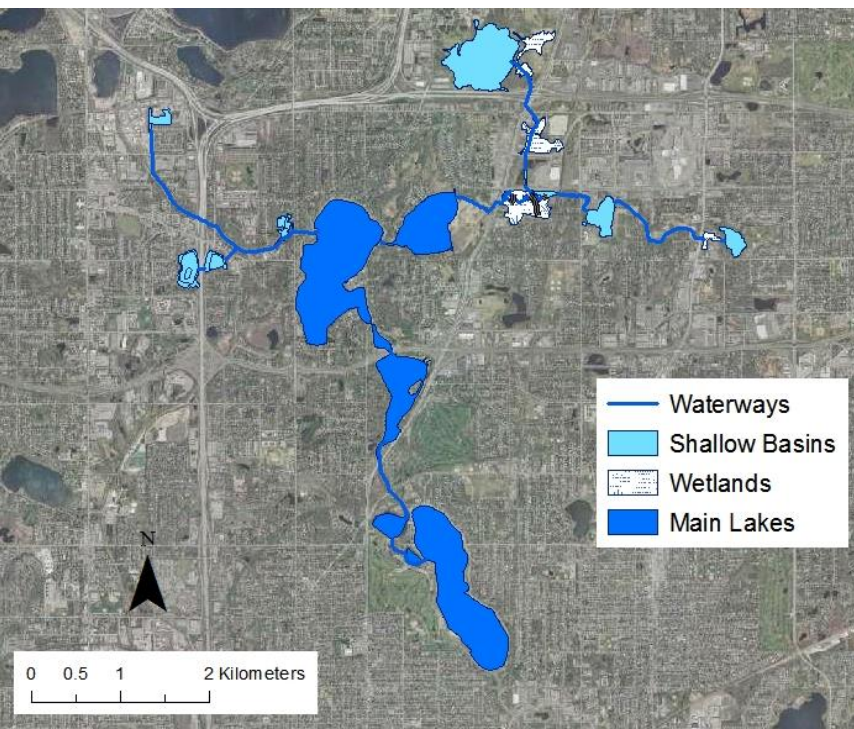
-Lakes Casey restoration



*Casey*

# Adult removal in main lakes

- Seining winter aggregations
- Baited box net (summer)
- Spawning runs



# Carp now sustainably controlled

## Starting Point in 2009:

Lake	Abundance	Biomass (kg/ha)*
Kohlman	1,825 ± 355	207
Gervais	3,976 ± 773	143
Keller	2,239 ± 435	262
Phalen	2,307(?)	98 (?)

**8,041 ± 1,563**  
**(177 kg/ha)**

\*Based on average weight of 3.4kg

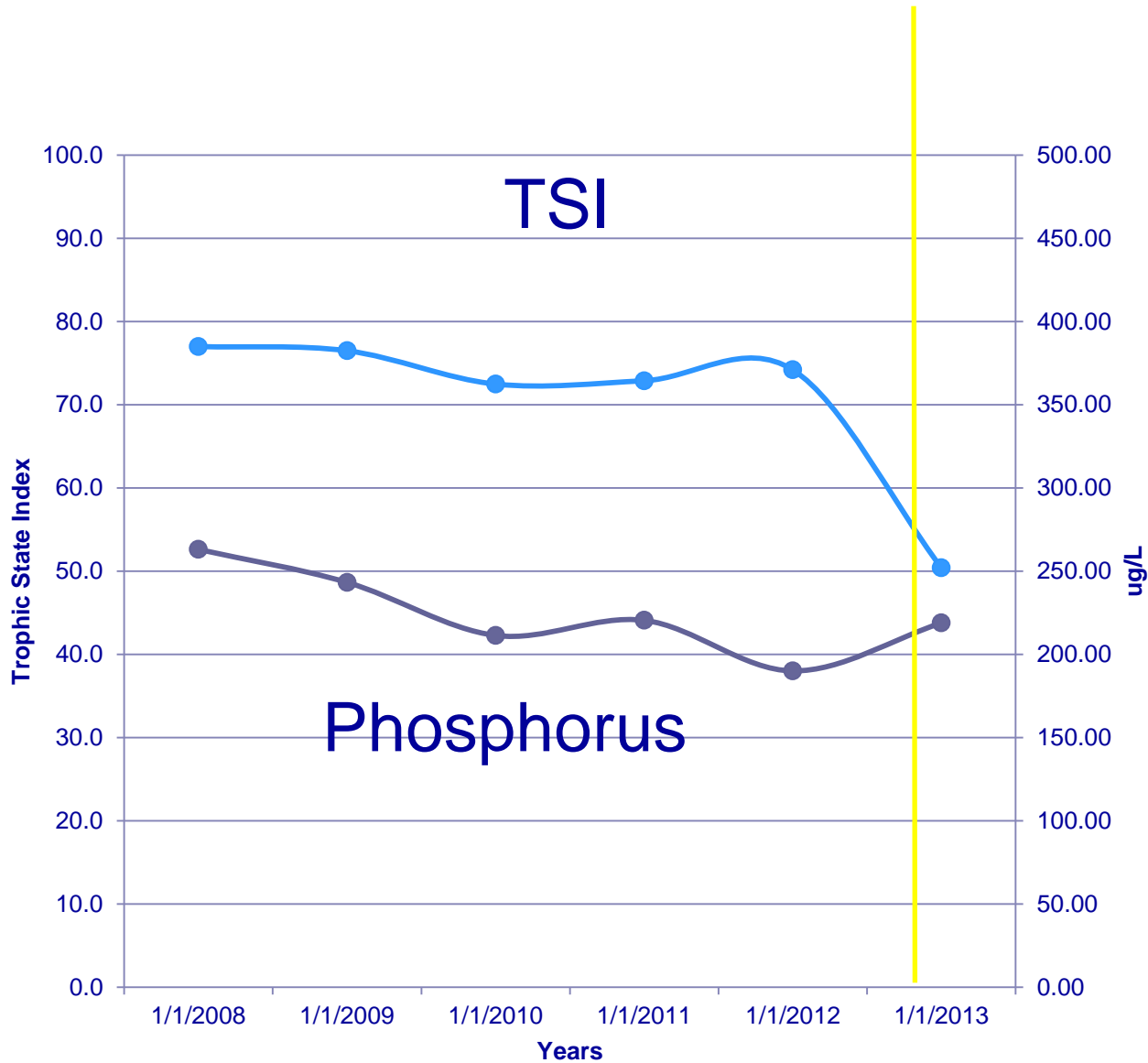
## 2014 Population Estimates:

Lake	Abundance	Biomass (kg/ha)
Kohlman	417 ± 355	47
Gervais	2,134 ± 773	77
Keller	382 ± 435	45
Phalen	1,700 (1,300–2,600)	72 (56-110)

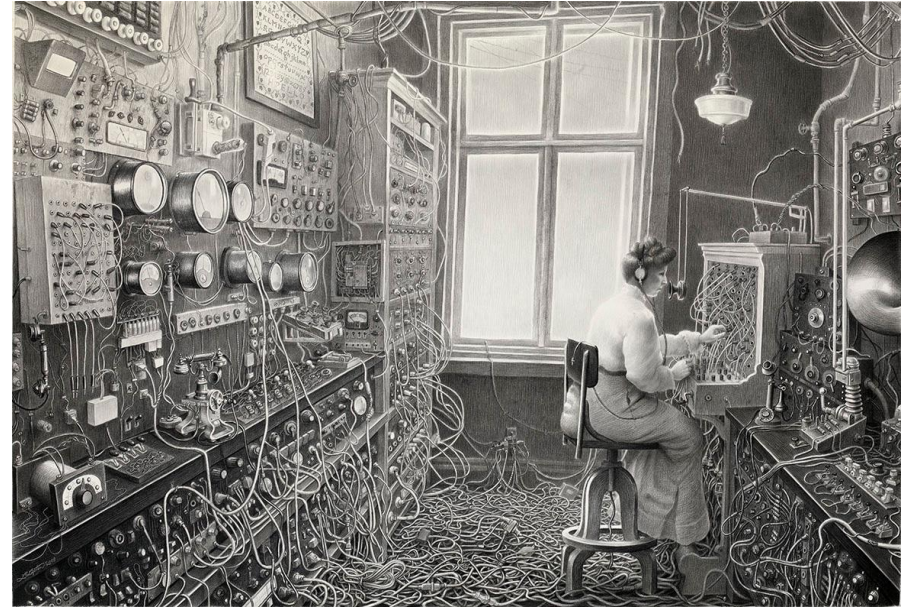
**2,933 ± 1,563**  
**(61 ± 32 kg/ha)**



# Casey Lake



# Lessons from Common Carp



# The Best Answer for Common carp would have been??

Prevention

Protection  
*(Refuge areas)*

Control

- Habitat restoration
- Recruitment control
- Adult removal
- Ecosystem management



*Questions , Comments?*

# 'Carp'

'Eurasia'



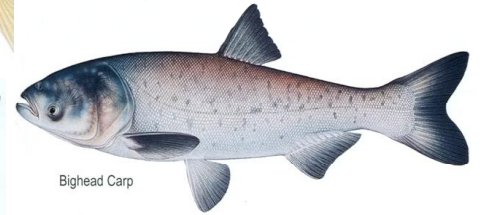
India



'Asia'



Black Carp



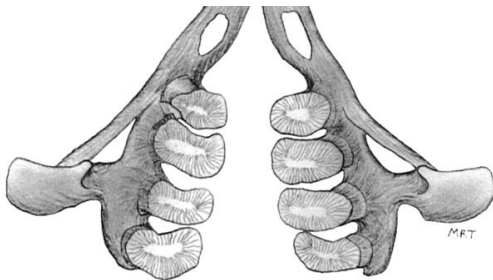
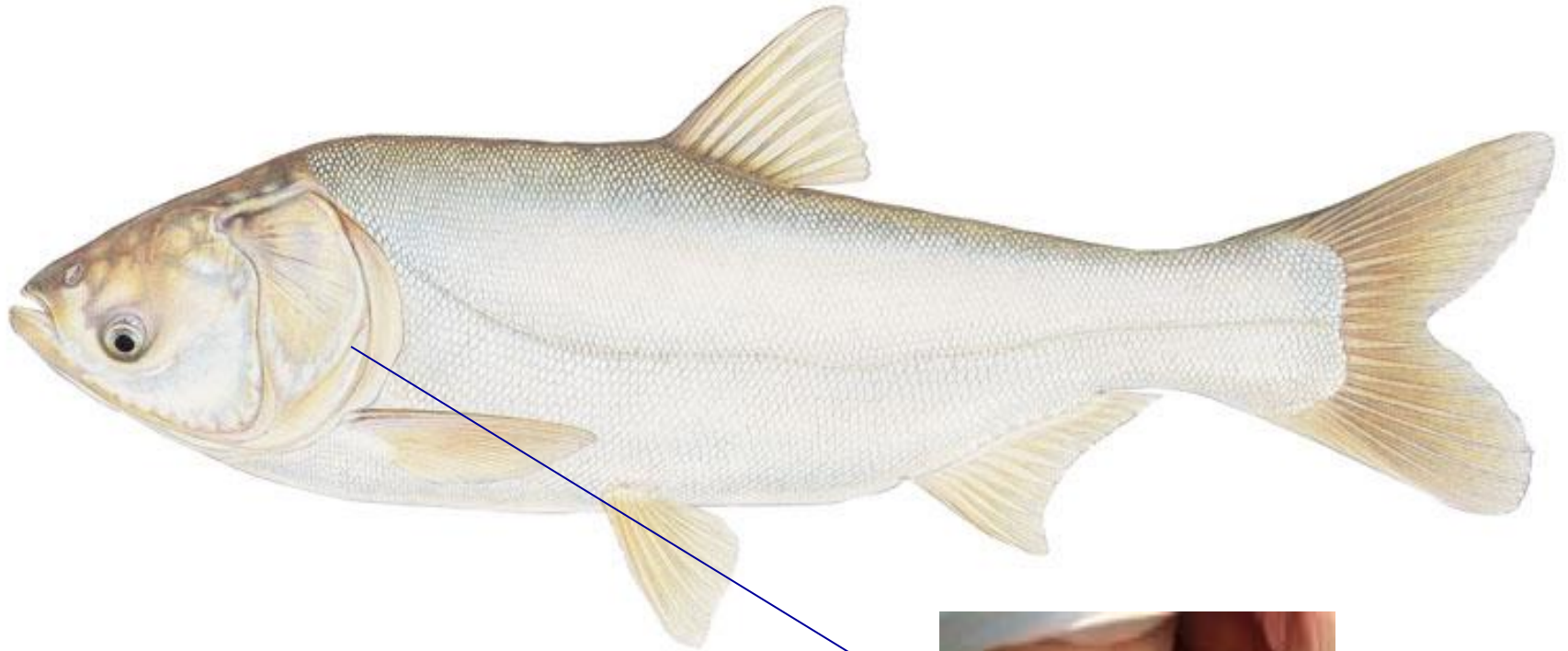
Bighead Carp



