

A STORY OF RIVER REDEMPTION

How science is working to restore
lost features and creatures in the
urban Mississippi River



A STORY OF RIVER REDEMPTION

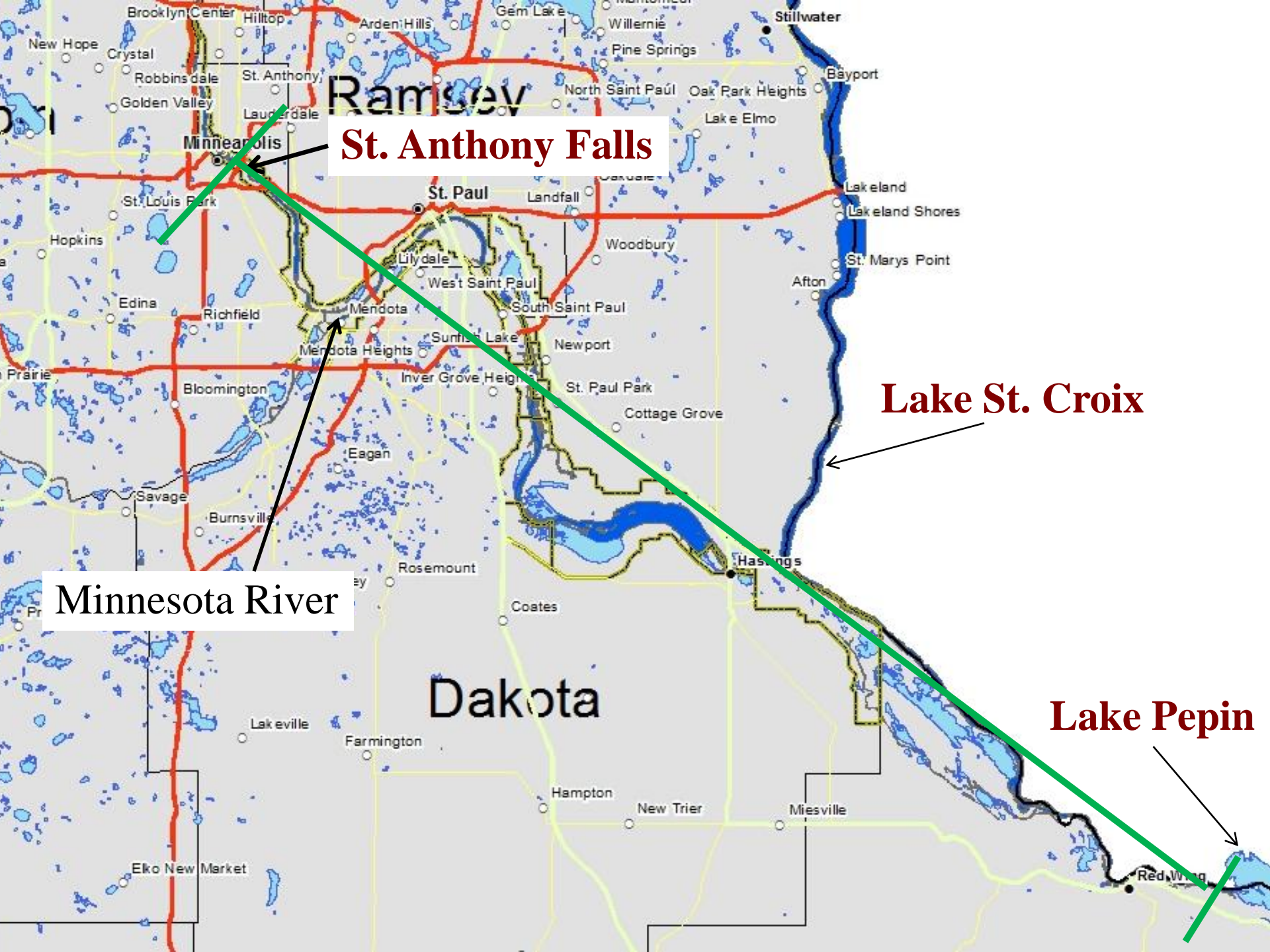
- **PART 1**
- **Geographic and geologic setting**
- **The Mississippi's first Dead Zone and the race against an exploding human population**
- **An urban river's redemption – boosted by two angry women and a lot of science!**
- **PART 2**
- **What are native mussels - and why care?**
- **Gone for a century - endangered mussels return with a little help from an unlikely source**



Mississippi
River



North America from space



St. Anthony Falls

Lake St. Croix

Minnesota River

Lake Pepin

Ramsey

Dakota

Minneapolis

St. Paul

Hastings

Red Wing

Richfield

Bloomington

Burnsville

Lakeville

Farmington

Hampton

New Trier

Miesville

Elko New Market

New Hope

Crystal

Robbinsdale

Golden Valley

Lauderdale

St. Louis Park

Hopkins

Edina

Prairie

Savage

Pr

Arden Hills

Gem Lake

Willernie

Pine Springs

North Saint Paul

Lake Elmo

Landfall

Lilydale

West Saint Paul

Mendota Heights

Inver Grove Heights

Eagan

Rosemount

Coates

Woodbury

South Saint Paul

Newport

St. Paul Park

Cottage Grove

Stillwater

Bayport

Lakeland

Lakeland Shores

St. Marys Point

Afton

Lake St. Croix

Lake Pepin

St. Anthony Falls

Minnesota River

Lake Pepin

Upper Mississippi River

St. Anthony Falls

Minneapolis

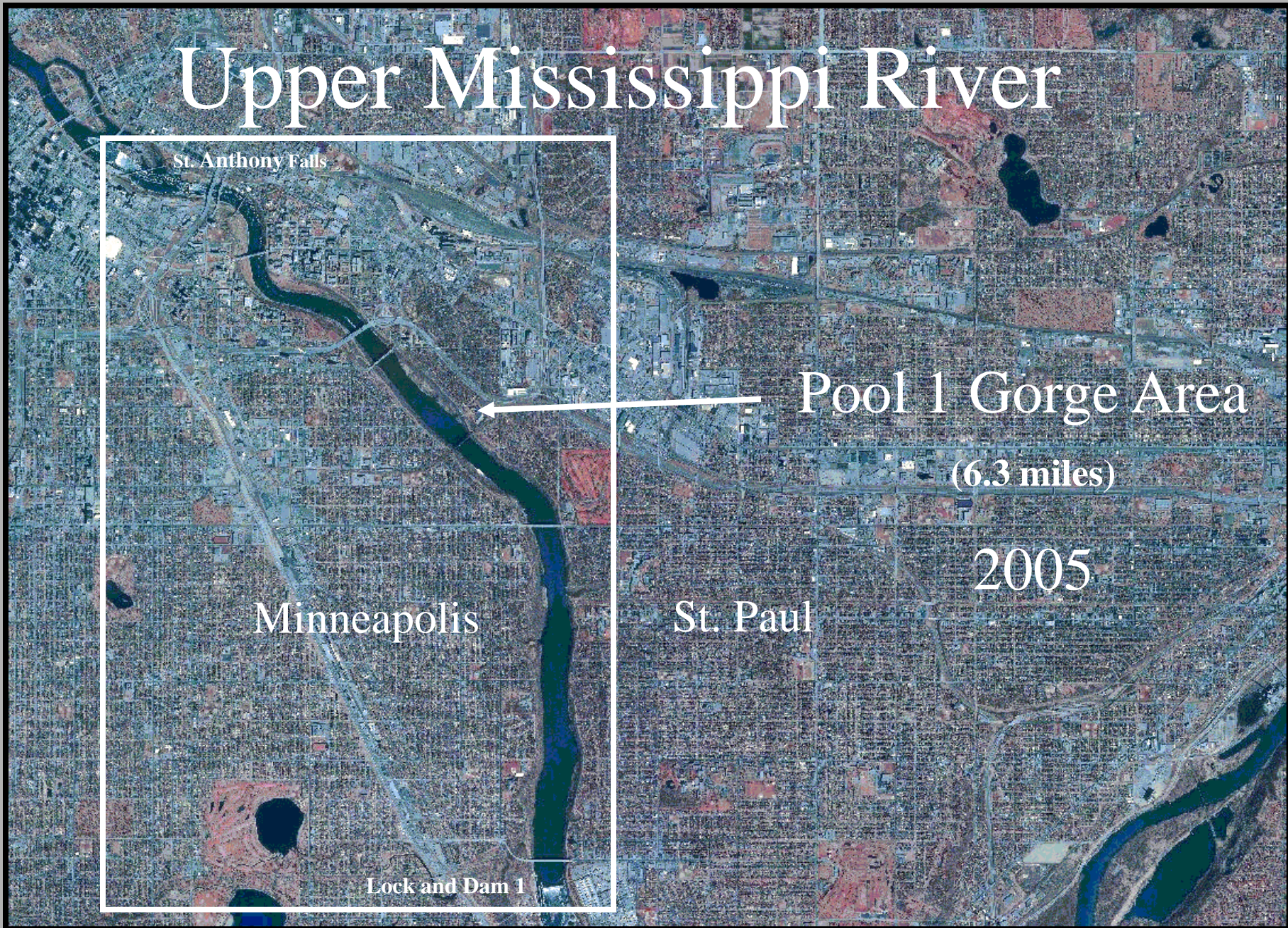
Lock and Dam 1

Pool 1 Gorge Area

(6.3 miles)

2005

St. Paul





✓ St Anthony Falls & Rapids

Minneapolis
Saint Paul



62 miles from
Lake Pepin to
gorge and rapids



✓ Lake Pepin

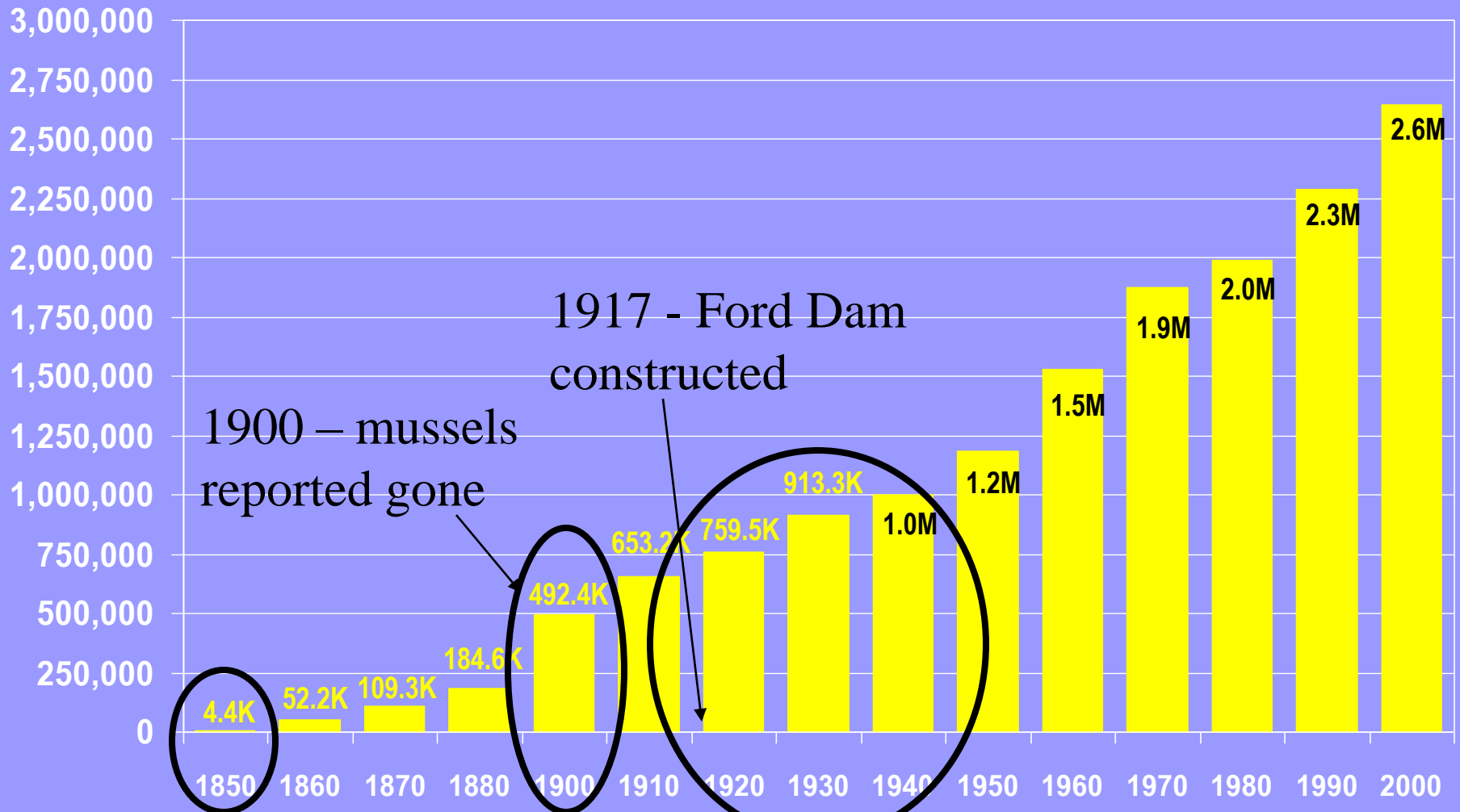


A STORY OF RIVER REDEMPTION

- **PART 1**
- **The Mississippi's first Dead Zone and the race against an exploding human population**
- **An urban river's redemption – boosted by two angry women and a lot of science!**