Grass Carp

# 'Silver Carp'

*Hypophthalmichthys molitrix*



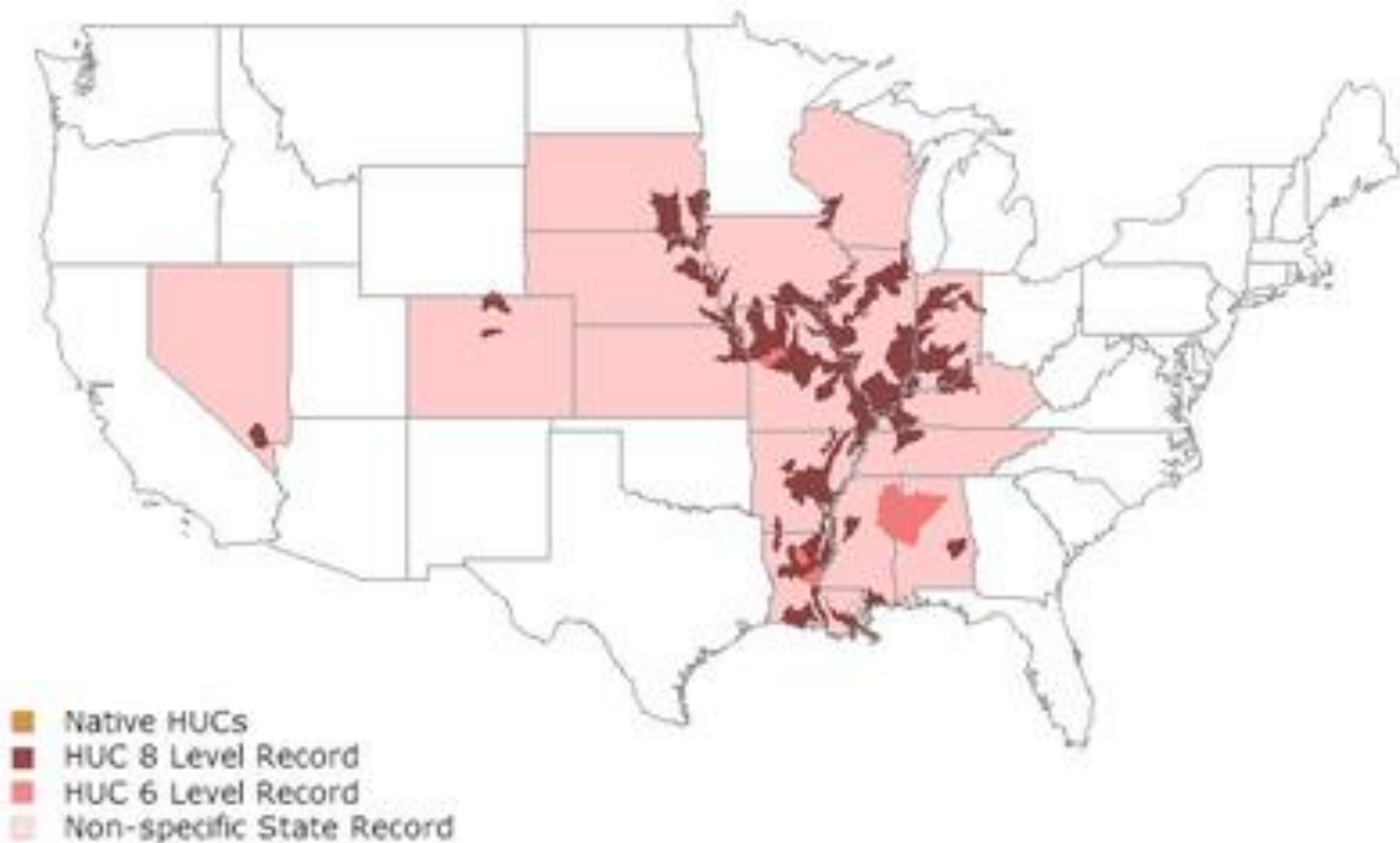
10 microns



# Silver carp today



*Hypophthalmichthys molitrix*



Map created on 6/8/2011, United States Geological Survey

# How did this happen?



# 1963:

US Fish & Wildlife Service wonders how to solve invasive plant problem after prompting by public imports grass carp!



Photo: "Draft Management and Control Plan for Asian Carps in the United States," April 2006

The first grass carp shipment from Malaysia was delivered on Nov. 16, 1963, at the U.S. Fish and Wildlife Service laboratory at Stuttgart, Ark.



Grass Carp



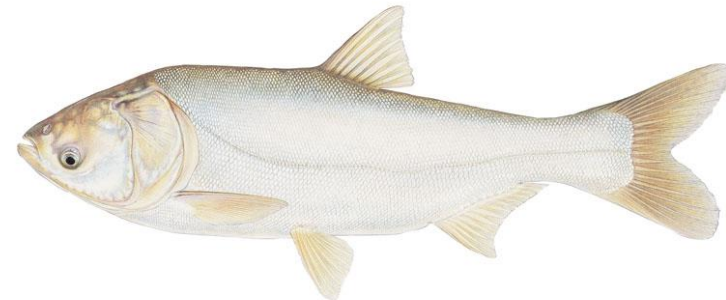
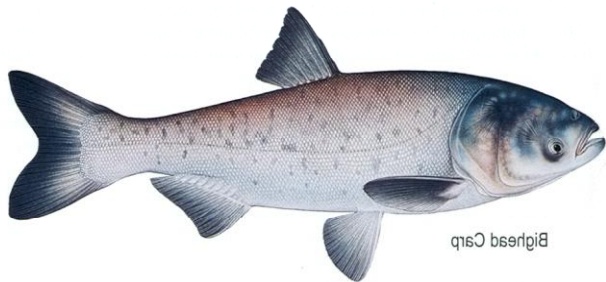


# 1973: Fish farmer imports Bighead and Silver carps



Photo: "Draft Management and Control Plan for Asian Carps in the United States," April 2006

The first grass carp shipment from Malaysia was delivered on Nov. 16, 1963, at the U.S. Fish and Wildlife Service laboratory at Stuttgart, Ark.



# 1974

Arkansas Fish and Game buys Bighead and Silver carps and starting breeding them



# 1976

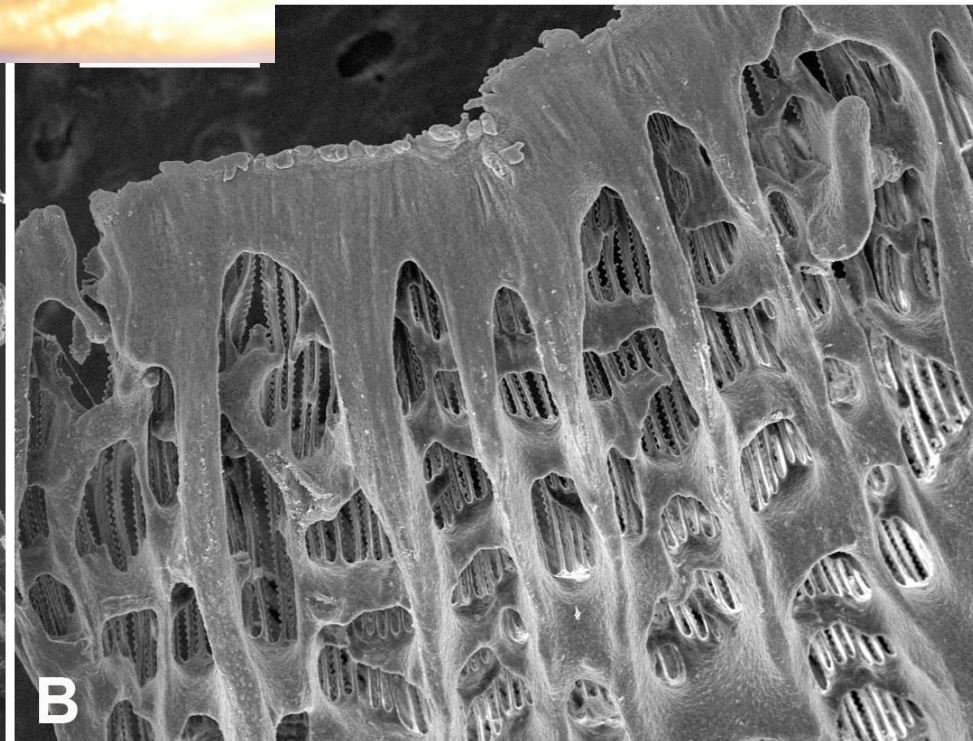
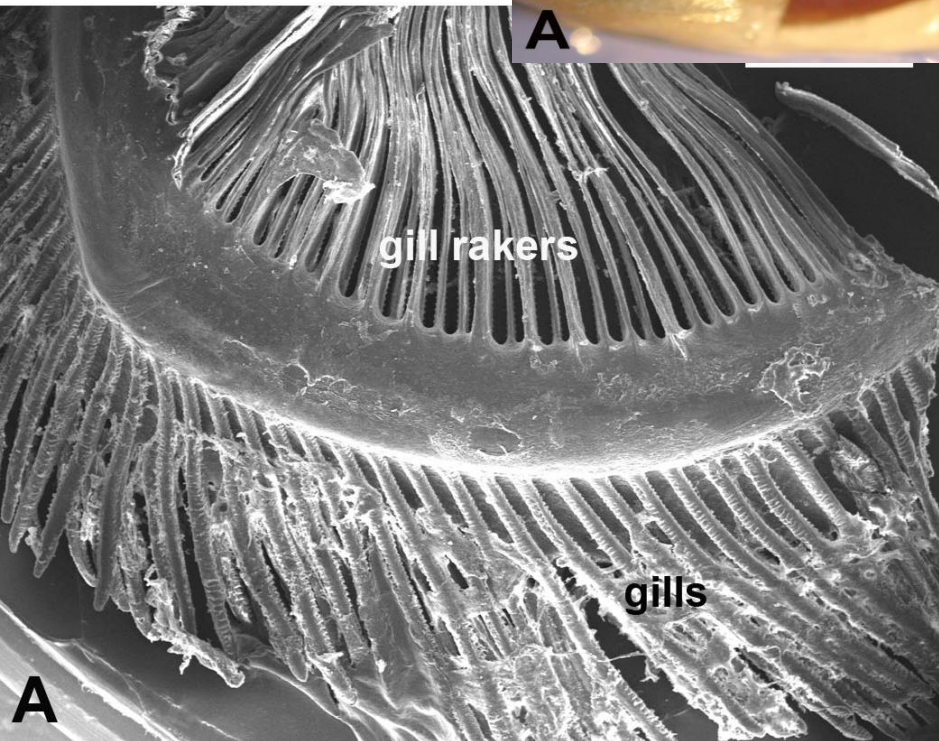
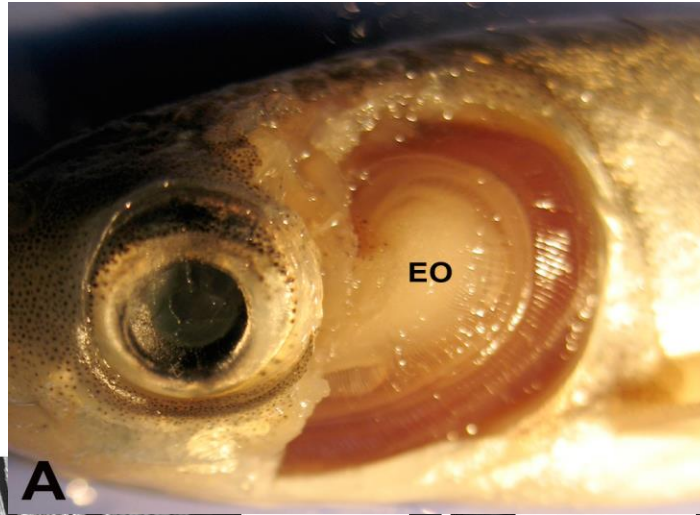
Arkansas Fish and Game stocks Bighead and Silver carps with funding from the US EPA to clean up sewage treatment ponds





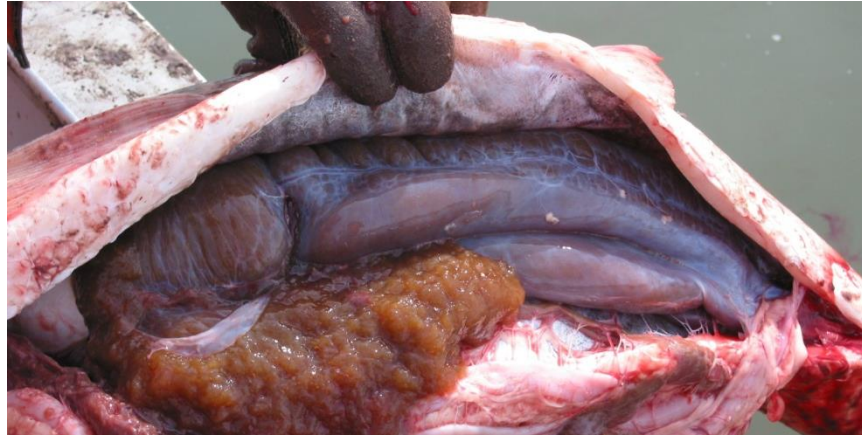
# Why did they do this?

(Highly specialized filter feeding apparatus)





# Fecund!



Large Asian carps of all species are capable of producing hundreds of thousands, sometimes millions, of eggs each year:

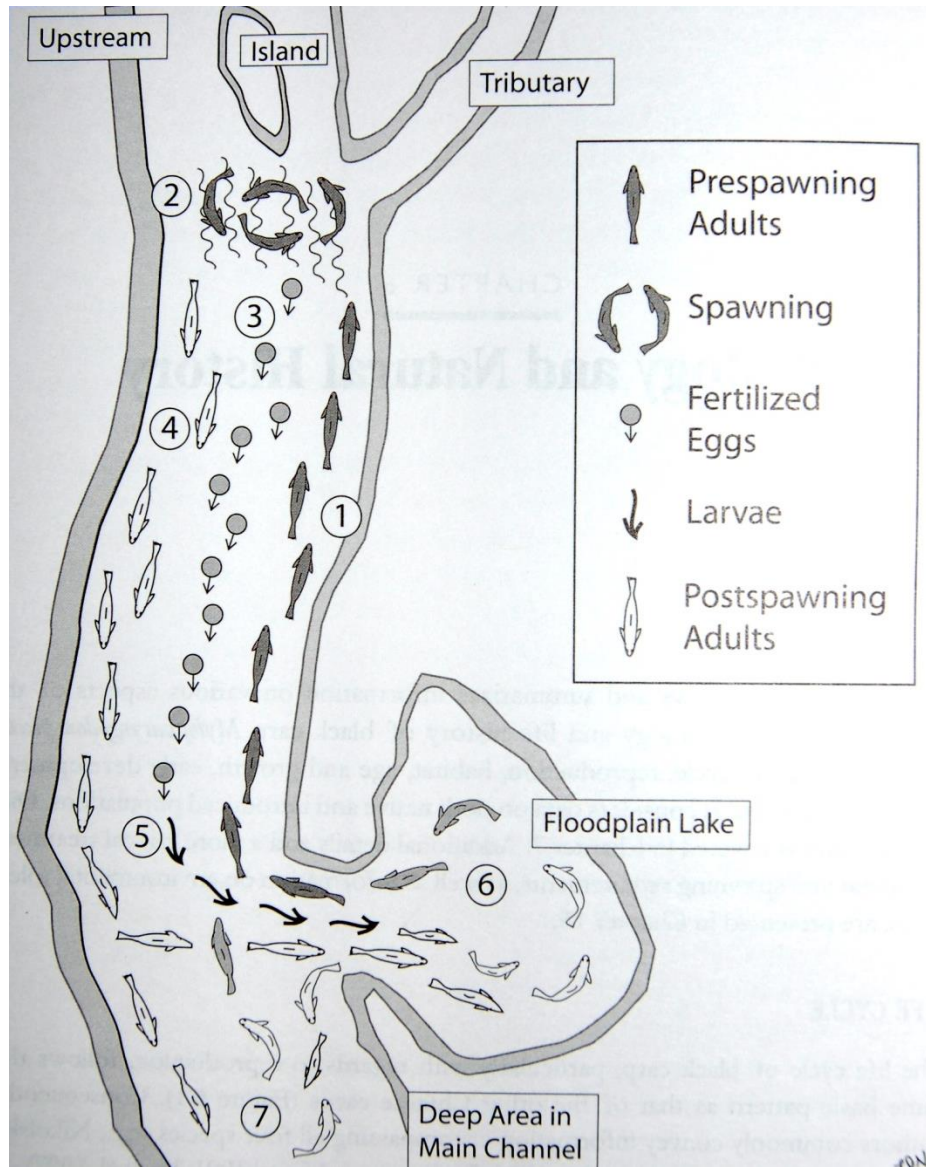
Silver carp: 4.2 million : 12 kg fish

Bighead carp: 1.1 million : 18 kg fish

Black carp: 1 million : 4.5 kg fish



# Migratory!

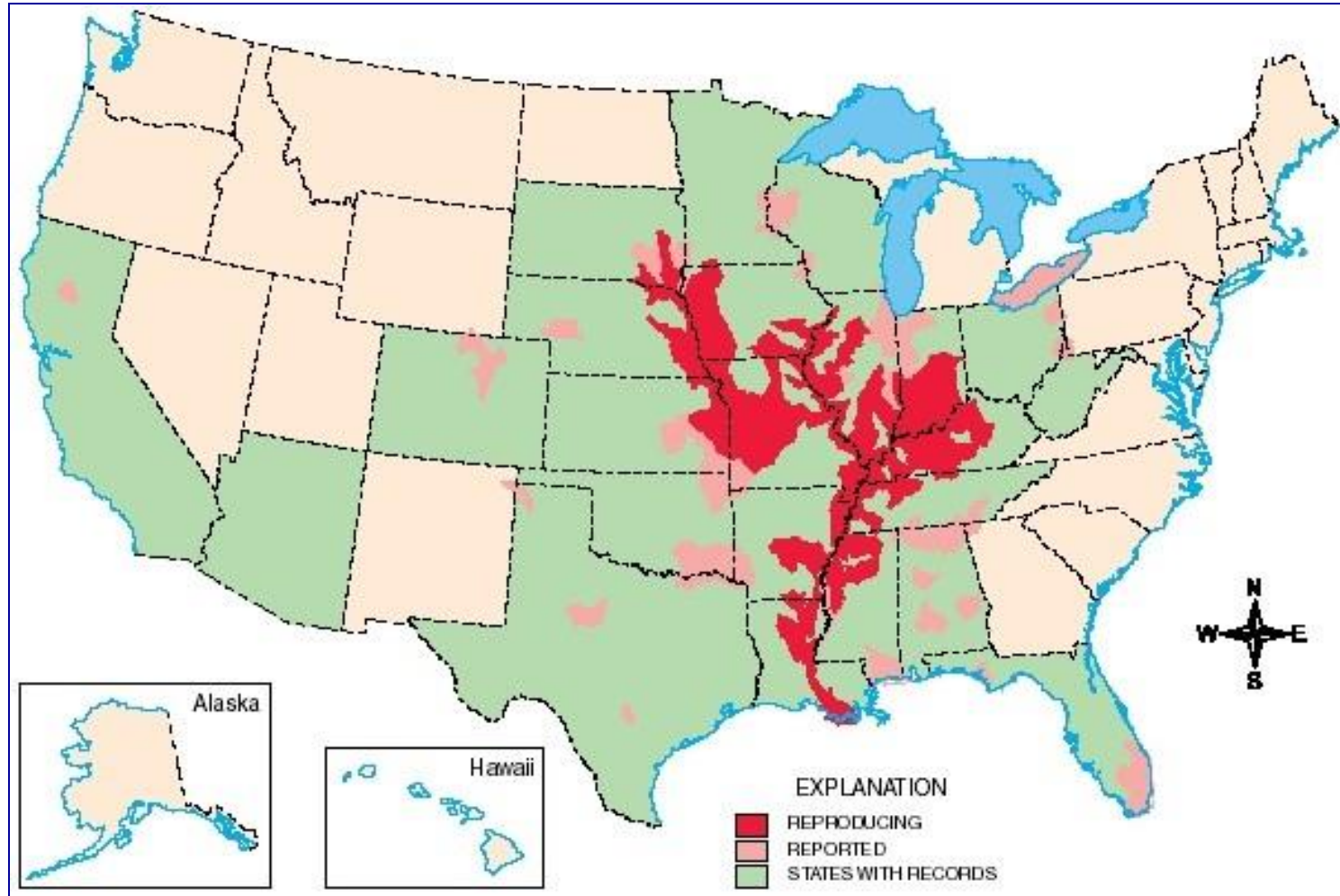


# 1980

## Silver carp reported in the Mississippi!



# Fairly Rapid Spread North then East and West





# Illinois River vs Upper Miss?



# Chicago Ship Canal

*\$30 million! + 1/yr*

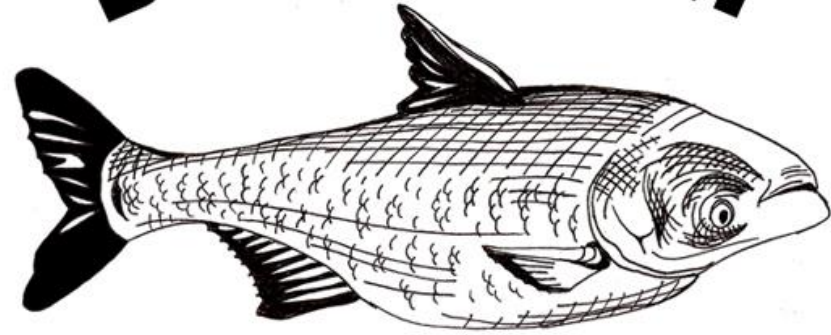


**US Army Corps  
of Engineers®**

Eating your way out (again)