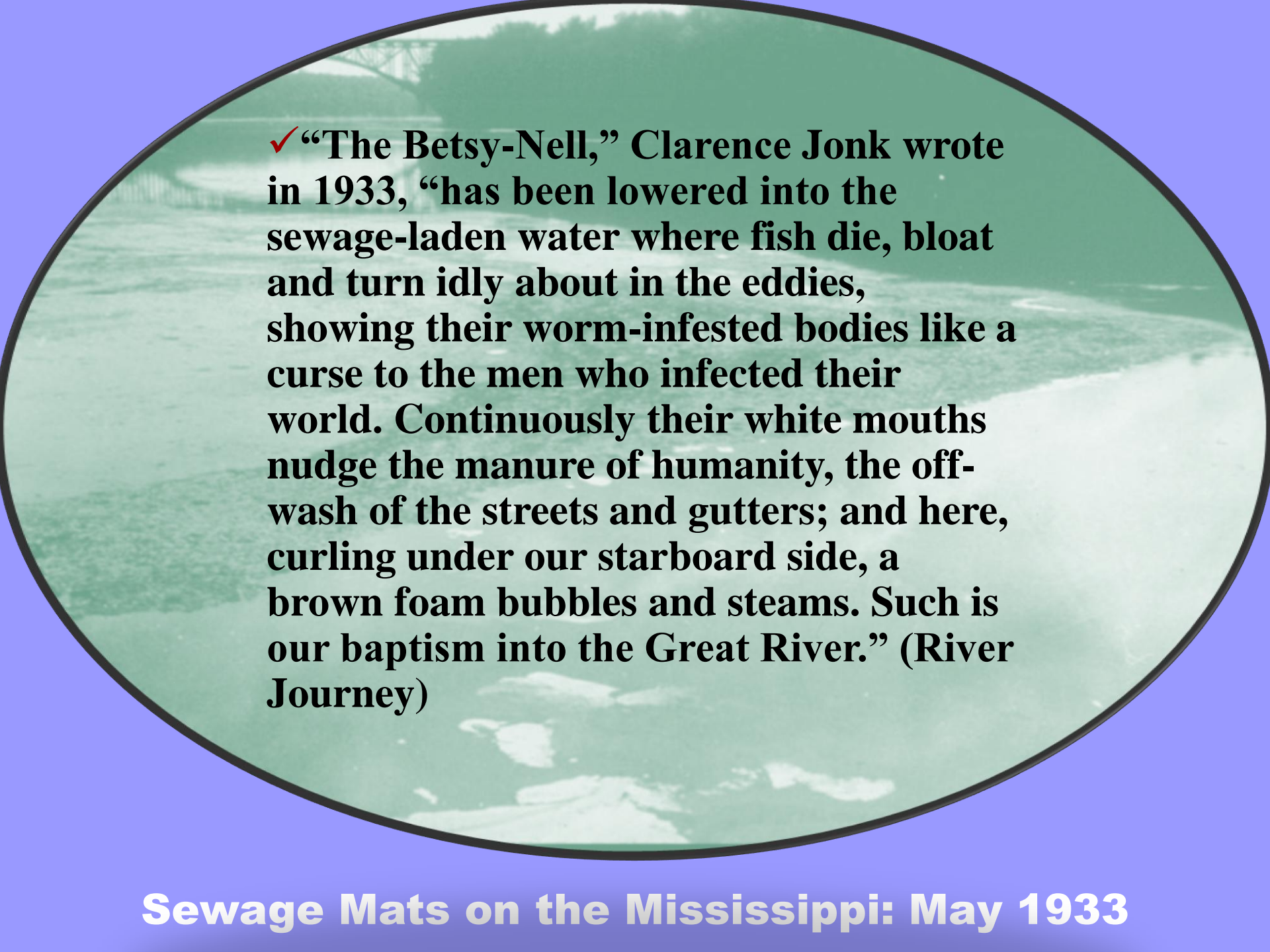
Population Growth

Minneapolis/Saint Paul Area





Sewage Mats on the Mississippi: May 1933

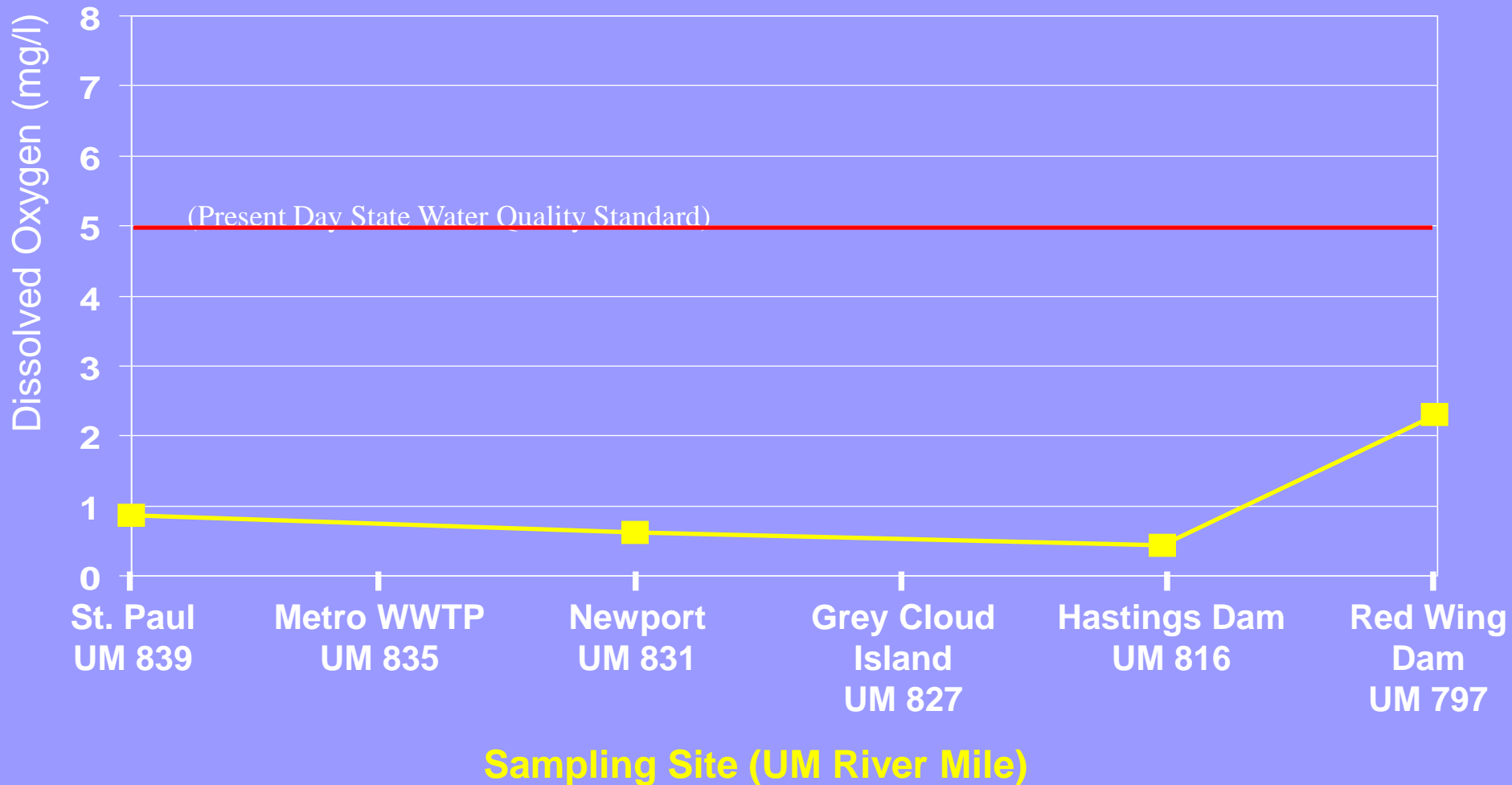


✓ “The Betsy-Nell,” Clarence Jonk wrote in 1933, “has been lowered into the sewage-laden water where fish die, bloat and turn idly about in the eddies, showing their worm-infested bodies like a curse to the men who infected their world. Continuously their white mouths nudge the manure of humanity, the off-wash of the streets and gutters; and here, curling under our starboard side, a brown foam bubbles and steams. Such is our baptism into the Great River.” (River Journey)

Sewage Mats on the Mississippi: May 1933

Mississippi River: 1926

Mean August Dissolved Oxygen Concentration*



*Mean of all August observations for the time period

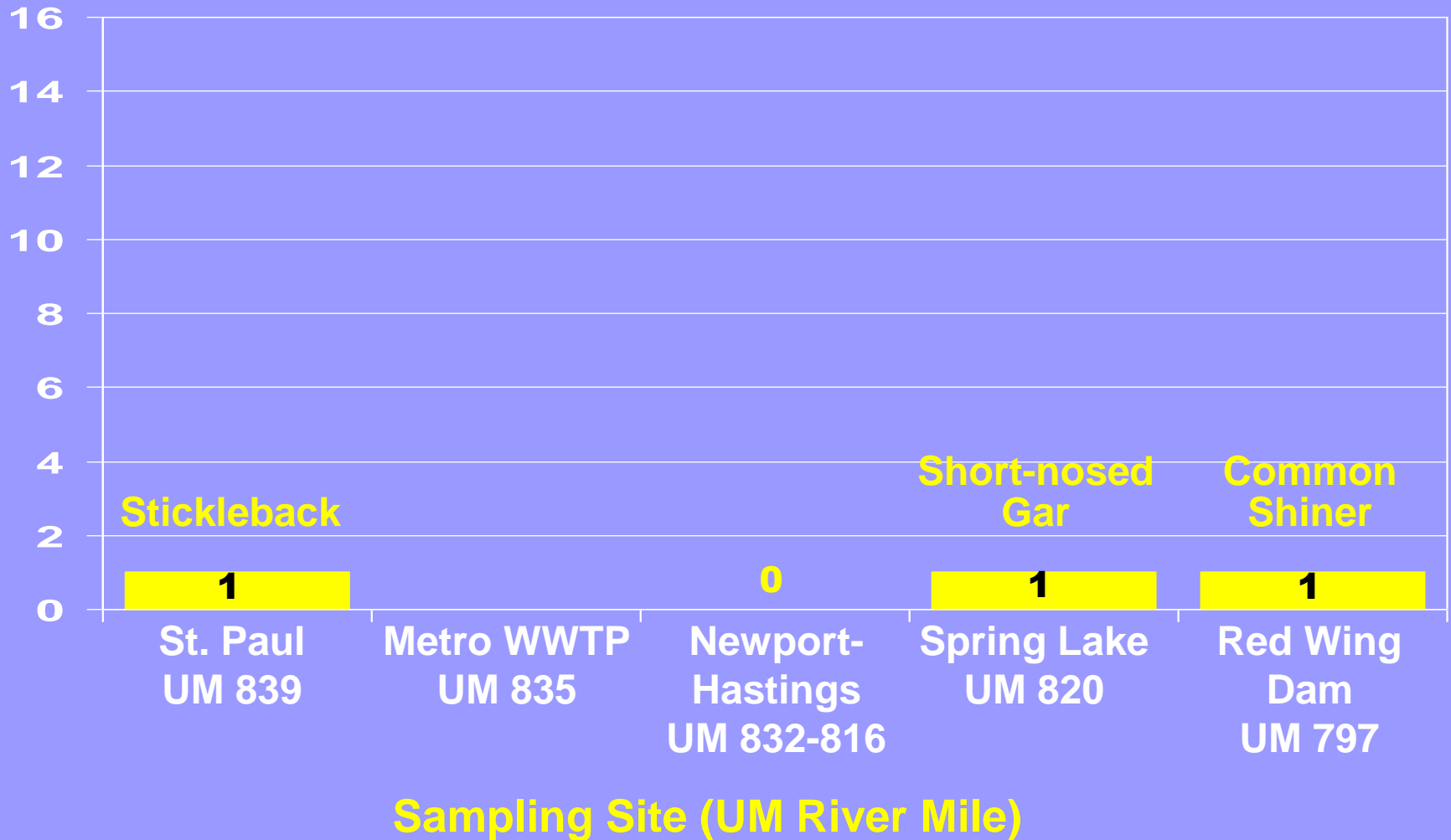
Coliform Bacteria Concentrations

Mississippi River: August 1926

| Site | Coliform Bacteria (No. /100 ml.) |
|-------------------------------------|-------------------------------------|
| St. Paul (UM 839) | 296,400 |
| Newport (UM 831) | 75,500 |
| Hastings Dam (UM 816) | 275,000 |
| Red Wing Dam (UM 797) | 14,700 |
| State Water Quality Standard | < 200 |