**DO YOUR PART**



**EAT A CARP**

**BIGHEAD AND SILVERFIN CARP  
THREATEN TO OUTCOMPETE  
THE NATIVE FISH OF THE GREAT  
LAKES. IT MIGHT BE TOO LATE.**

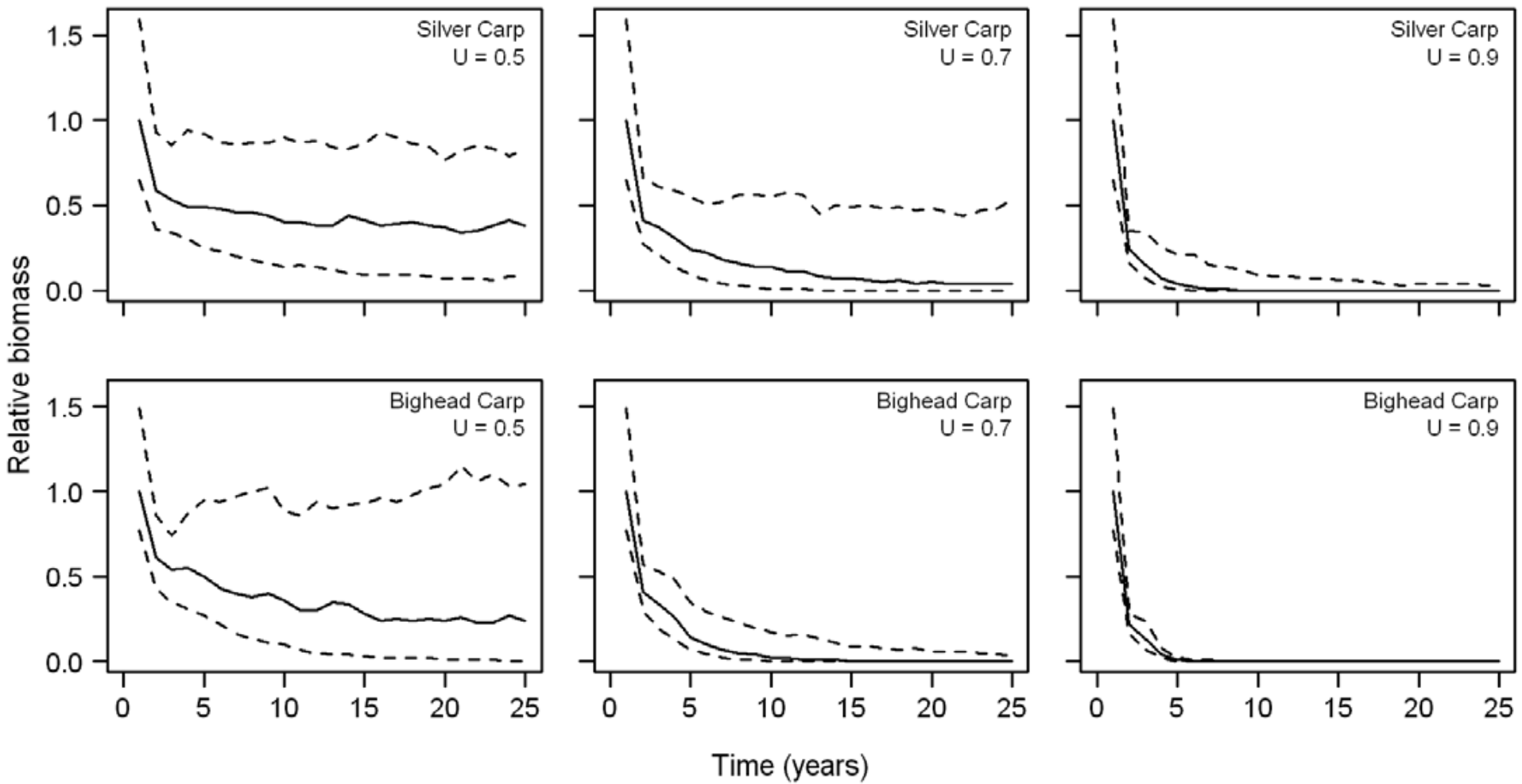
**IF YOU CAN'T BEAT 'EM  
EAT 'EM**



# Commercial fish removal (again)



# It cannot work



# How do we prevent this in Minnesota?

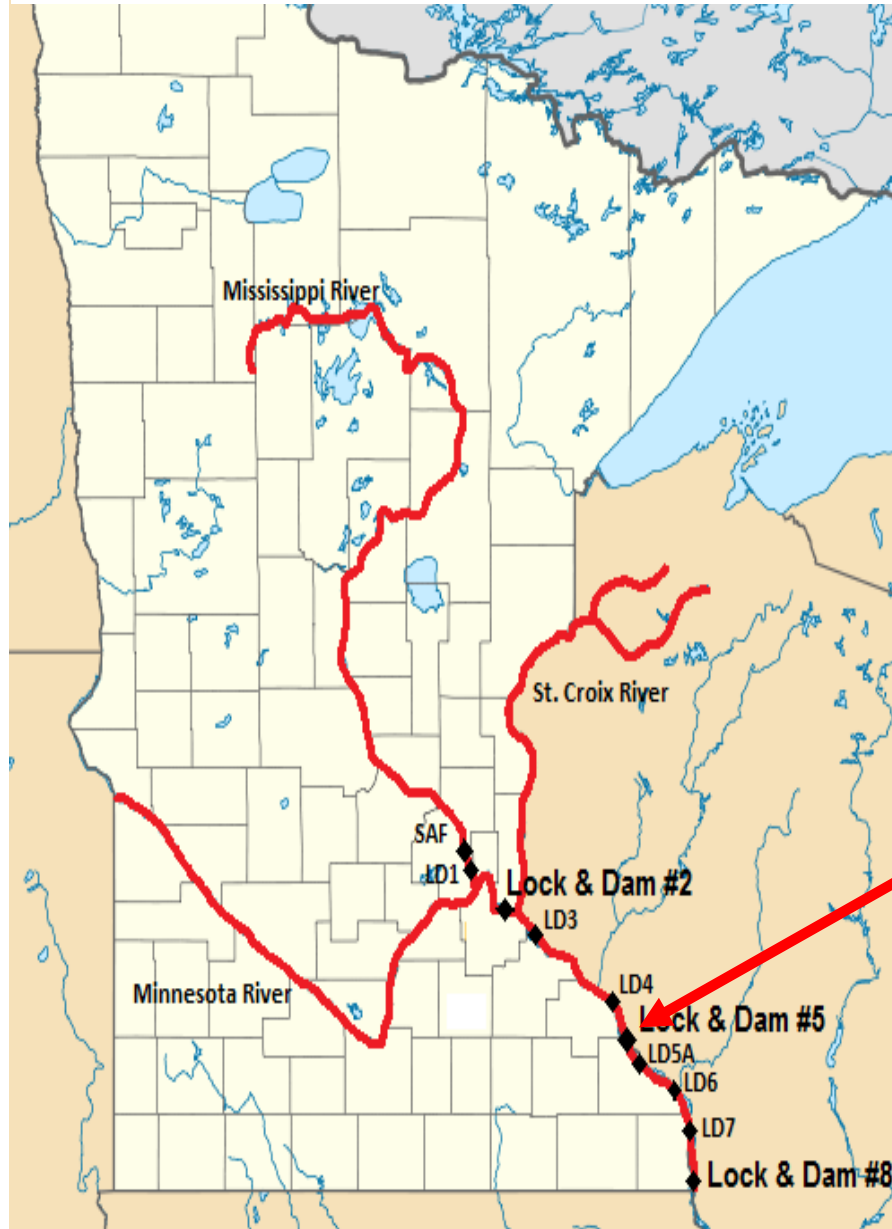




# Lock and Dam #5 is the Key



# *Location, location, location...*



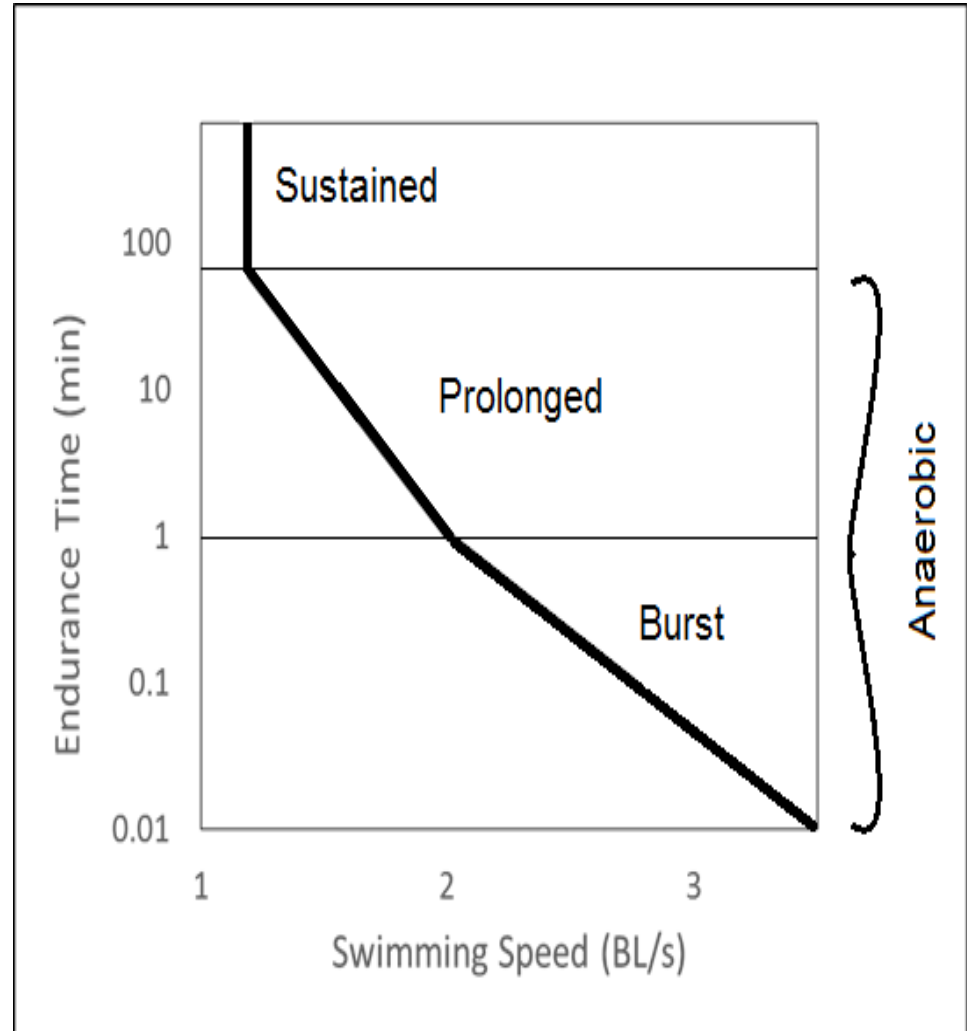
- Protects Minnesota, St Croix and Upper Mississippi
- Gates out of water 2%
- No spillways

# Asian Carp Facts:

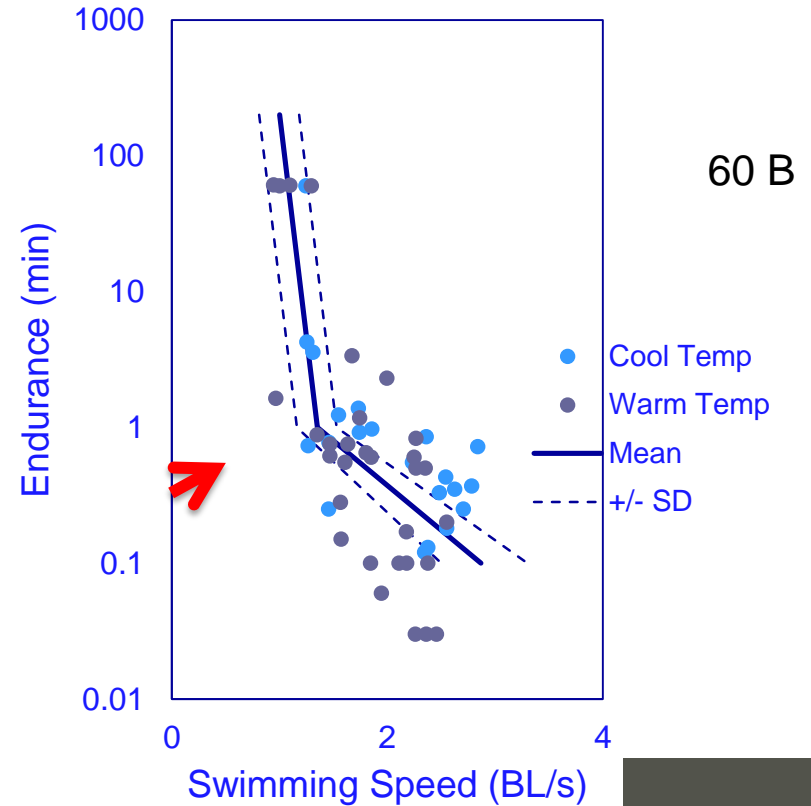
1. Bigheaded carp swimming performance is less than that of many native fishes—so **flow-fields through locks and dams** slow their movement upstream—and this could be **enhanced by slight modification in gate operations**.
2. Bigheaded carp **sensitivity to sound** is greater than that of most native fishes—so **sound could be deployed in locks** to further deter their invasion.
3. Native fish eat young carp in flood plains



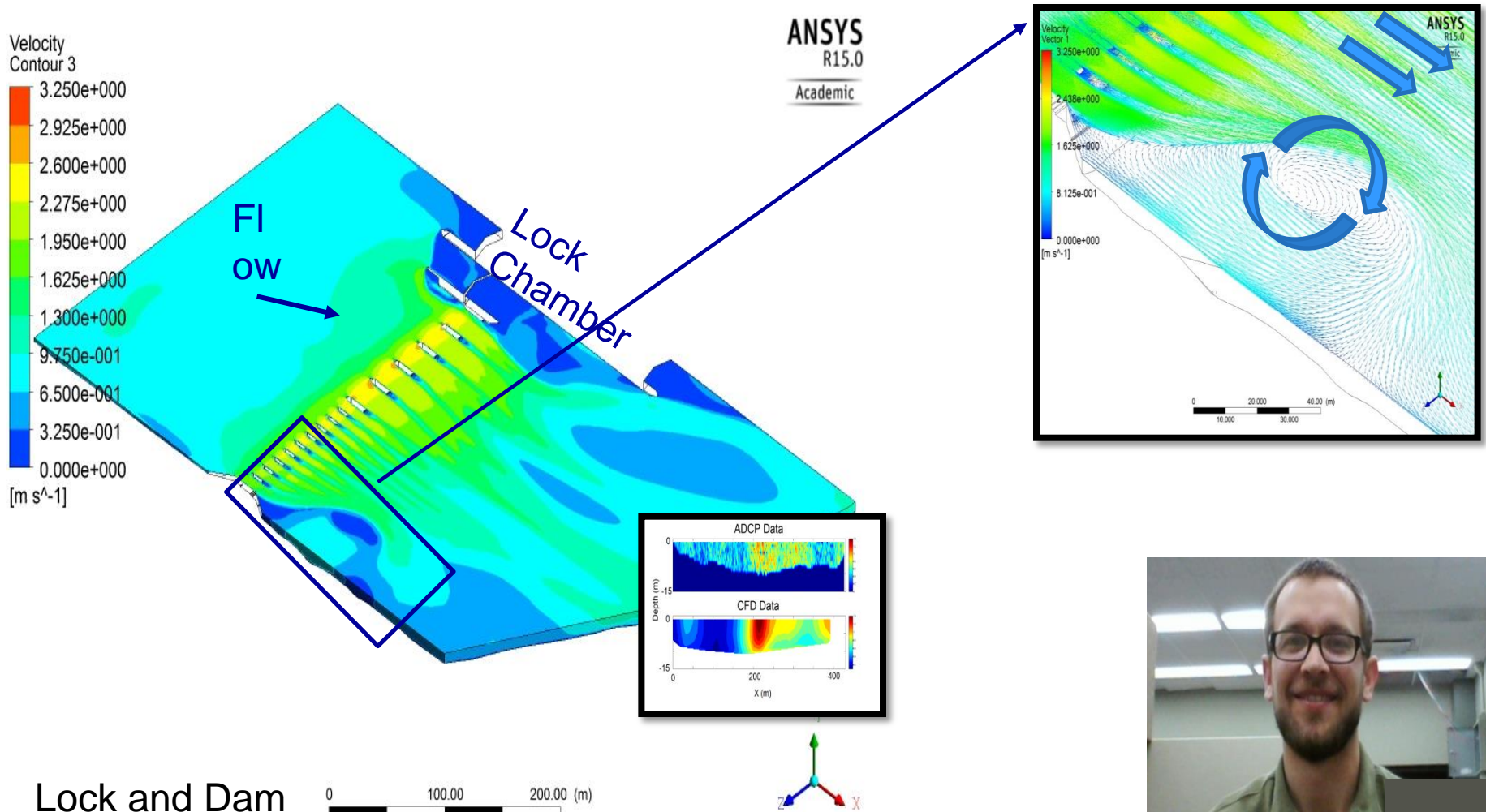
# Locomotion



# Silver Carp may jump, but they are very ordinary swimmers



# Statistical Modeling shows flows are unbalanced and creating weaknesses



Lock and Dam #8 (Genoa, WI)





# These weaknesses permit carp passage, at certain spots and times

**$Q=82,000$  cfs (worst case scenario!)**

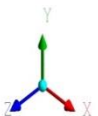
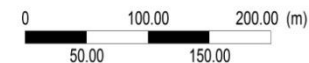
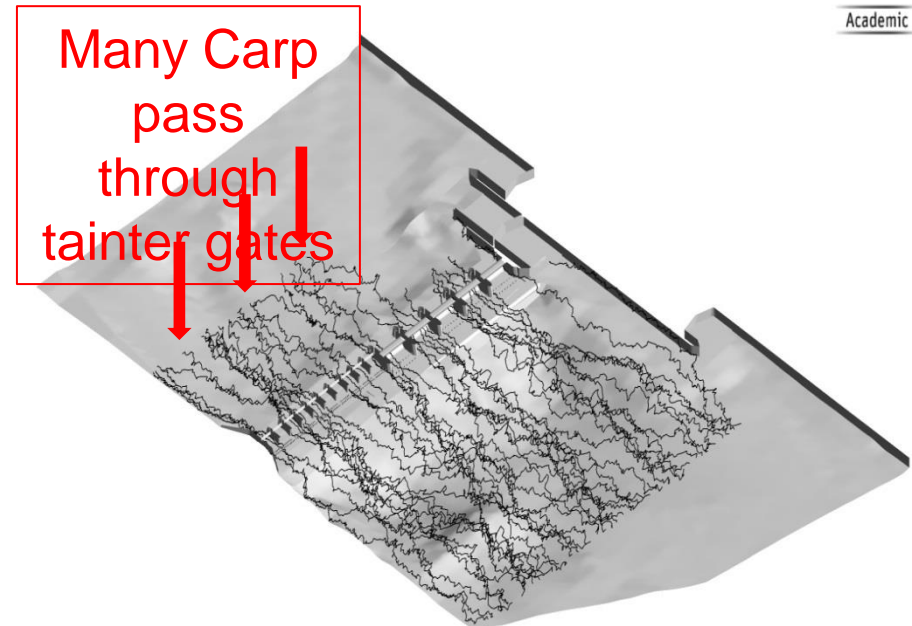
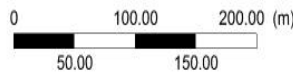
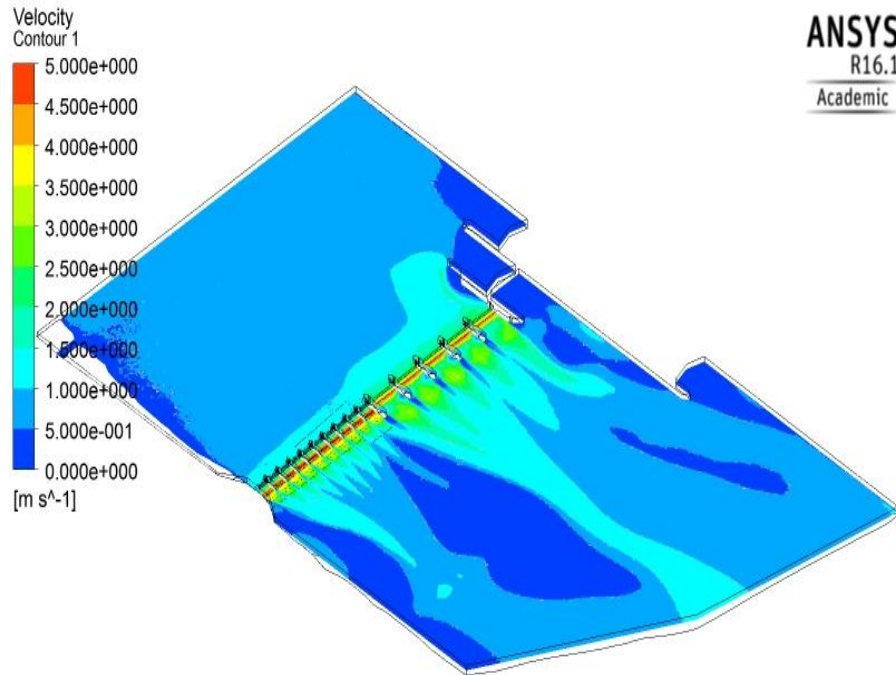
Gate openings:

Roller Gates: 12.1' → TW Velocity = 2.1 m/s

Tainter Gates: 8.0' → TW Velocity = 1.4 m/s

Simulated Fish Size	% Blocked
TL = 700 mm	99 ± 3%
TL = 900 mm	51 ± 7%

ANSYS  
R15.0  
Academic



# This weaknesses can be corrected with changes to gate operations

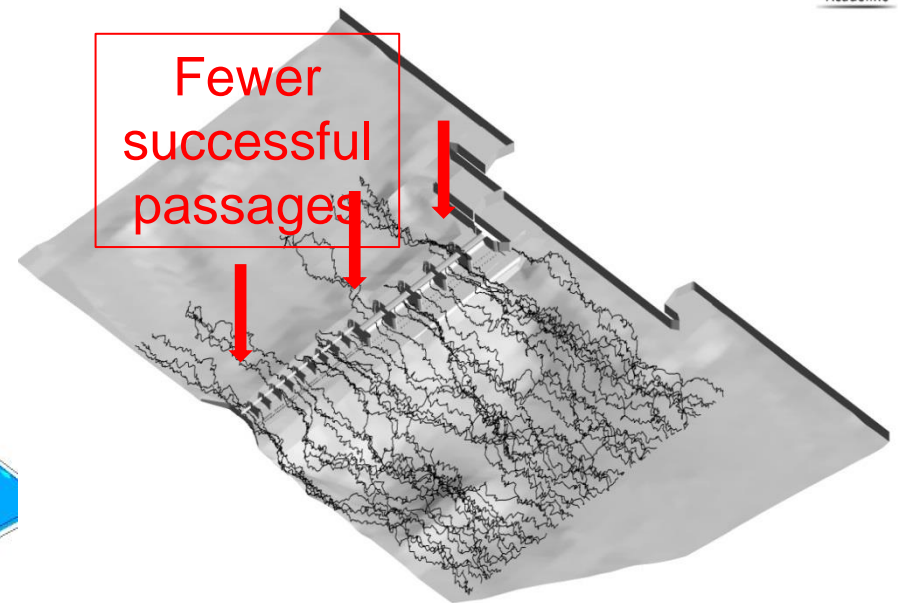
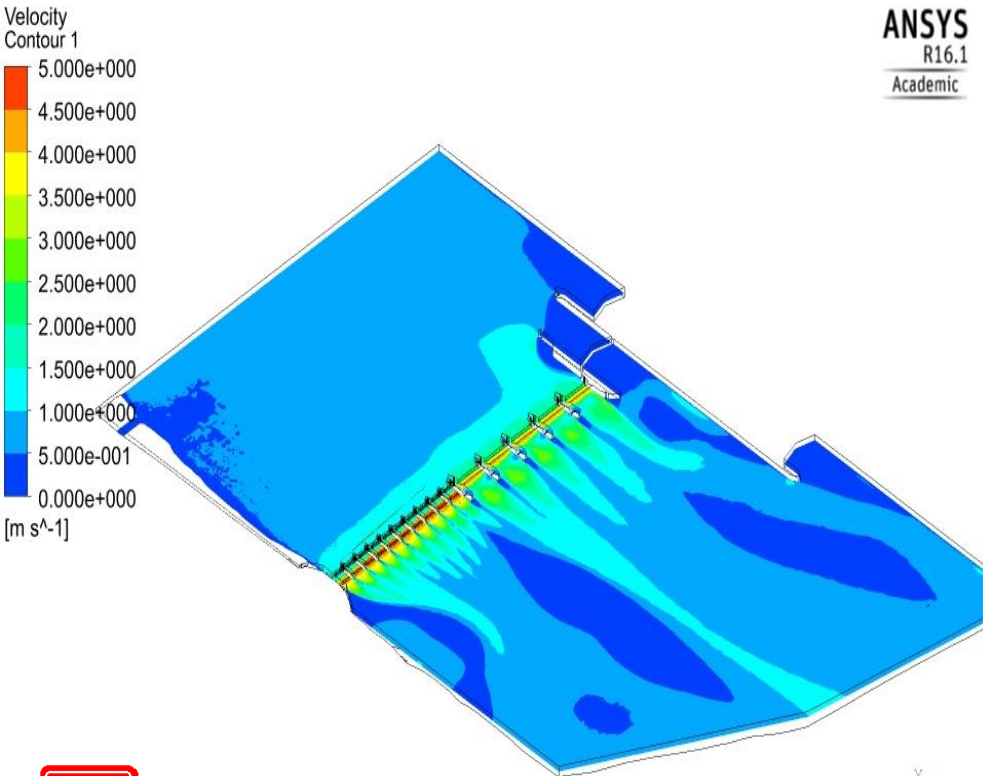
## Q=82,000 cfs, Modified Gate Operations

Gate openings:

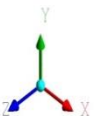
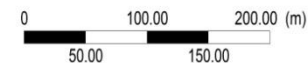
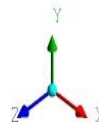
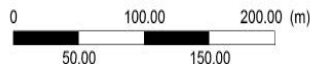
Roller Gates: 11.3' (-0.8') → TW Velocity = 1.79 m/s