Mississippi River Fish: 1926

Total Taxa

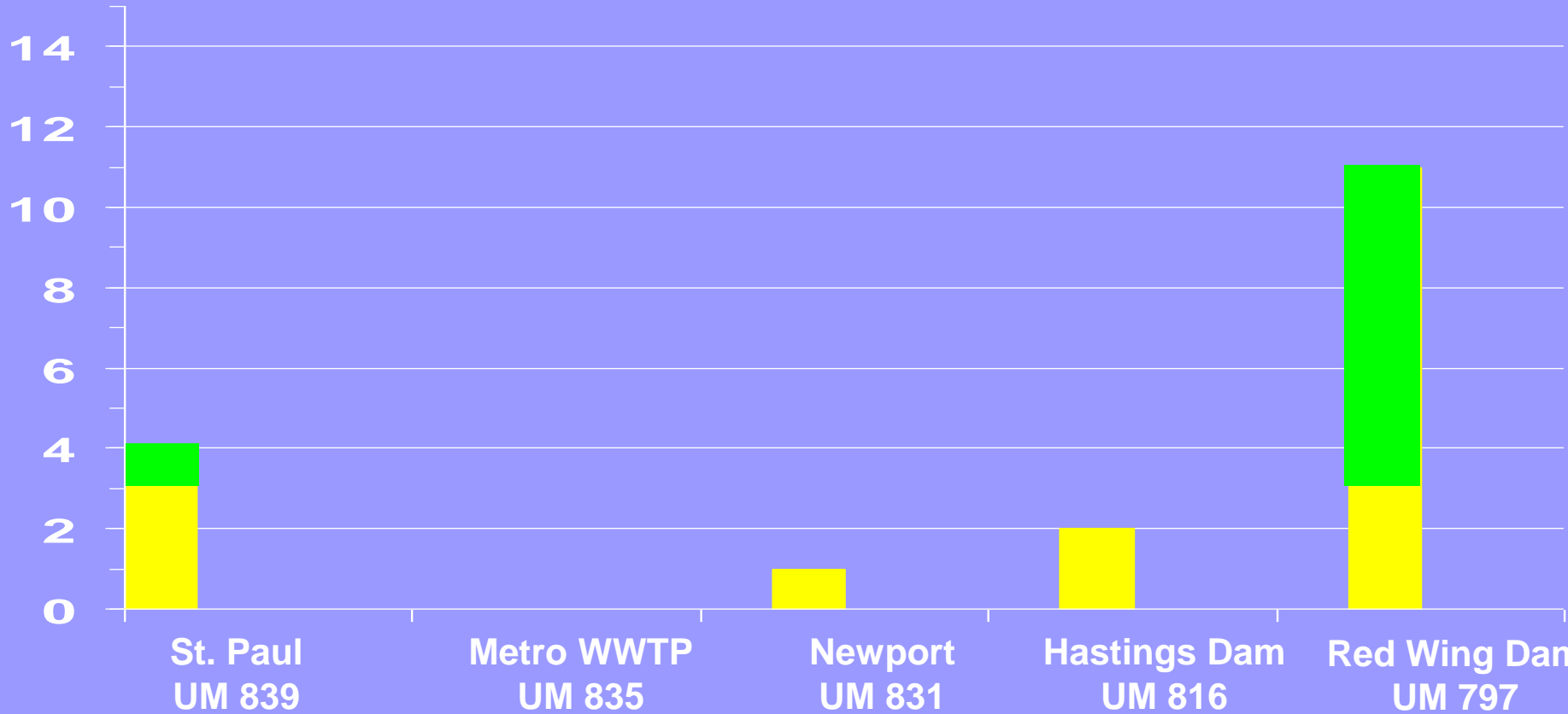


Mississippi Macroinvertebrates

Ponar Grab Sampling: 1926

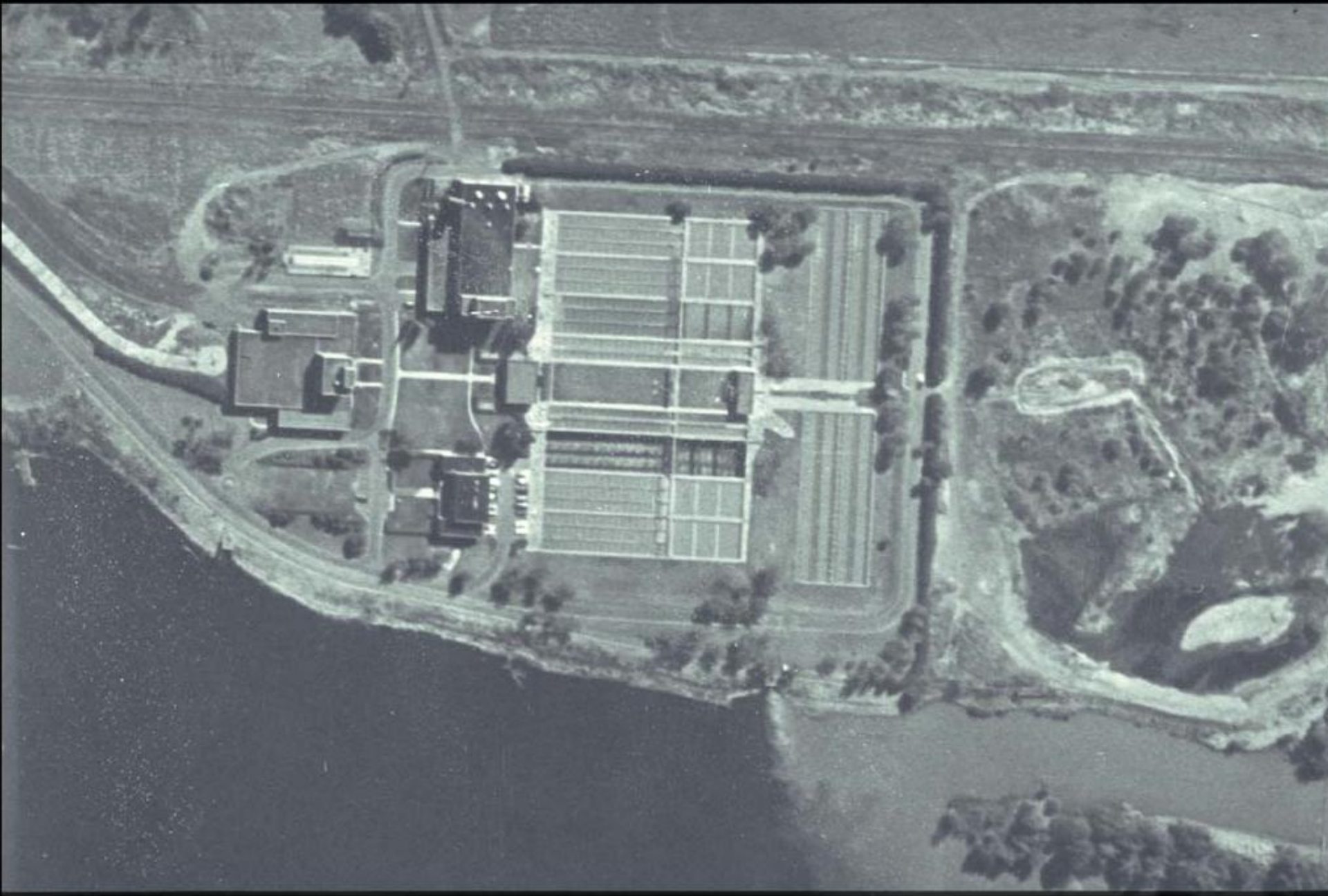
Pollution-Tolerant and Clean-Water Organisms

Total Taxa

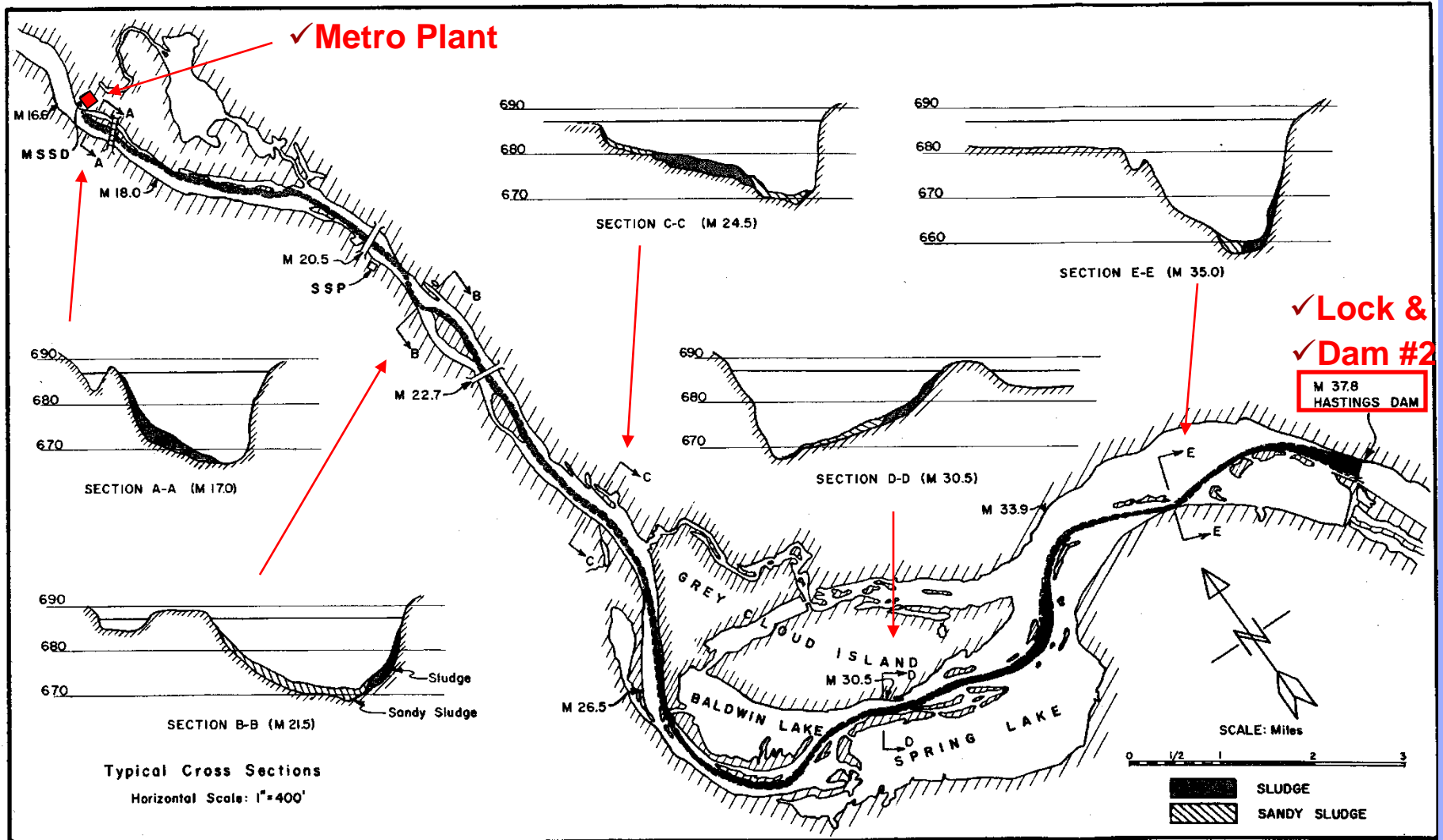


1926  Clean-Water
1926  Pollution-Tolerant

Sampling Site (UM River Mile)



Metropolitan Wastewater Treatment Plant: 1942



LOCATION OF SLUDGE DEPOSITS IN HASTINGS POOL, MISSISSIPPI RIVER

FIG. 33

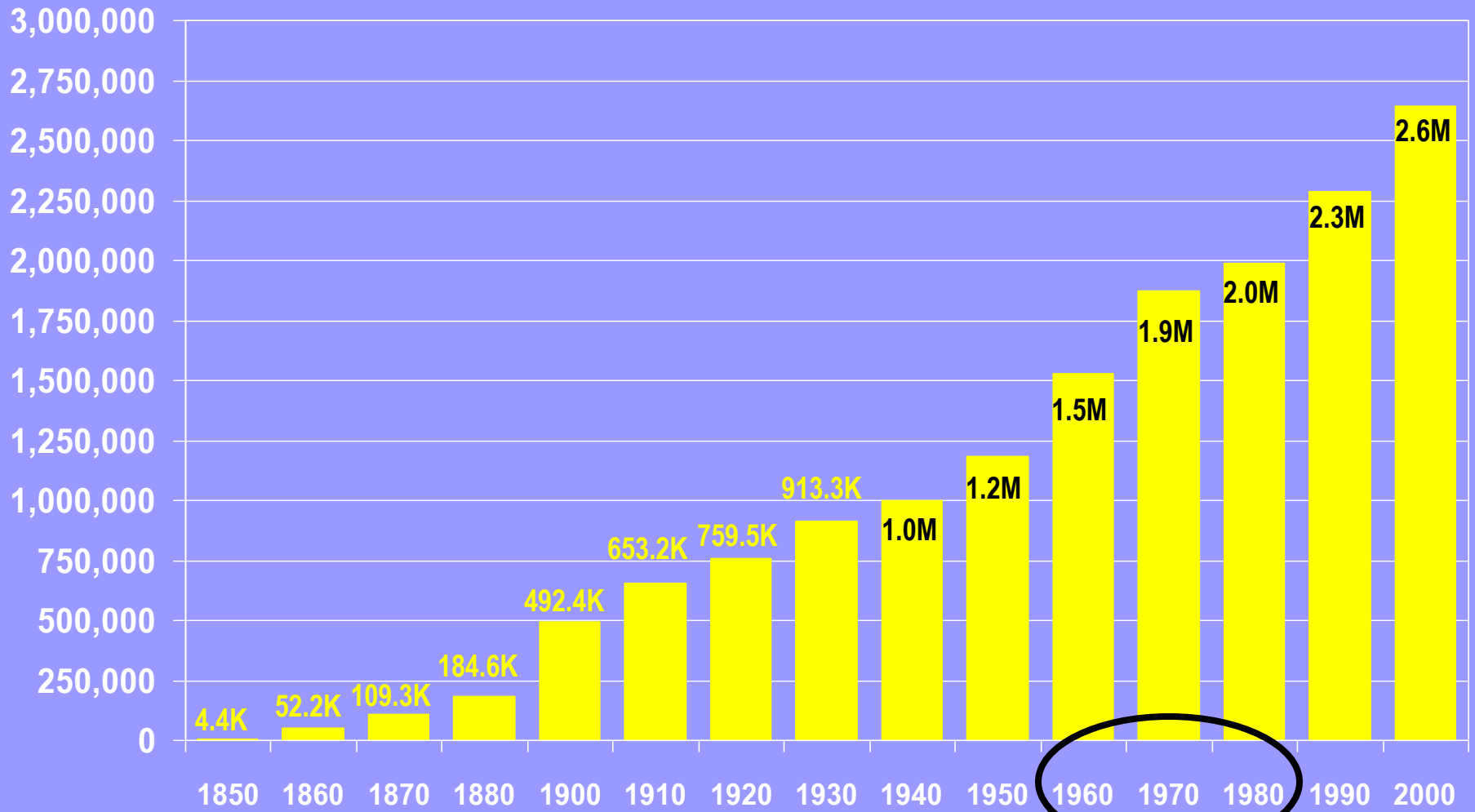
✓ Research in 1959 identified the location of sludge deposits from the Metro Plant in the Mississippi River above Lock and Dam 2.