Tainter Gates: 8.8' (+0.8') → TW Velocity = 1.78 m/s

Simulated Fish Size	% Blocked
TL = 700 mm	100 ± 0%
TL = 900 mm	77 ± 2%



US Army Corps of Engineers®



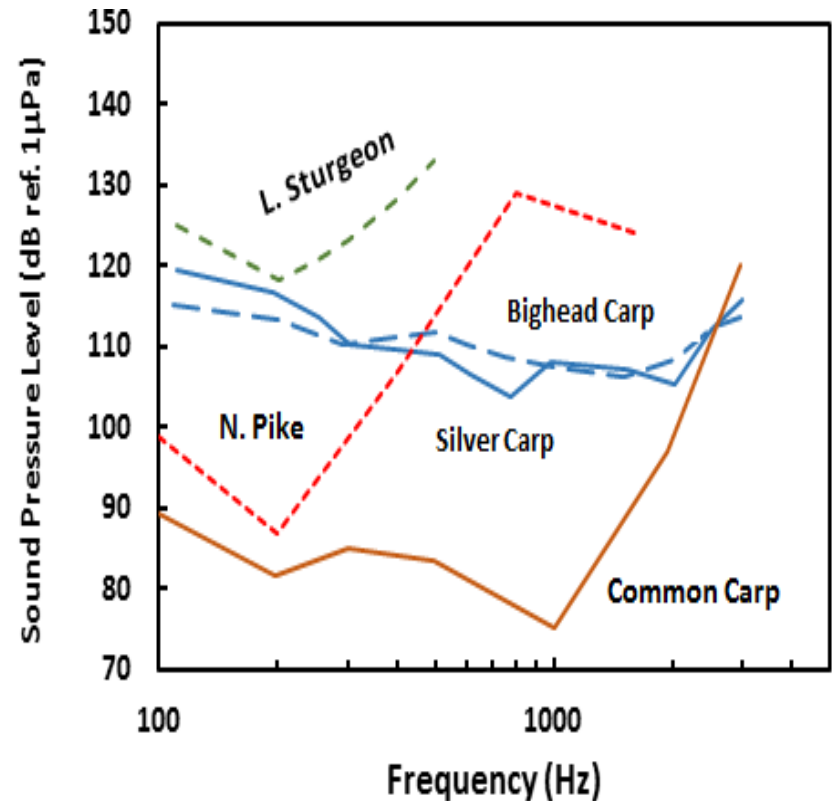
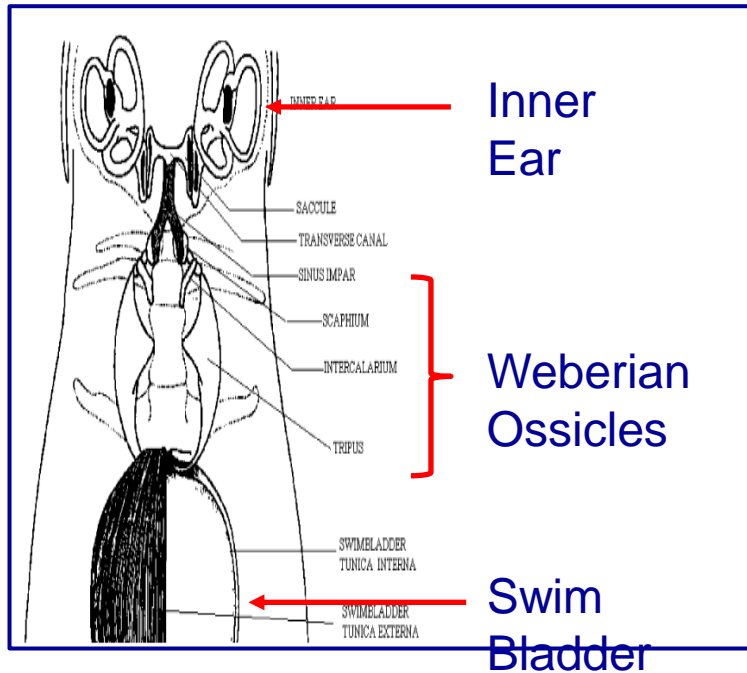
Once the gates operating procedures are fixed, the lock is the Achilles Heel



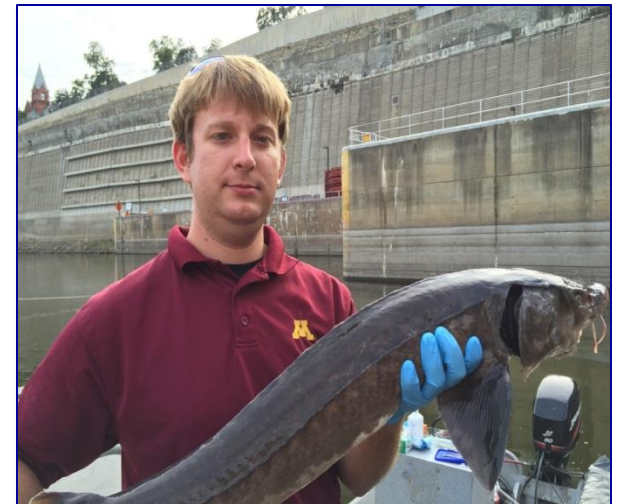
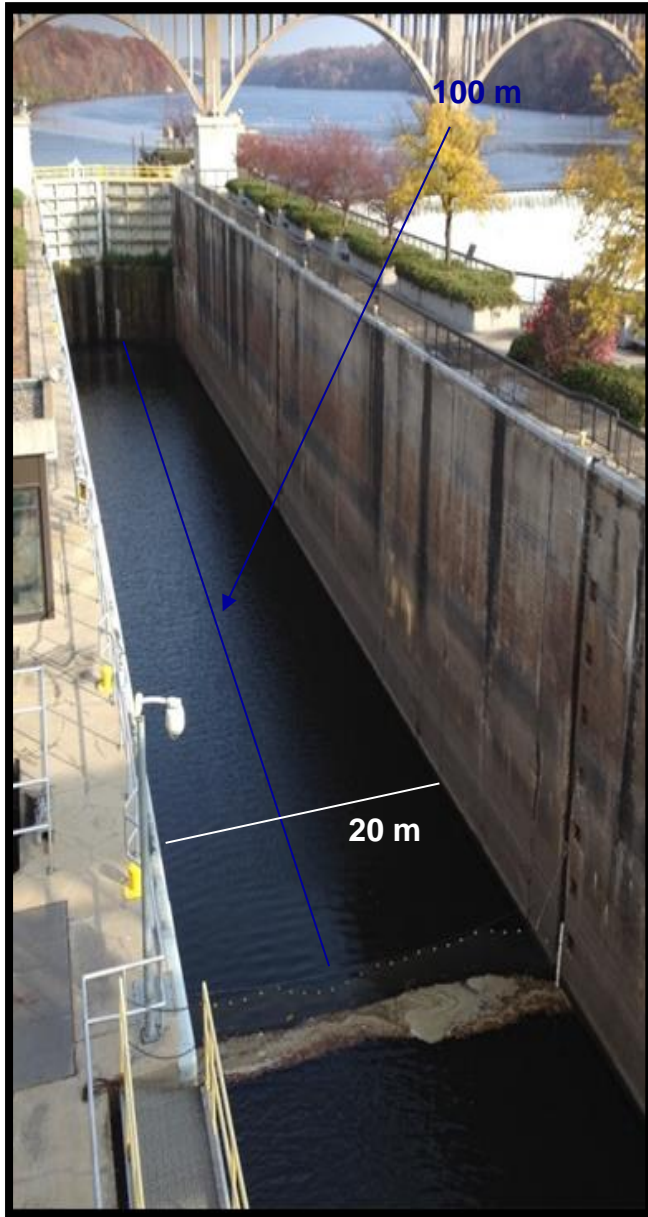


# Species-specific deterrents for locks:

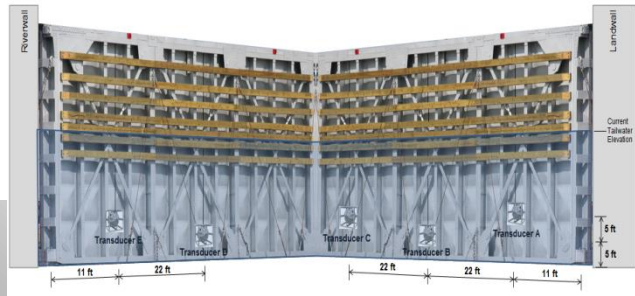
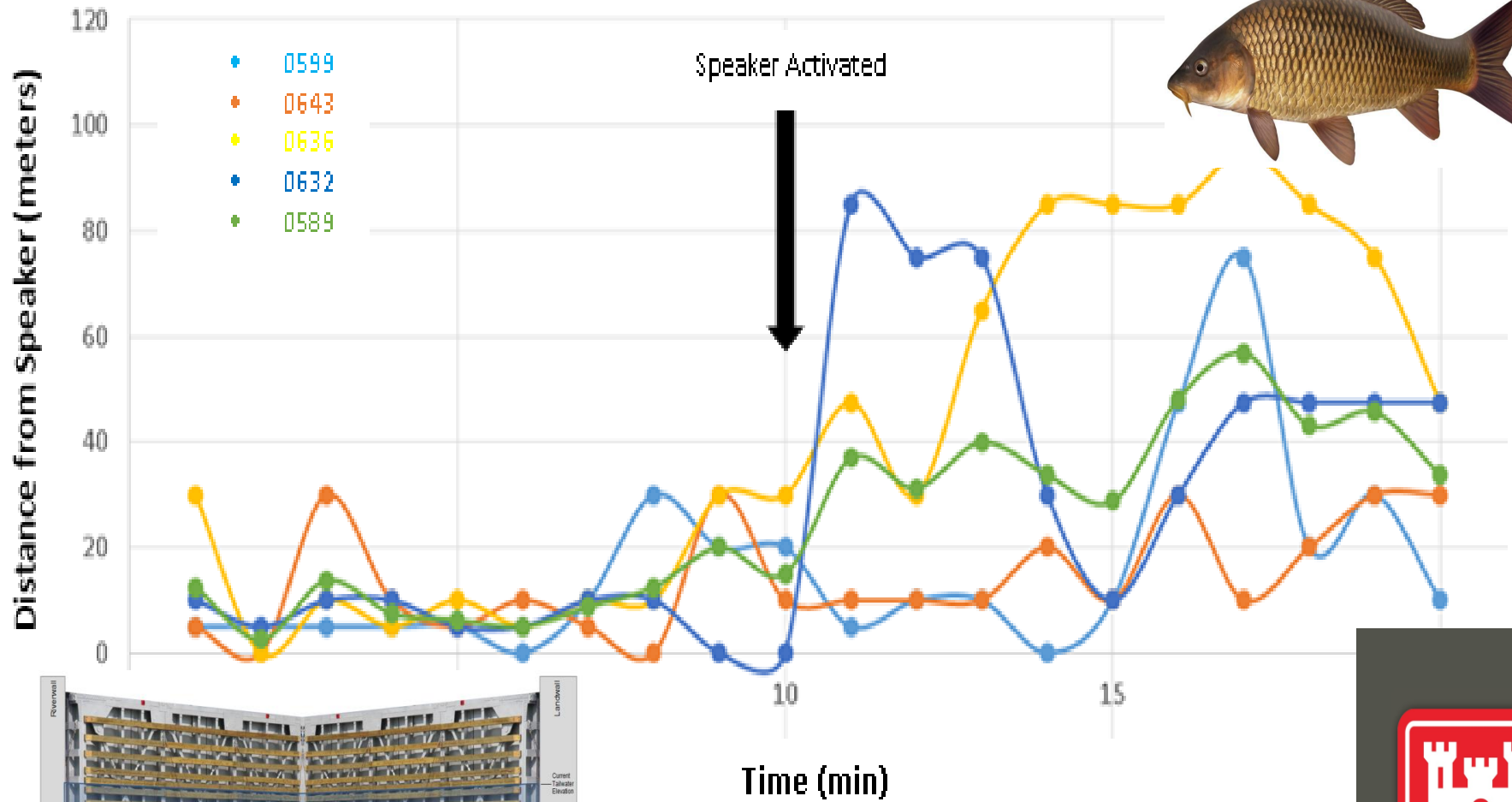
## Carp have excellent hearing



# Field test of sound in a lock and dam #1

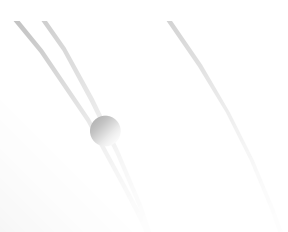
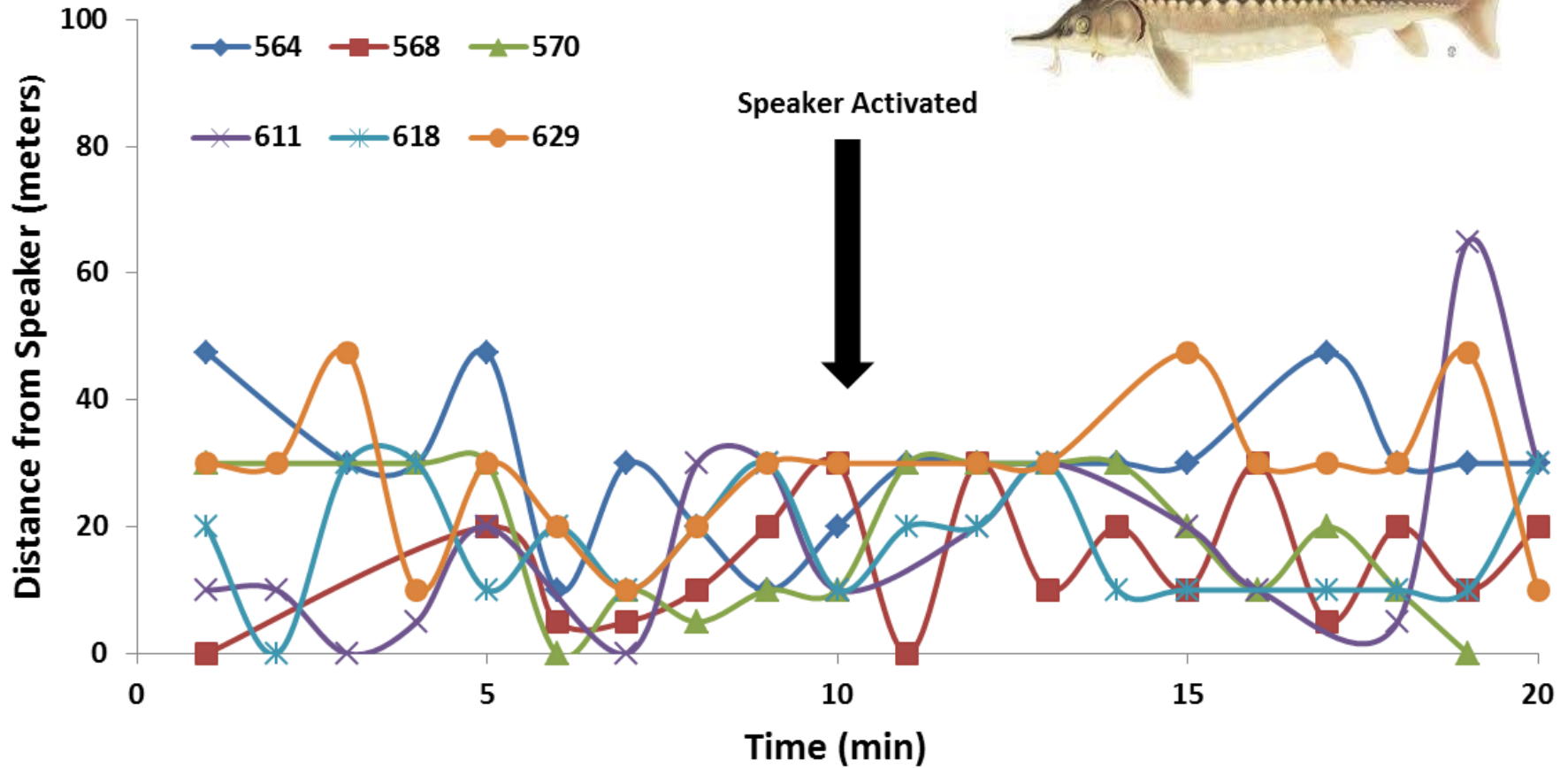


# We can deter carp in locks using sound alone

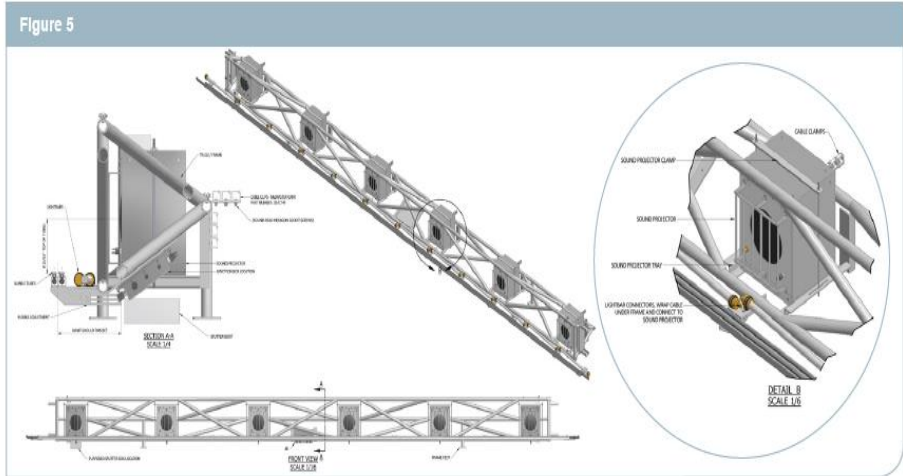
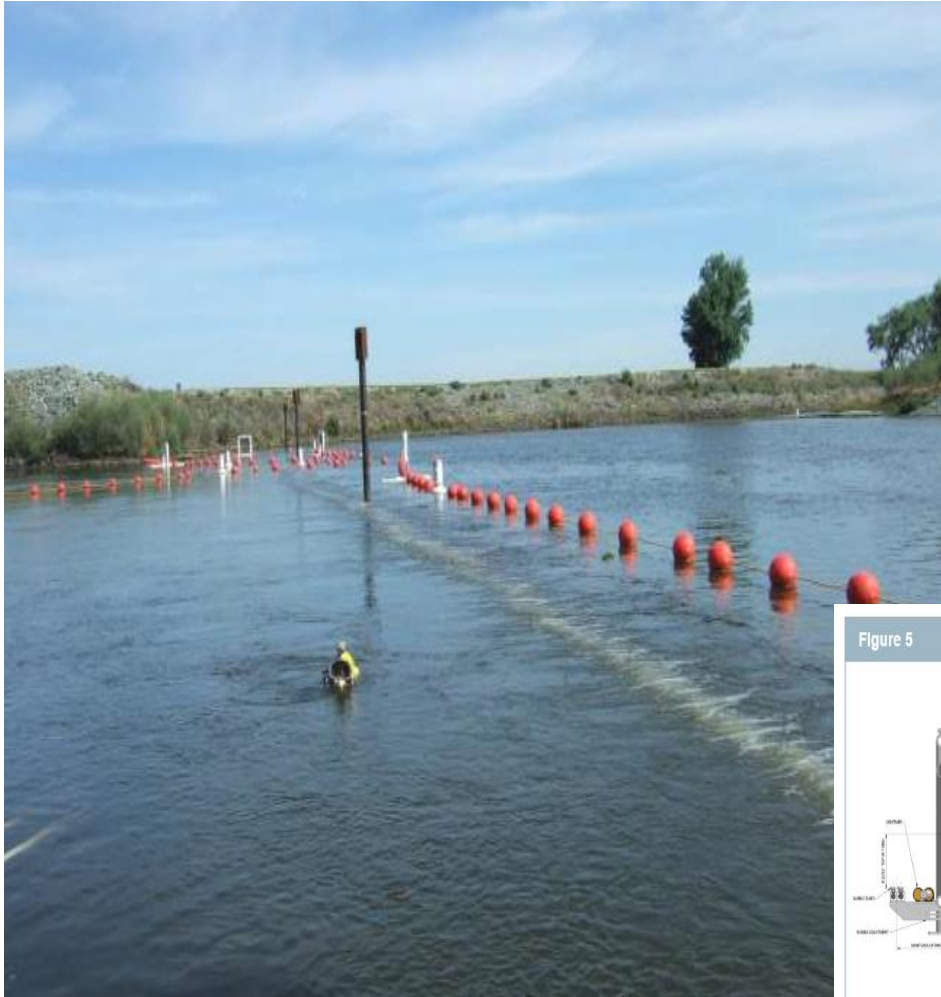




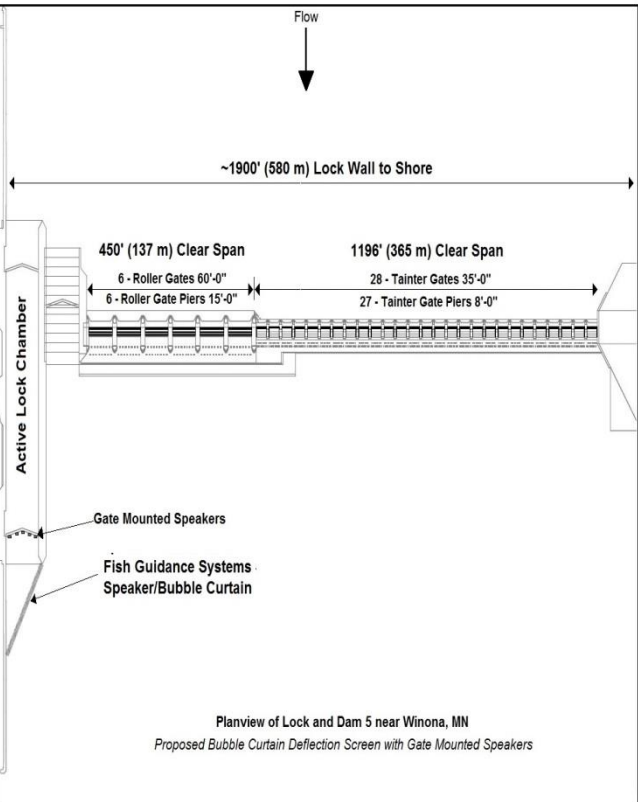
# Sound *does not* deter native fish



# BAFF/ SPA Air curtains would focus sound as a deflection shield



# Can we do this – yes, its easy?



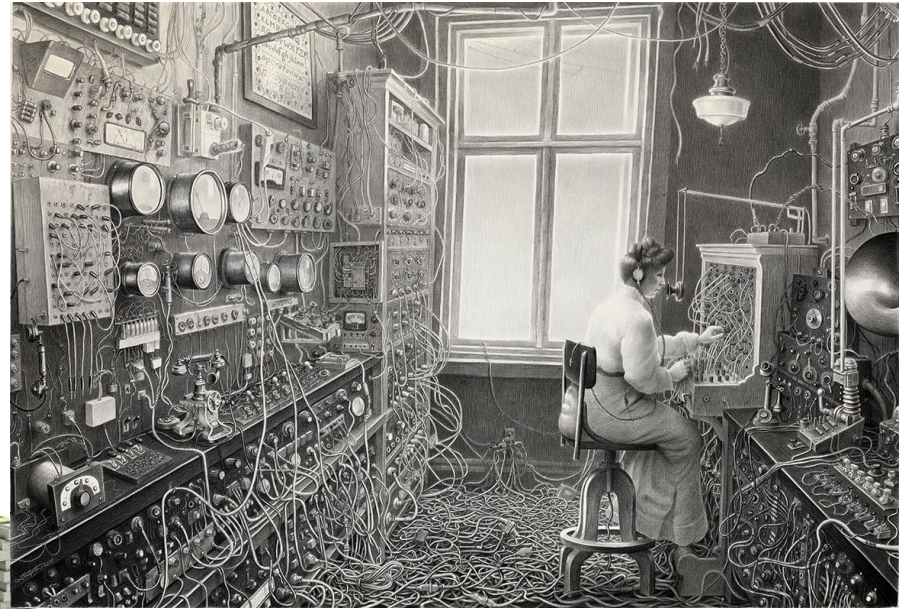


# Proposed Plan: Methods

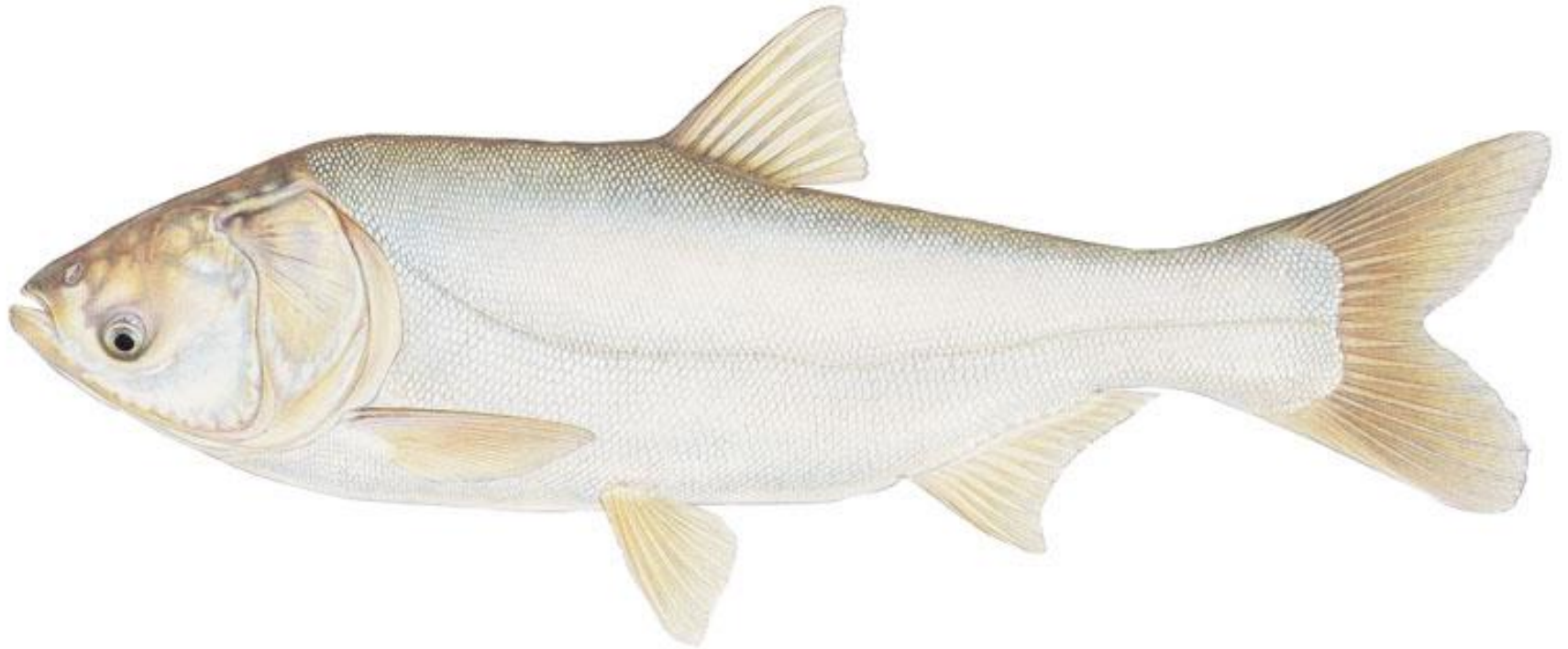
- Adjust gate operations with USACE
- Assess and optimize gate operations for carp and native fish
- Install sound deterrent in lock
- Assess and optimize sound
- Monitor carp and native fish using eDNA and work to improve habitat
- Fix spillways
- Hand over to the DNR