Metropolitan Wastewater Treatment Plant: 1966

Population Growth

Minneapolis/Saint Paul Area



Mississippi River

Compliance With Water Quality Standard

Dissolved Oxygen (5.0 mg/l)

Grey Cloud Island (UM 827)

1976: 53%

1976

Dorothy Hill, Pepin Wisconsin,
started a group known as Citizens
for a Clean Mississippi River

3,000 members outraged at the Twin
Cities use of Lake Pepin as their
defacto sewage treatment plant for
the past 100 years!



Carp do well in polluted and impounded rivers

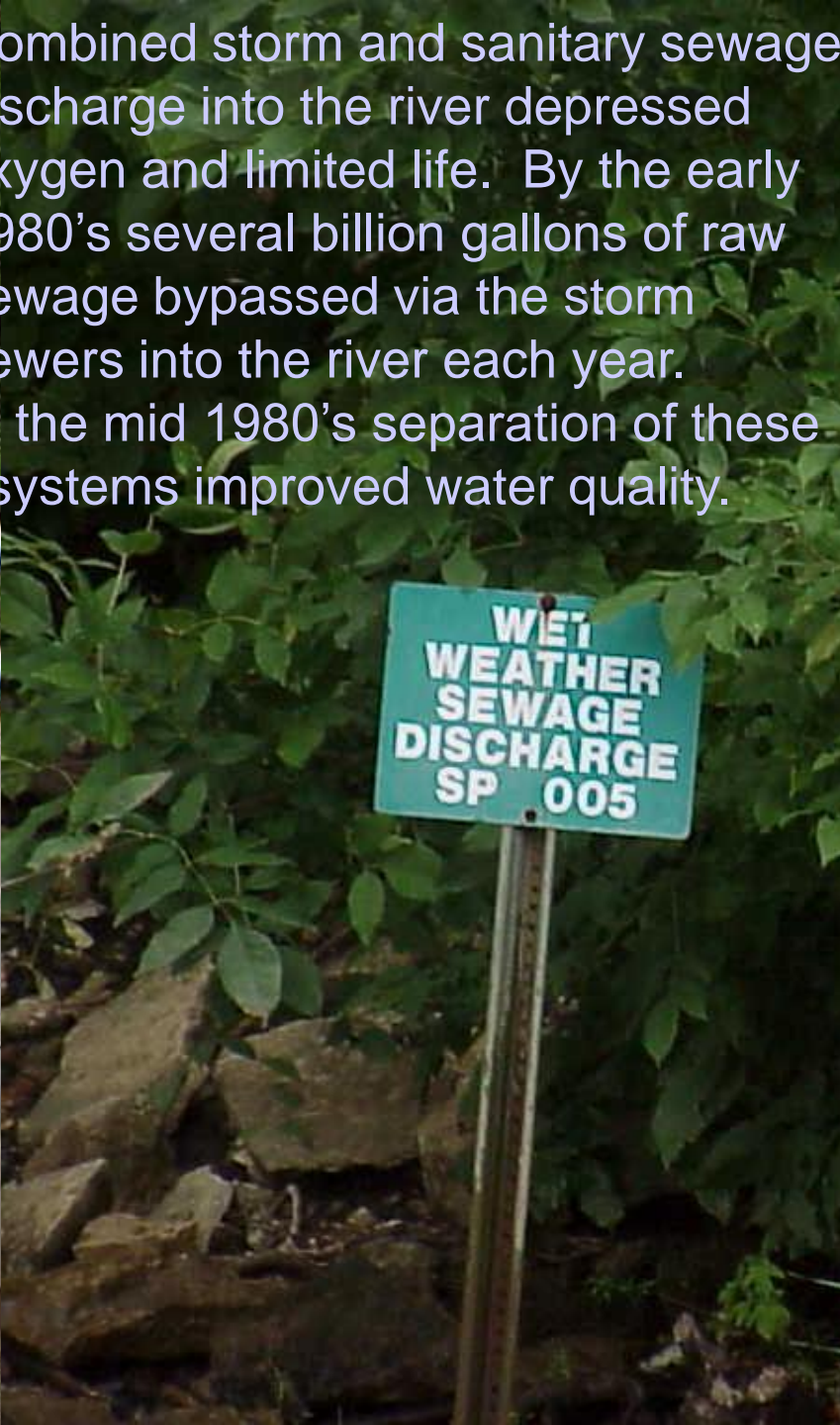
“Carpopolis” Photo courtesy of CitiPages – Mike Mosedale



Metropolitan Wastewater Treatment Plant: ca. 1982



Combined storm and sanitary sewage discharge into the river depressed oxygen and limited life. By the early 1980's several billion gallons of raw sewage bypassed via the storm sewers into the river each year. In the mid 1980's separation of these systems improved water quality.



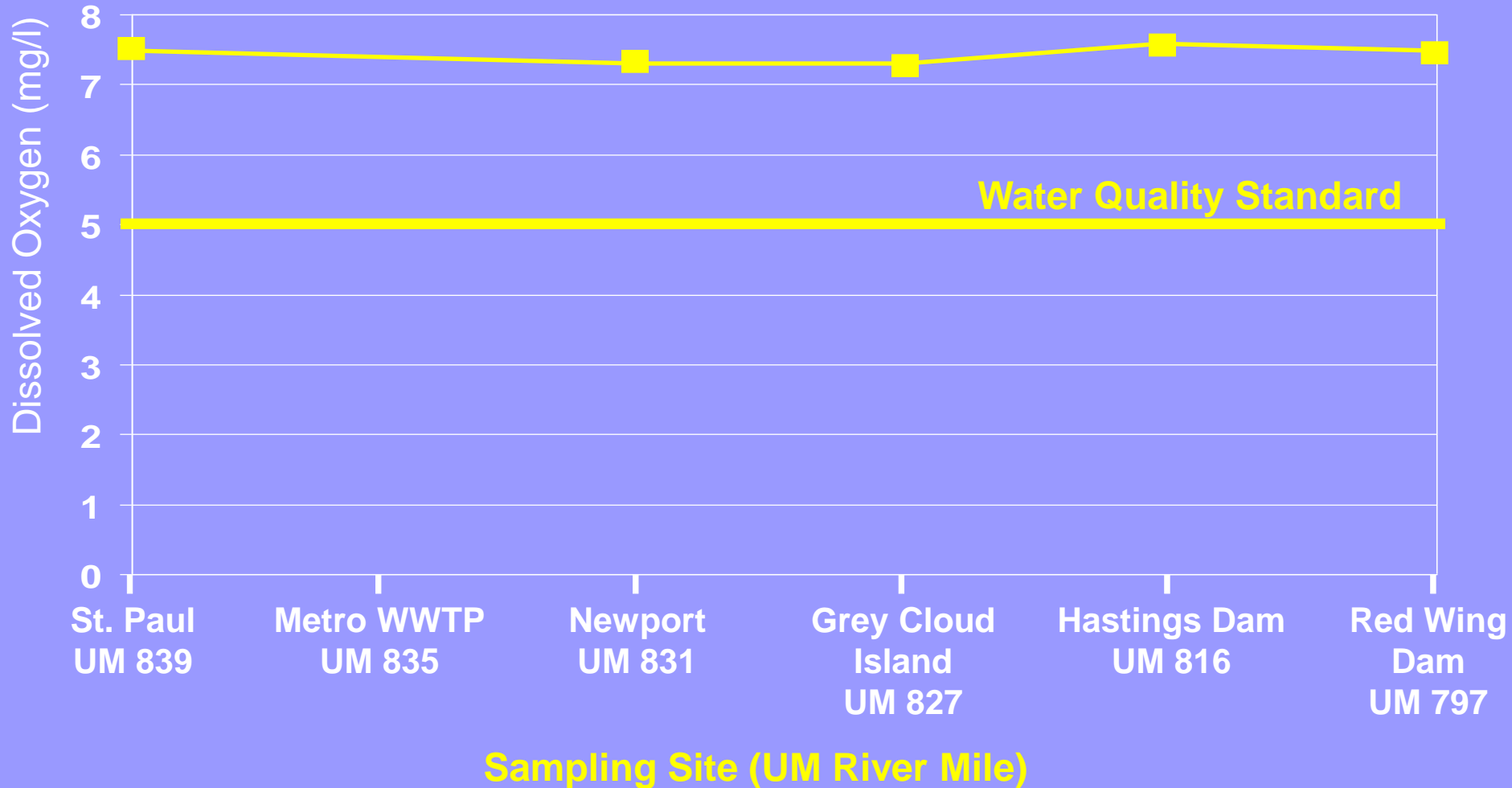
Coliform Bacteria Concentrations

Mississippi River

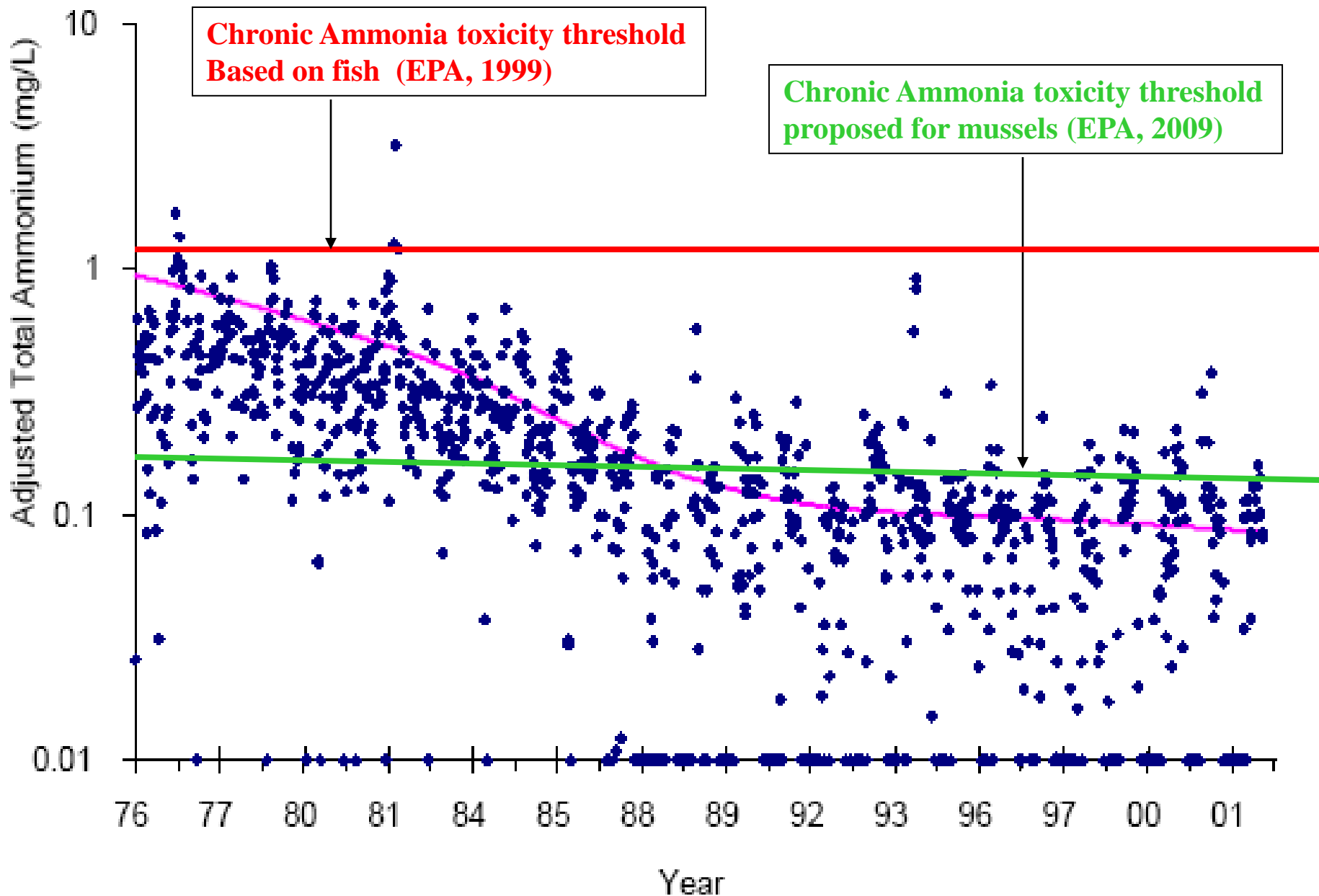
| Site | Aug., 1926 Coliform Bacteria (No. /100 ml) | Aug., 1987 Fecal Coliform (No./100 ml) |
|------------------------------|---|---|
| St. Paul (UM 839) | 296,400 | 722 |
| Newport (UM 831) | 75,500 | 442 |
| Hastings Dam (UM 816) | 275,000 | 46 |
| Red Wing Dam (UM 797) | 14,700 | 32 |
| State Water Quality Standard | | < 200 |

Mississippi River: 1988–1997

Mean August Dissolved Oxygen Concentration*



*Mean of all August observations for the time period



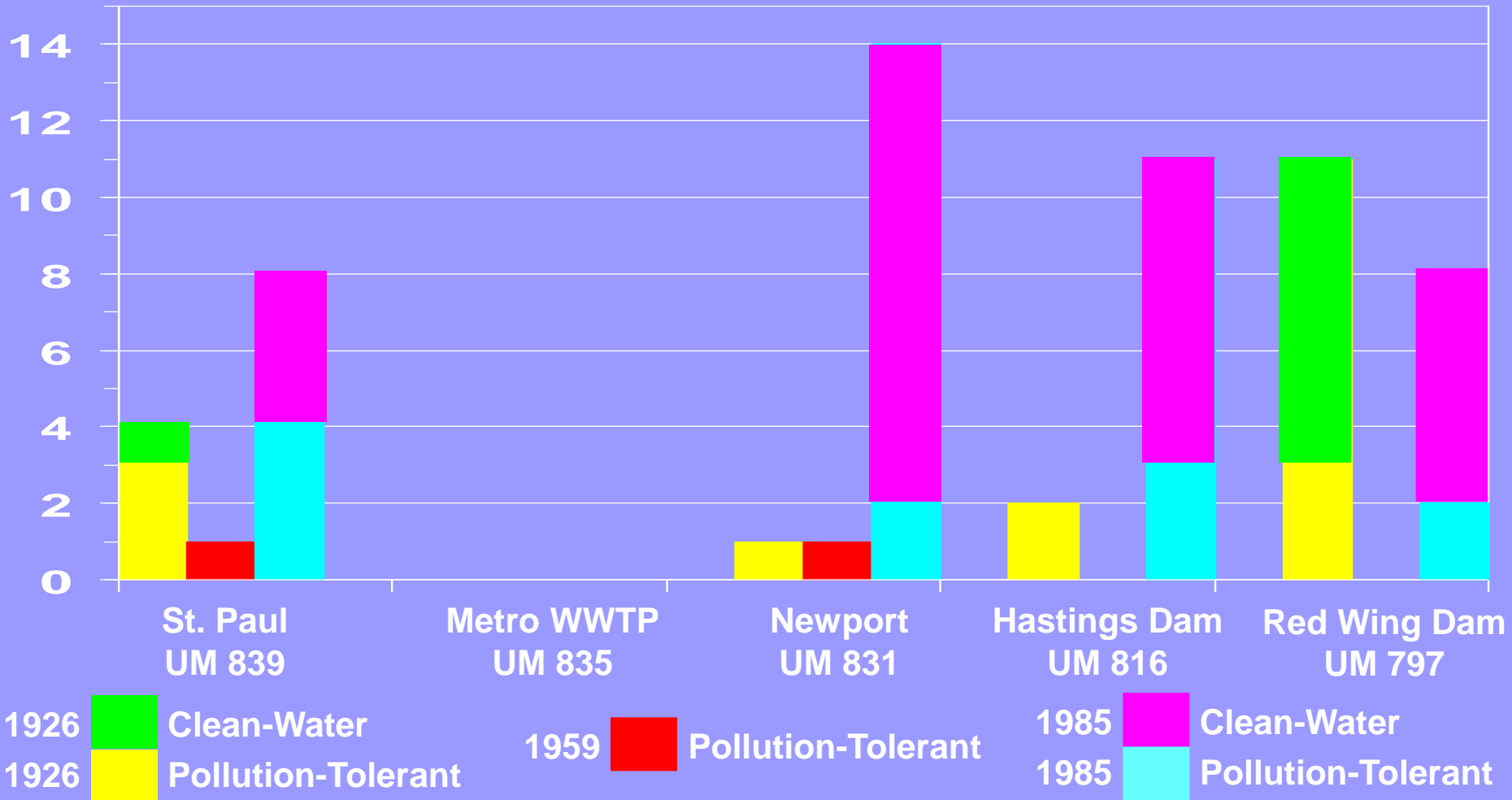
Flow-adjusted ammonia concentrations plotted against time for the Mississippi River at Red Wing.

Mississippi Macroinvertebrates

Ponar Grab Sampling: 1926, 1959, 1985

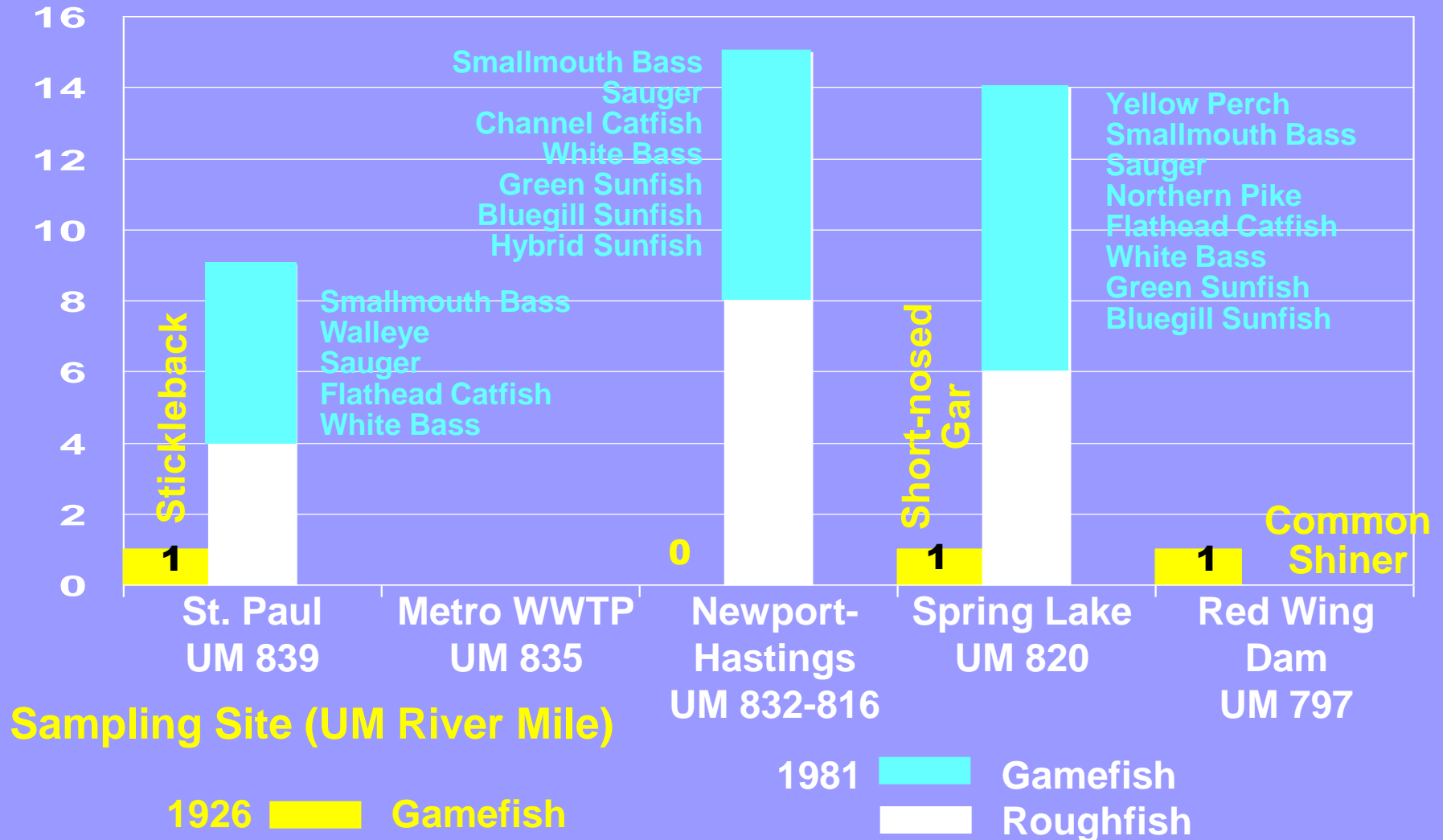
Total Taxa

Pollution-Tolerant and Clean-Water Organisms



Mississippi River Fish: 1926, 1981

Total Taxa





Walleyes Return to the Mississippi River



| Minnesota Fishes of the Mississippi River | Above The Falls |
|--|--------------------------------|
|--|--------------------------------|

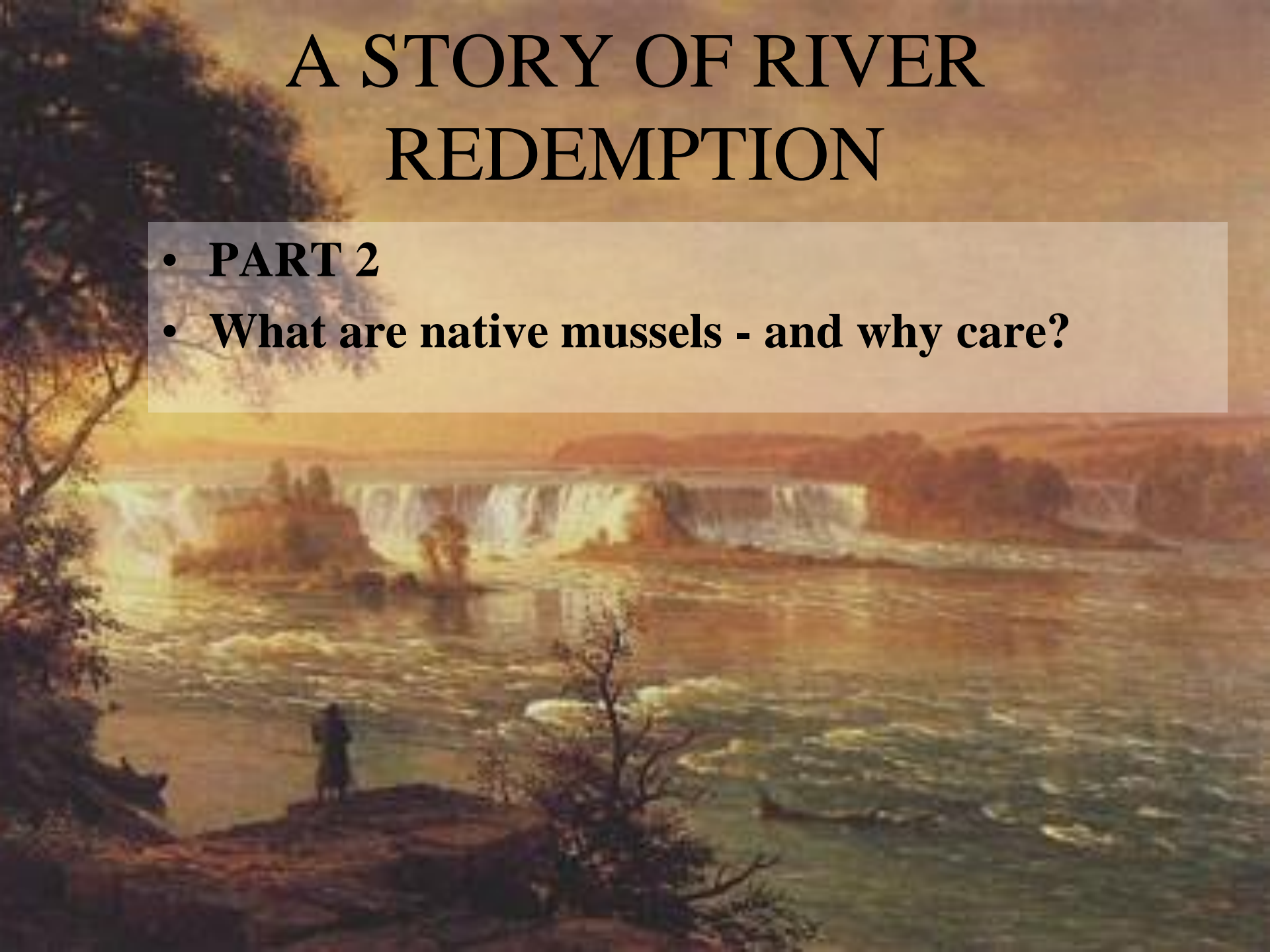
| | |
|---------------------------|-----------|
| No. of families | 18 |
| No. of genera | 47 |
| Total no. of species | 75 |
| No. of introduced species | 10 |
| No. of native species | 65 |
| No. of ETS species | 2 |

| Minnesota Fishes of the Mississippi River | Below The Falls |
|--|--------------------------------|
|--|--------------------------------|

| | |
|---------------------------|------------|
| No. of families | 26 |
| No. of genera | 69 |
| Total no. of species | 126 |
| No. of introduced species | 7 |
| No. of native species | 119 |
| No. of ETS species | 16 |

A STORY OF RIVER REDEMPTION

- **PART 2**
- **What are native mussels - and why care?**



✓ **SO.....**

What are native mussels
and what do they do?