# Do these Lessons from Common Carp Apply?



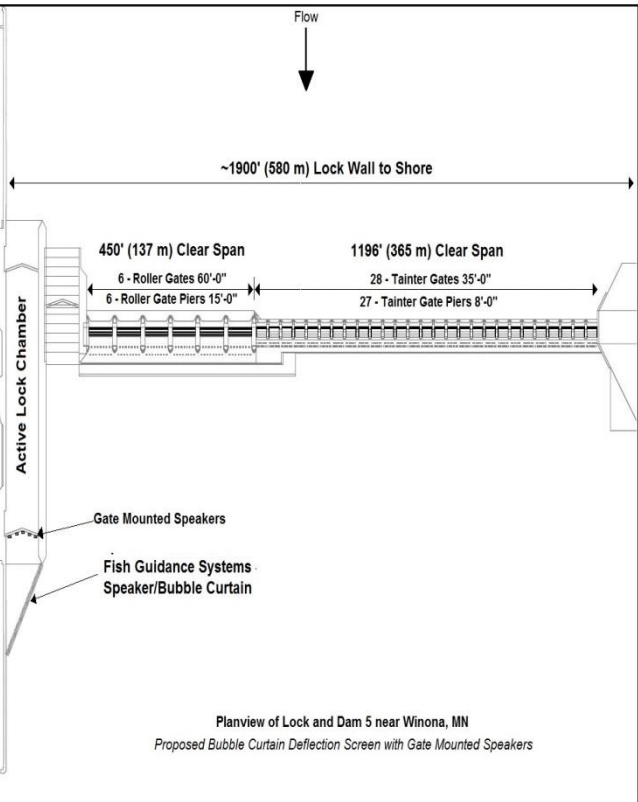
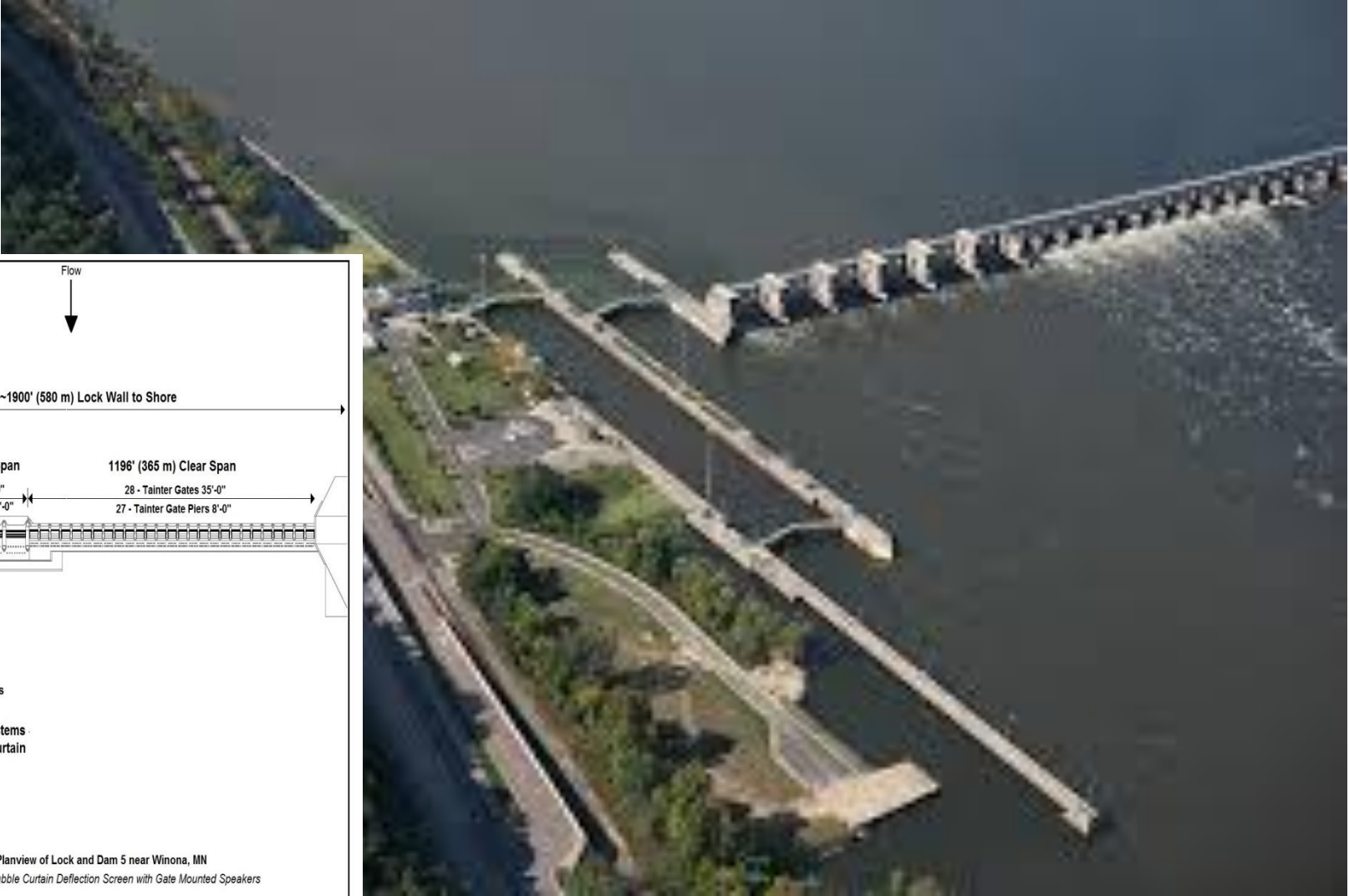
What to do?





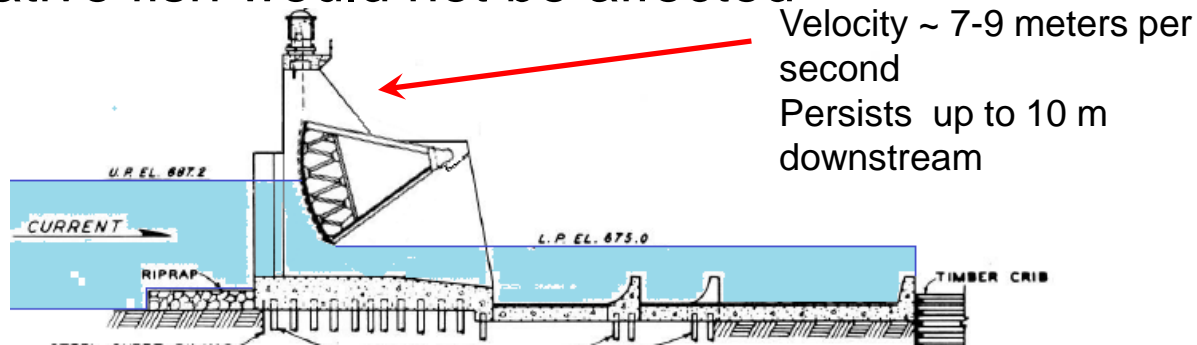


# Can we do this – yes, its easy?

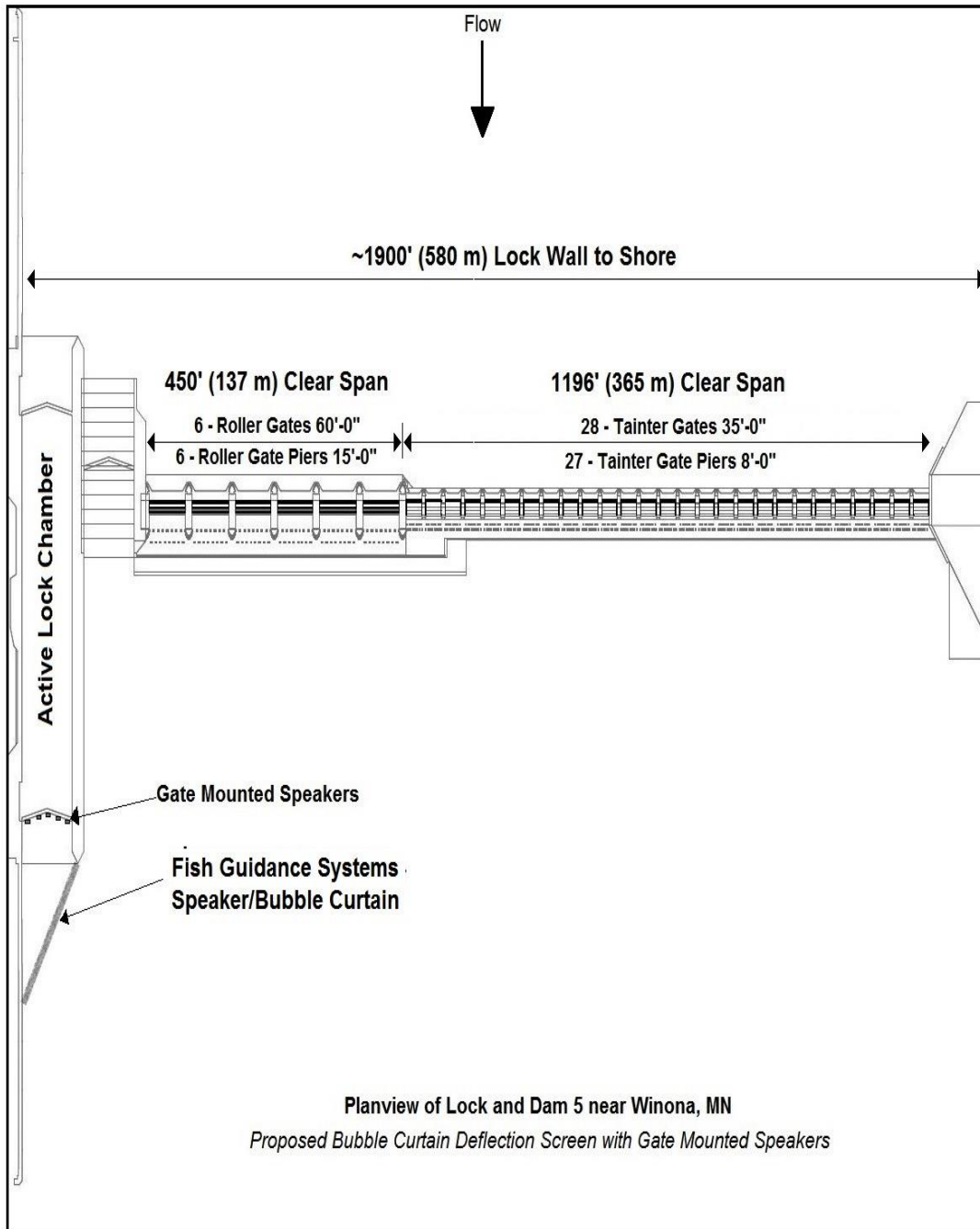


# Summary:

- Velocity flows greatly impede carp movement upstream through locks & dams
  - Modifying these flows can make them more effective under operating procedures.
  - The St. Paul District of the USACE will implement.
  - There is room for improvement, especially for native wild fishes!
- The sound of outboard motors repels Asian and Common carps
  - 75% efficient
  - Safe, easy and acceptable
  - Likely that sound could be enhanced
  - Most native fish would not be affected







Our ultimate goal: to preserve and restore native fish and their habitat



# Conclusions

Carp are pretty interesting but they are more of a symptom than cause

Carp have had us outsmarted for a while but I am convinced we'll eventually get it (if we think about it)

Lets stop making mistakes with alien species, take a closer look at how we live over lives and what we expect, and adjust.

Lets give science a decent chance to catch up and solve existing problems.

Thanks for your attention!



# Funding

- Environment and Natural Resources Trust Fund
- Riley Purgatory Bluff Creek Watershed District
- Ramsey Washington Metro Watershed District
- Invasive-Animals Cooperative Research Centre (Australia)
- National Science Foundation
- USGS
- GLFC
- Sea Grant