✓ Meet your “animal part” mussels -



✓ pigtoe



✓ deertoe



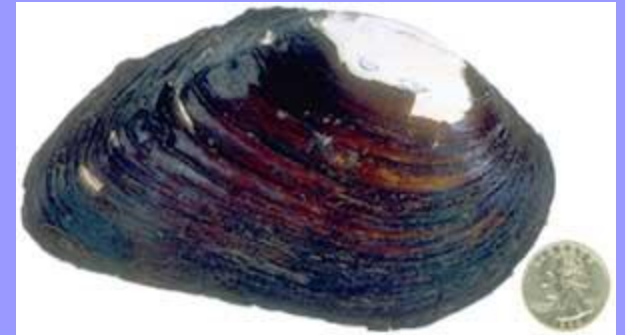
✓ fawnsfoot



✓ sheepnose



✓ elktoe



✓ elephant ear



✓ Round pigtoe



✓ Higgins' eye



✓ monkeyface



✓ Purple wartyback



✓ snuffbox



✓ butterfly



✓ pistolgrip

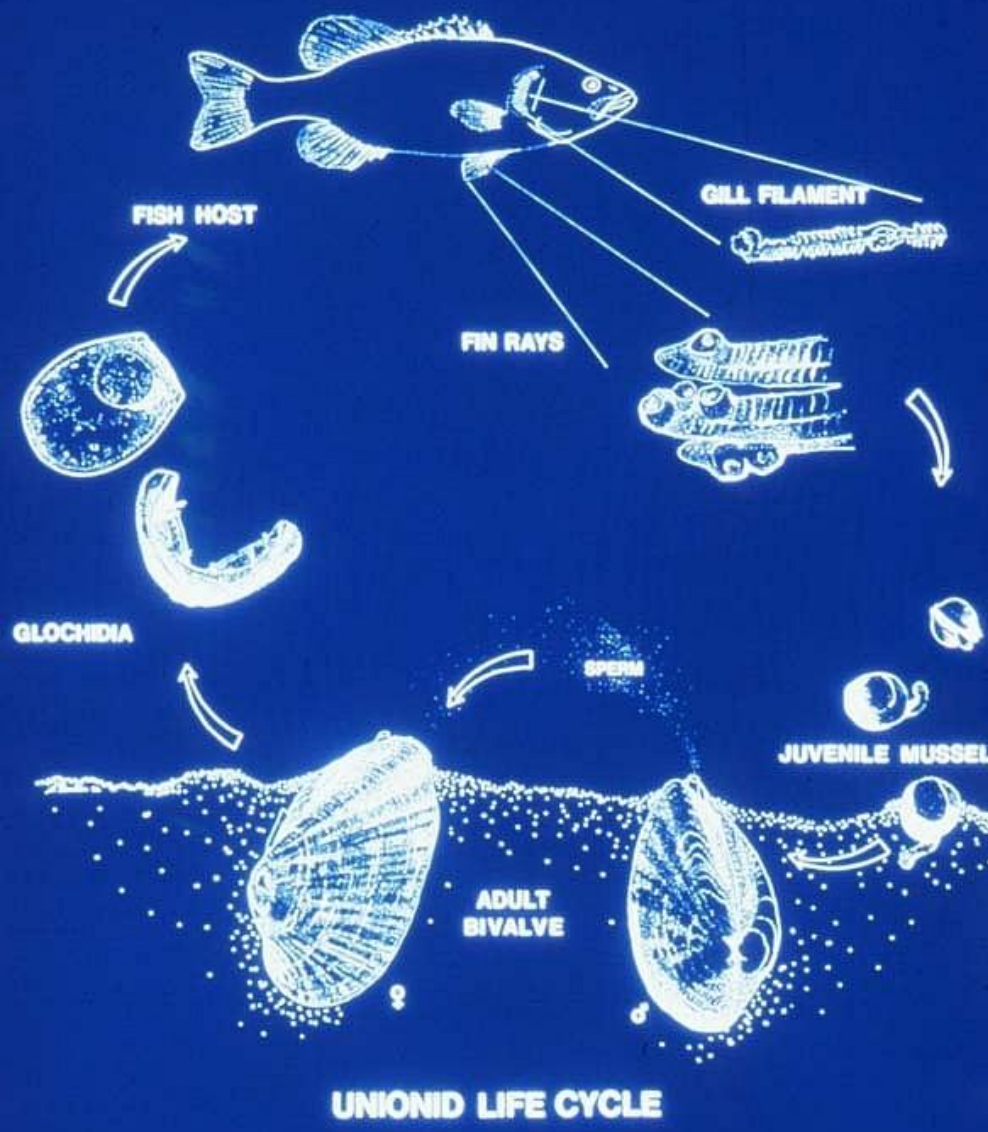


✓ pocketbook



✓ fat mucket

M. C. Barnhart 1998



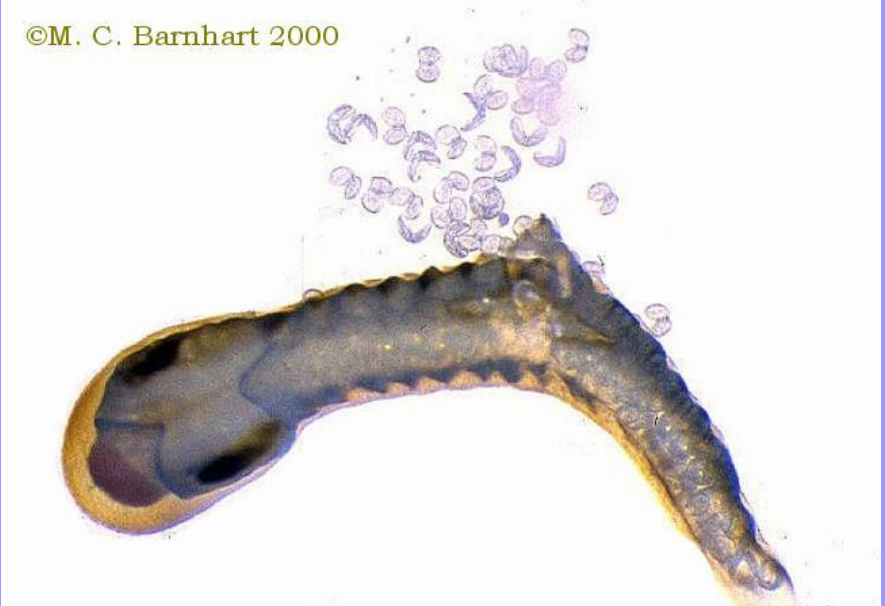
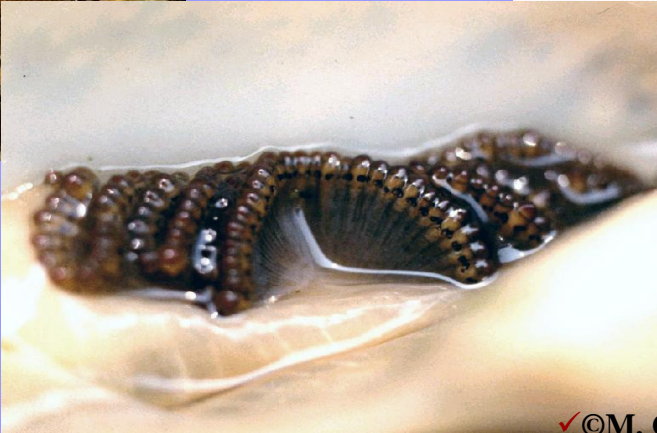
UNIONID LIFE CYCLE

M. C. Barnhart 1998











From the *Unio* Gallery

M. C. Barnhart 1998

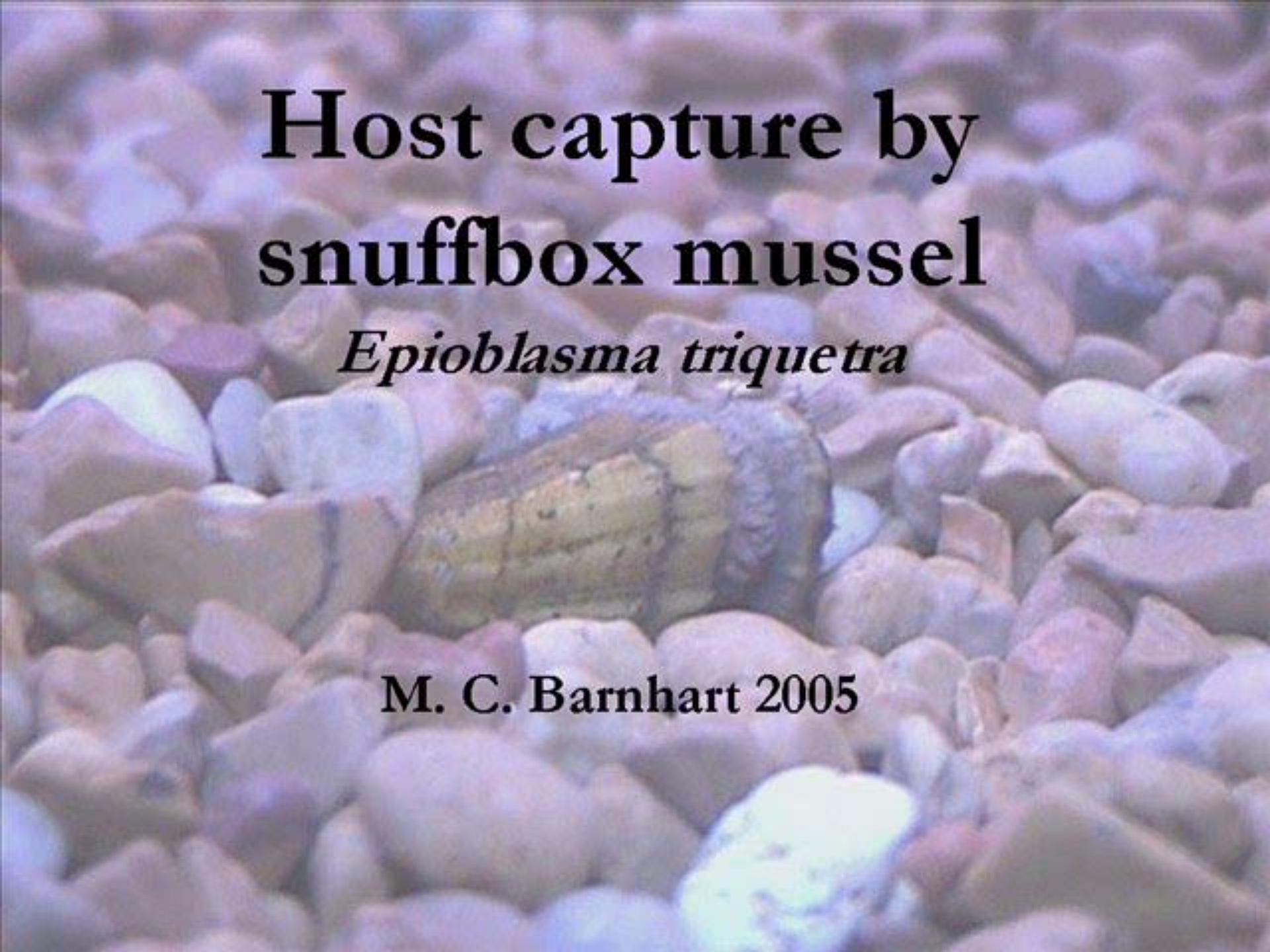




Conglutinates of
Obliquaria reflexa



Conglutinates of
Fusconaia flava

A photograph of a snuffbox mussel (Epioblasma triquetra) resting on a bed of smooth, light-colored pebbles. The mussel is the central focus, showing its characteristic three-sided shell shape. The background is a dense field of similar pebbles, creating a textured, natural setting.

Host capture by snuffbox mussel

Epioblasma triquetra

M. C. Barnhart 2005

Snuffbox with logperch

Bellows movements and glochidia release
(4X speed)

M. C. Barnhart 2005

A STORY OF RIVER REDEMPTION

- **PART 2 - Native Mussels**
- **Gone for a century – Why Care?**
- **42 species once lived in the Metro river**
- **By 1900 clammers could not find live mussels**
- **In a 1978 survey 7 live species were found in the Ford dam tailwaters, 0 in Pool 1 and 0 between St. Paul and Hastings**

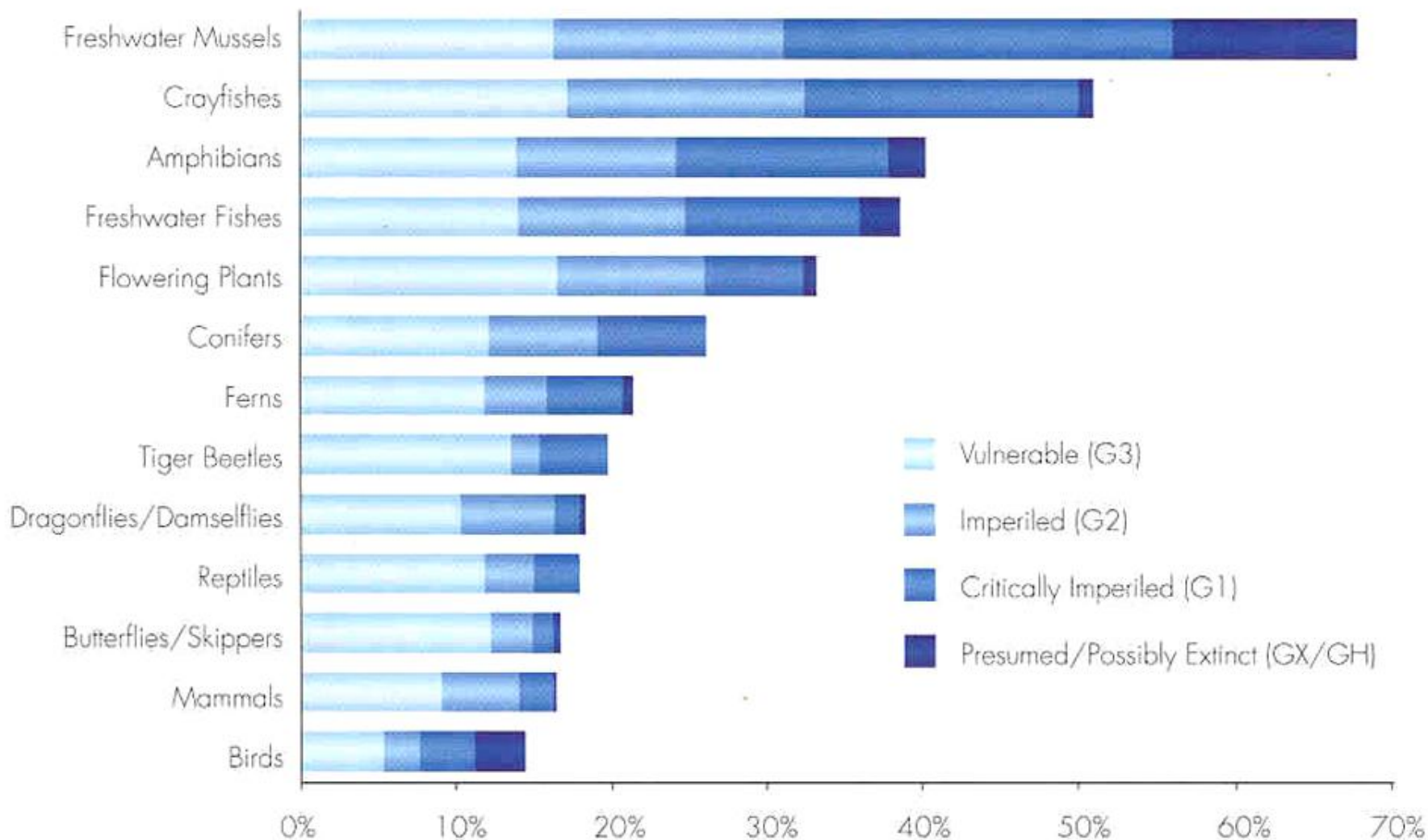
By 1900 clammers seeking shell for the button industry noted that only old empty shells could be found between Hastings and the mouth of the Minnesota River



**Ebonyshell
mussel bones**

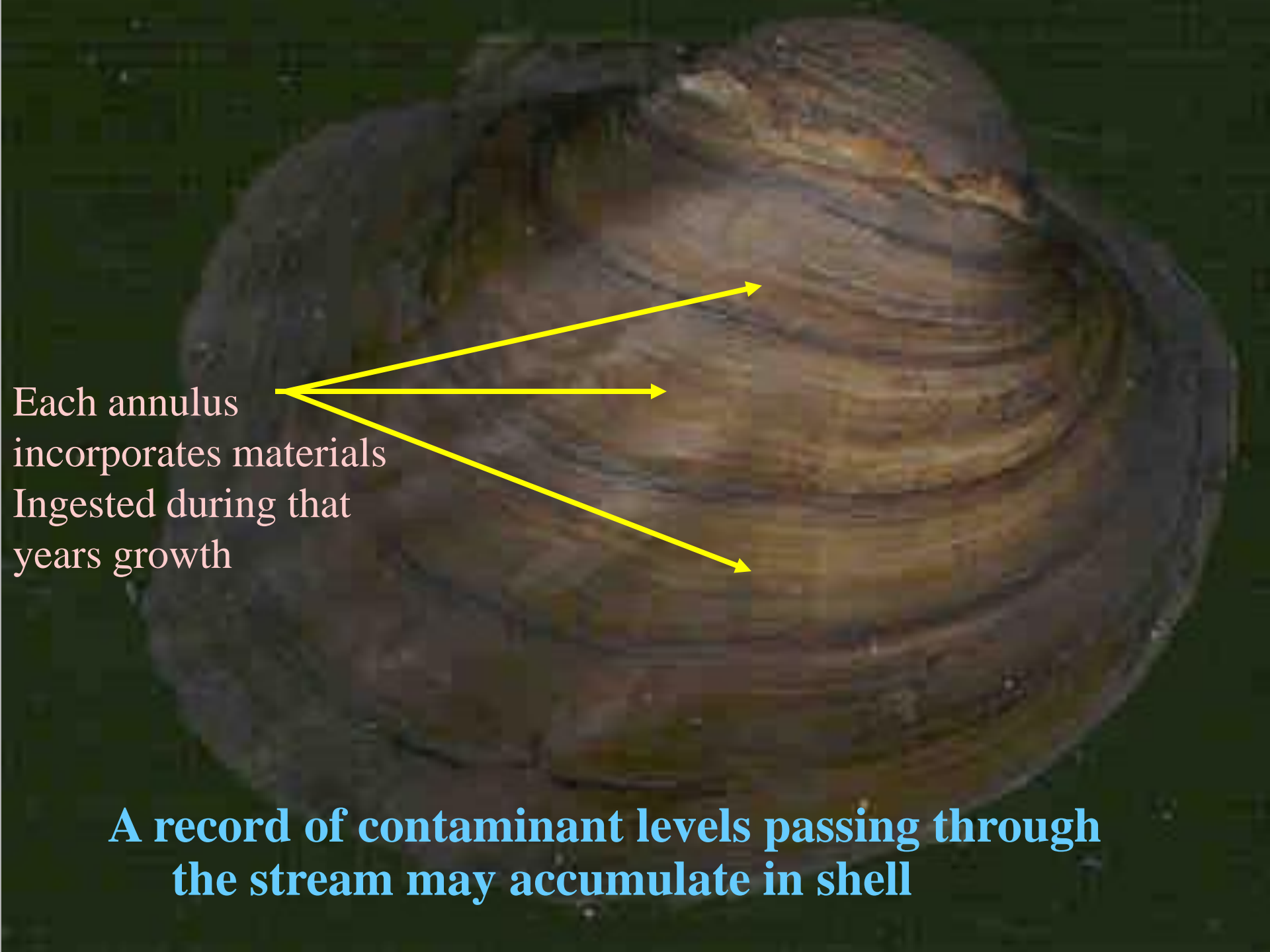
Figure 1. Proportion of U.S. Species at Risk

The species groups that are proportionately the most imperiled—mussels, crayfishes, and amphibians—consist entirely or primarily of freshwater species. (Source: 1997 Species Report Card²¹)



Six Reasons Mussels Are Important To River Health

- 1. Sessile, obligate consumers of FPOM**
- 2. Long lived (10 – 100+ years)**
- 3. Shell deposits reveal evidence of past existence**
- 4. Contaminants accumulate in shell annuli**
- 5. Mussel aggregations form habitat**
- 6. Fish love mussel beds**



Each annulus
incorporates materials
Ingested during that
years growth

**A record of contaminant levels passing through
the stream may accumulate in shell**

Aggregations of mussels create habitat in rivers.

Freshwater Biology (2006) 51, 1016–1024

doi:10.1111/j.1365-2427.2006.0

Context-dependent effects of freshwater mussels on stream benthic communities

DANIEL E. SPOONER AND CARYN C. VAUGHN

Oklahoma Biological Survey and Department of Zoology, University of Oklahoma, Norman, OK, U.S.A.

J. N. Am. Benthol. Soc., 2006, 25(3):691–700
© 2006 by The North American Benthological Society

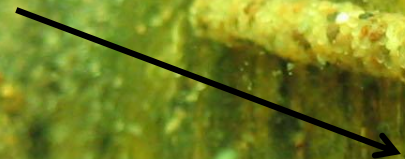
Unionid mussels influence macroinvertebrate assemblage structure in streams

Caryn C. Vaughn¹ AND Daniel E. Spooner²

*Oklahoma Biological Survey and Department of Zoology, University of Oklahoma,
Norman, Oklahoma 73019 USA*

Mussel Bed – Sunrise River, MN

Mussel



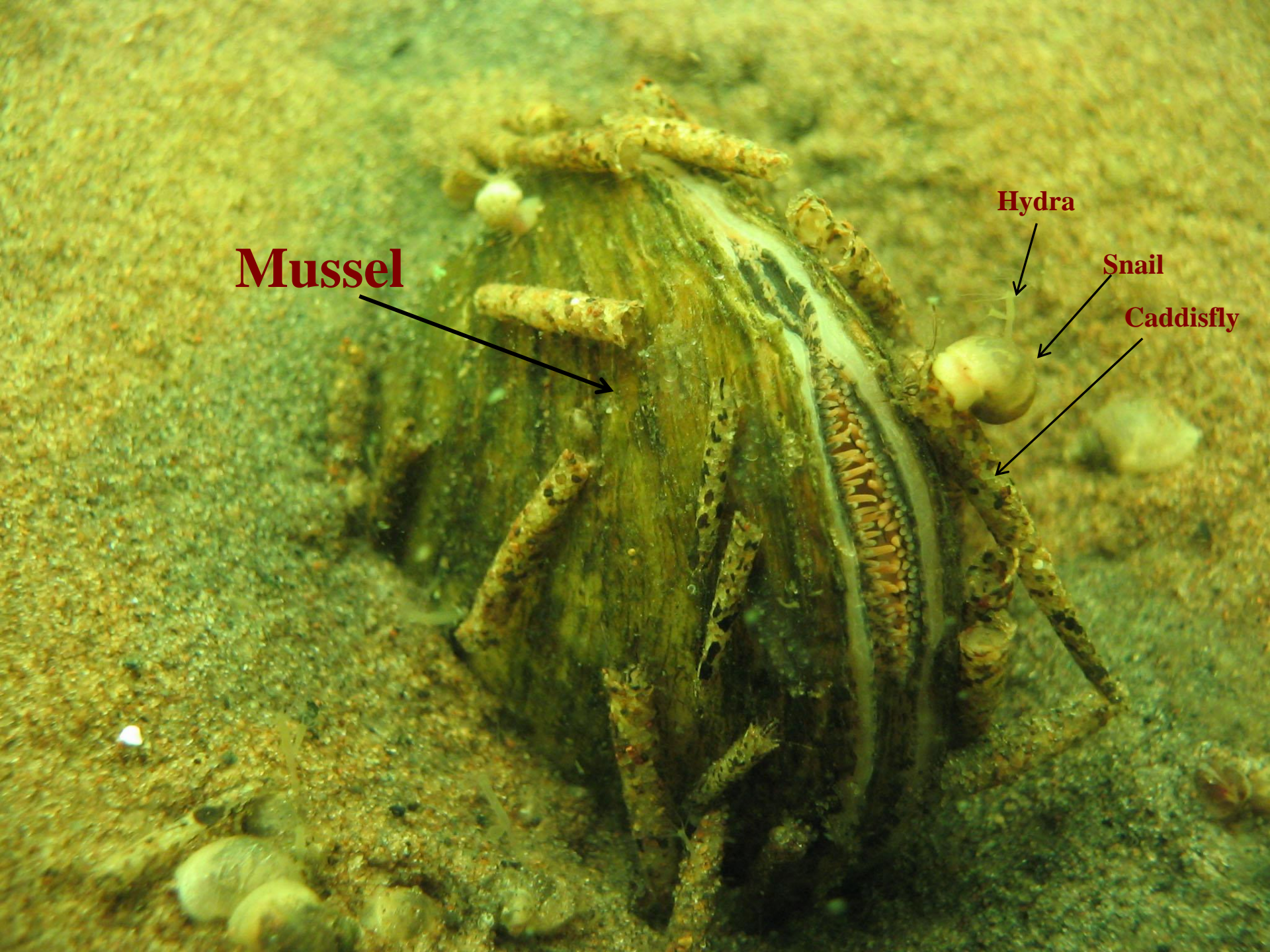
Hydra



Snail



Caddisfly



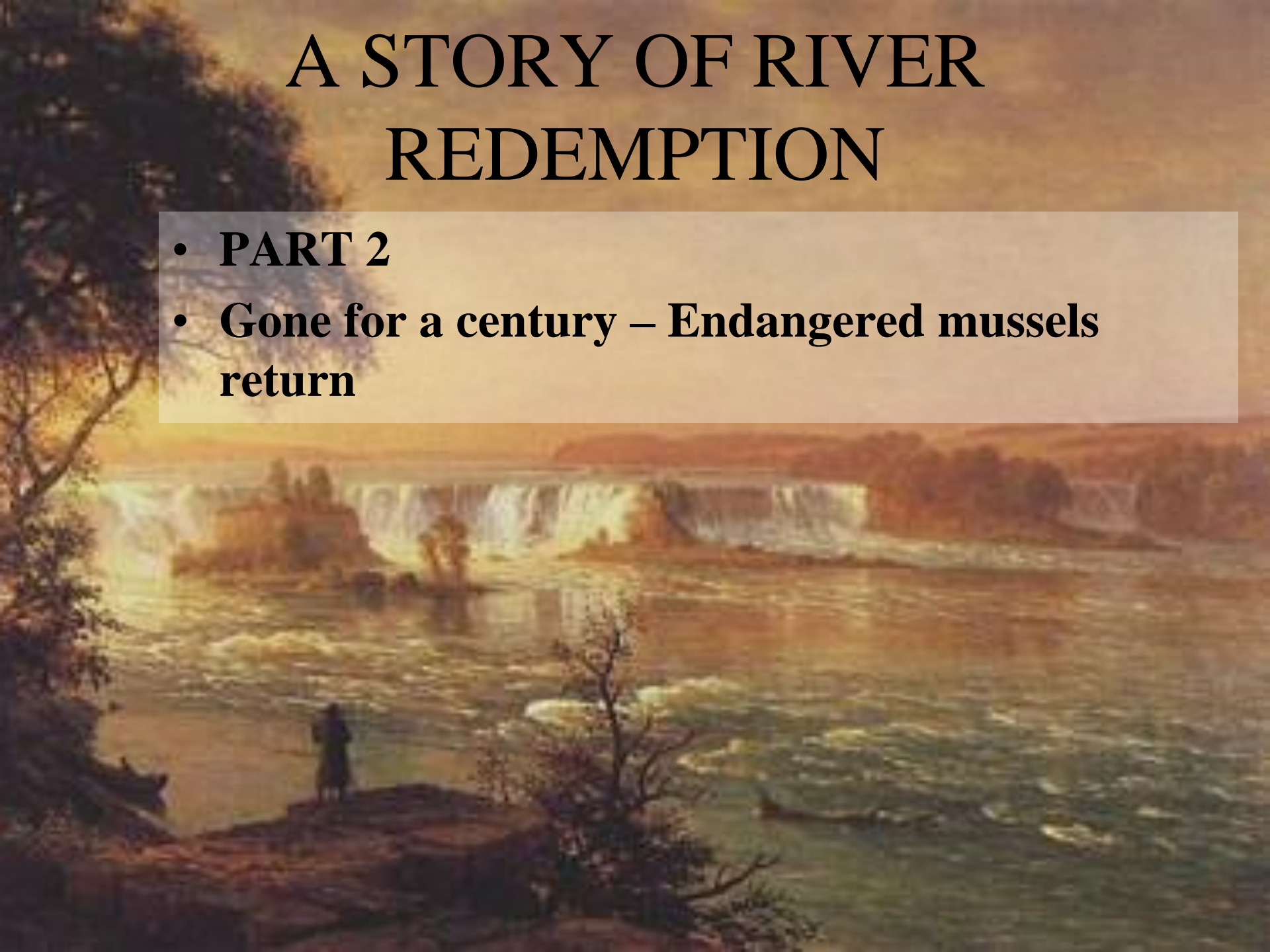


**Fish are attracted to mussel beds and
serve as hosts to their larvae**

Mussel bed at foot of Lake Pepin, Mississippi River

A STORY OF RIVER REDEMPTION

- **PART 2**
- **Gone for a century – Endangered mussels return**



USFWS Jeopardy Decision

April 2000 – *Lampsilis higginsii*

Jeopardized by upriver transport of invasive zebra mussels – reasonable and prudent measures identified as remedies included reintroducing *L. higginsii* to areas within its former range that were not heavily colonized by zebra mussels. This to be accomplished by moving adults and through artificial propagation of juveniles





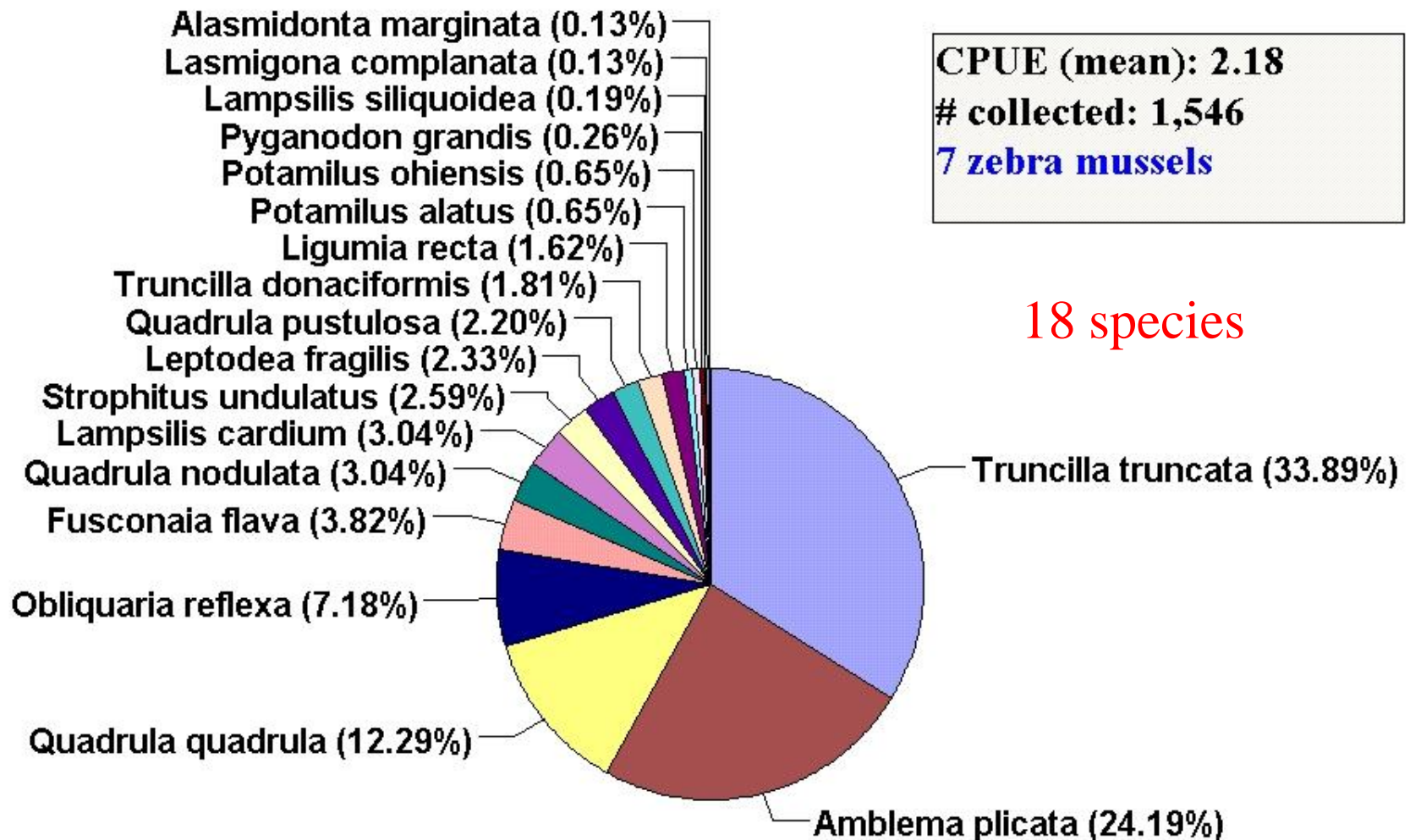
Mussel surveys on Mississippi River Pools 1, 2 and 3 began in the summer of 2000 .

POOL 2 MUSSEL ABUNDANCE

All Upper Pool Sites Combined

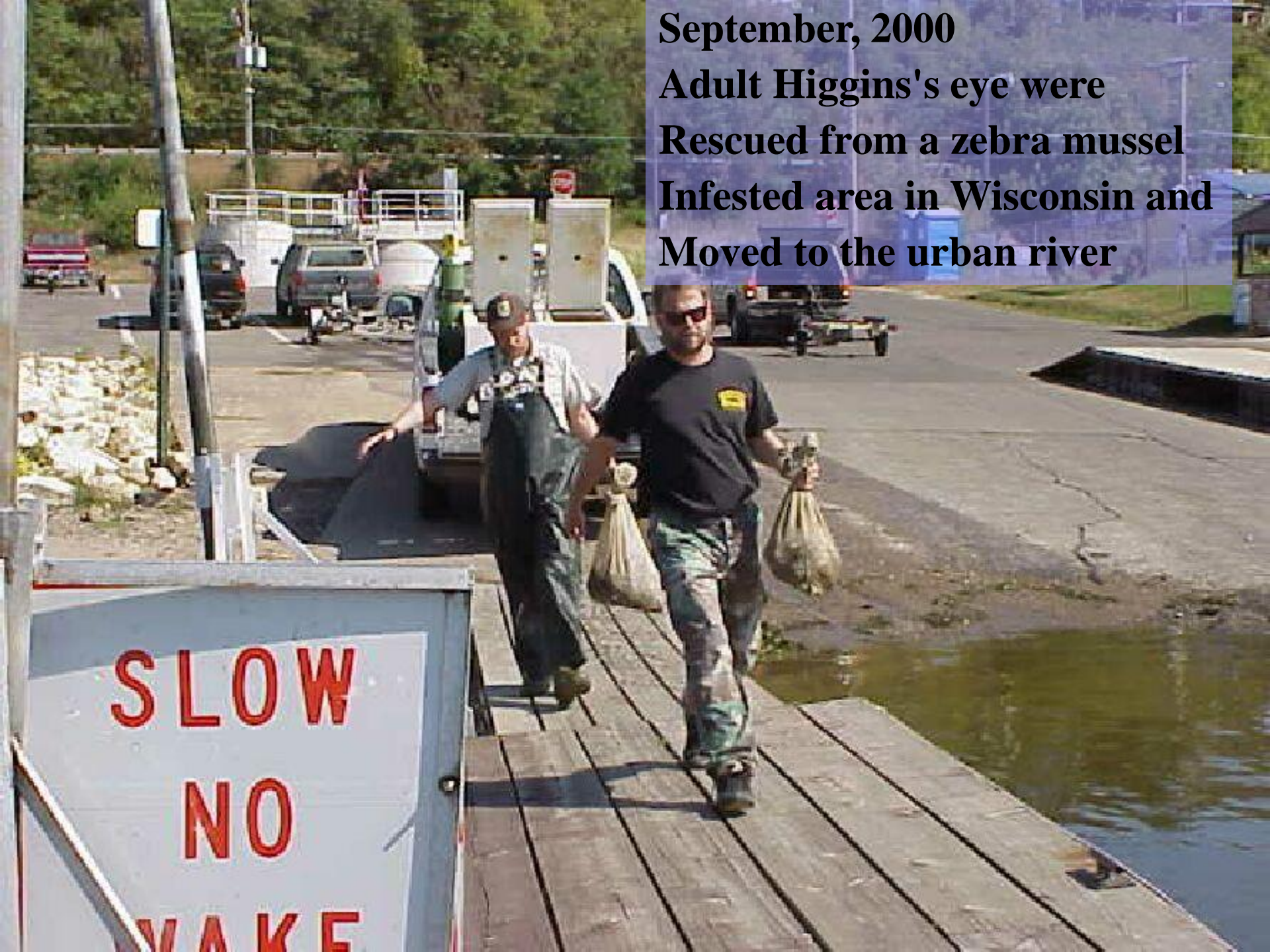
CPUE (mean): 2.18
collected: 1,546
7 zebra mussels

18 species



September, 2000

**Adult Higgins's eye were
Rescued from a zebra mussel
Infested area in Wisconsin and
Moved to the urban river**



**SLOW
NO
WAKE**

Higgins' eye transplant site 2000:
100-years after Harder reported all
Mussels were dead in 1900!

Ft Snelling



Propagation:
Collect gravid female Higgins' eyes





Harvest glochidia

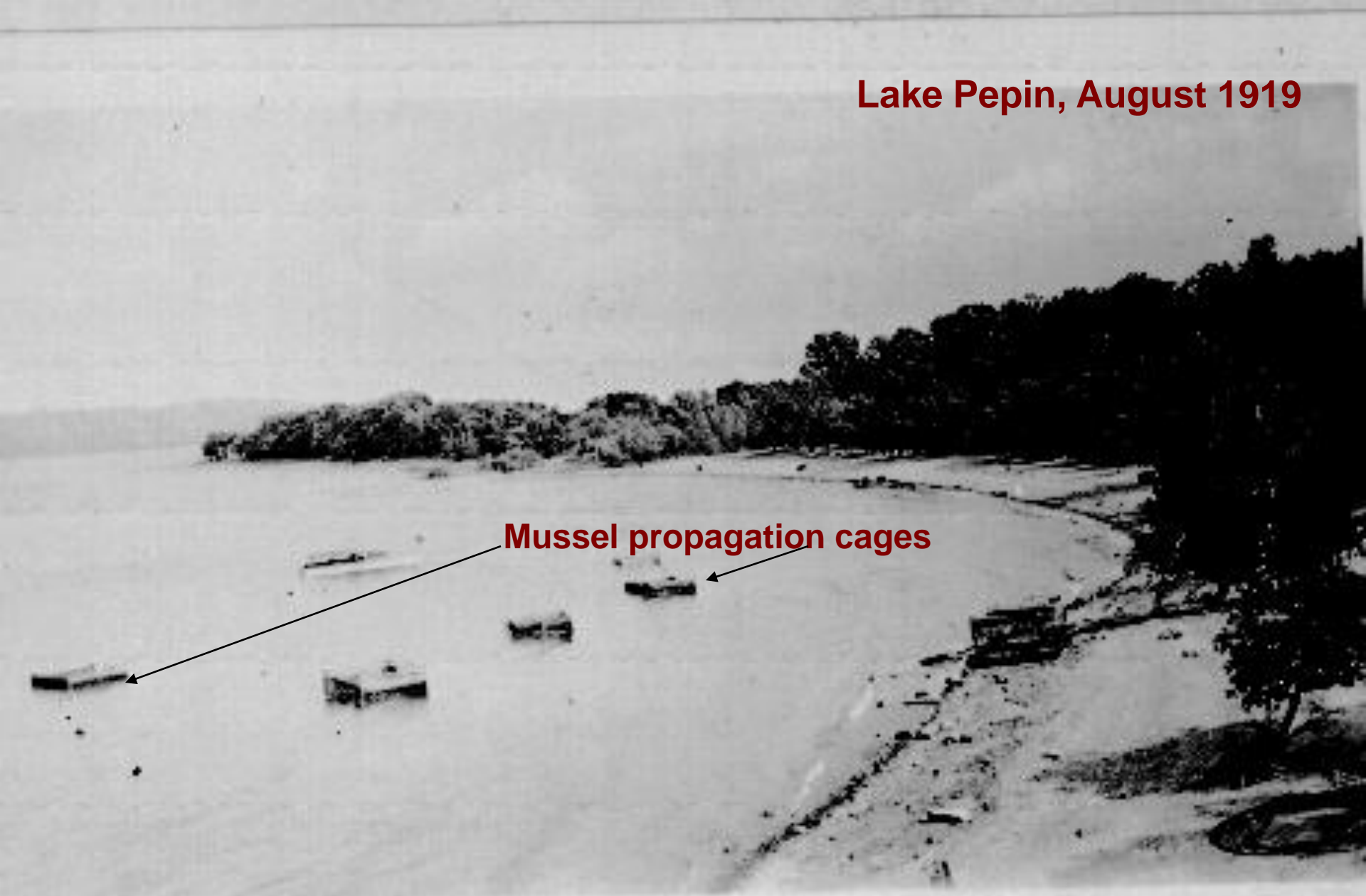
Infect host fishes gills



Caged fish are held in cages on river bottom until mussel larvae have transformed into juveniles



Lake Pepin, August 1919



Mussel propagation cages

30 August 1919

Photo courtesy of Milwaukee Public Museum





Lake Pepin
10/09/1919



Lake Pepin
9/24/2002
(83 years later)

Frontenac cage propagation site – cage fouled with zebra mussels



Many individuals from the 2006 year-class were smothered by zebra mussels and died





Gravid! Higgins' eye females transplanted in 2000 show conclusive evidence of reproduction at reintroduction sites in Pools 2&3 - September 2002 - 2006

**Gill "marsupium"
Filled with glochidia**

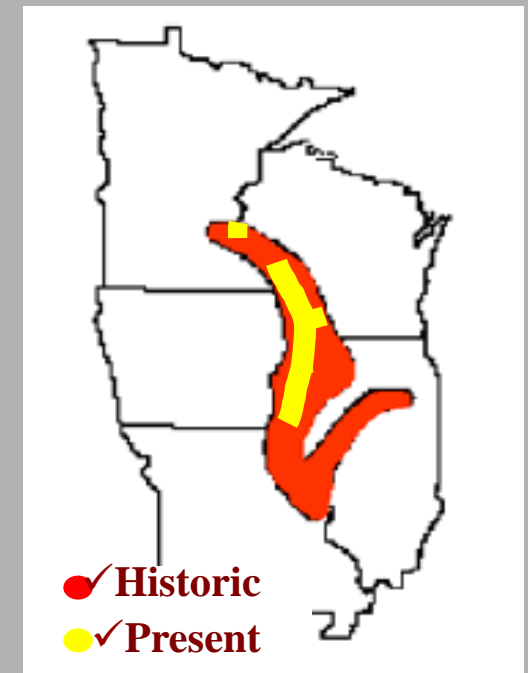
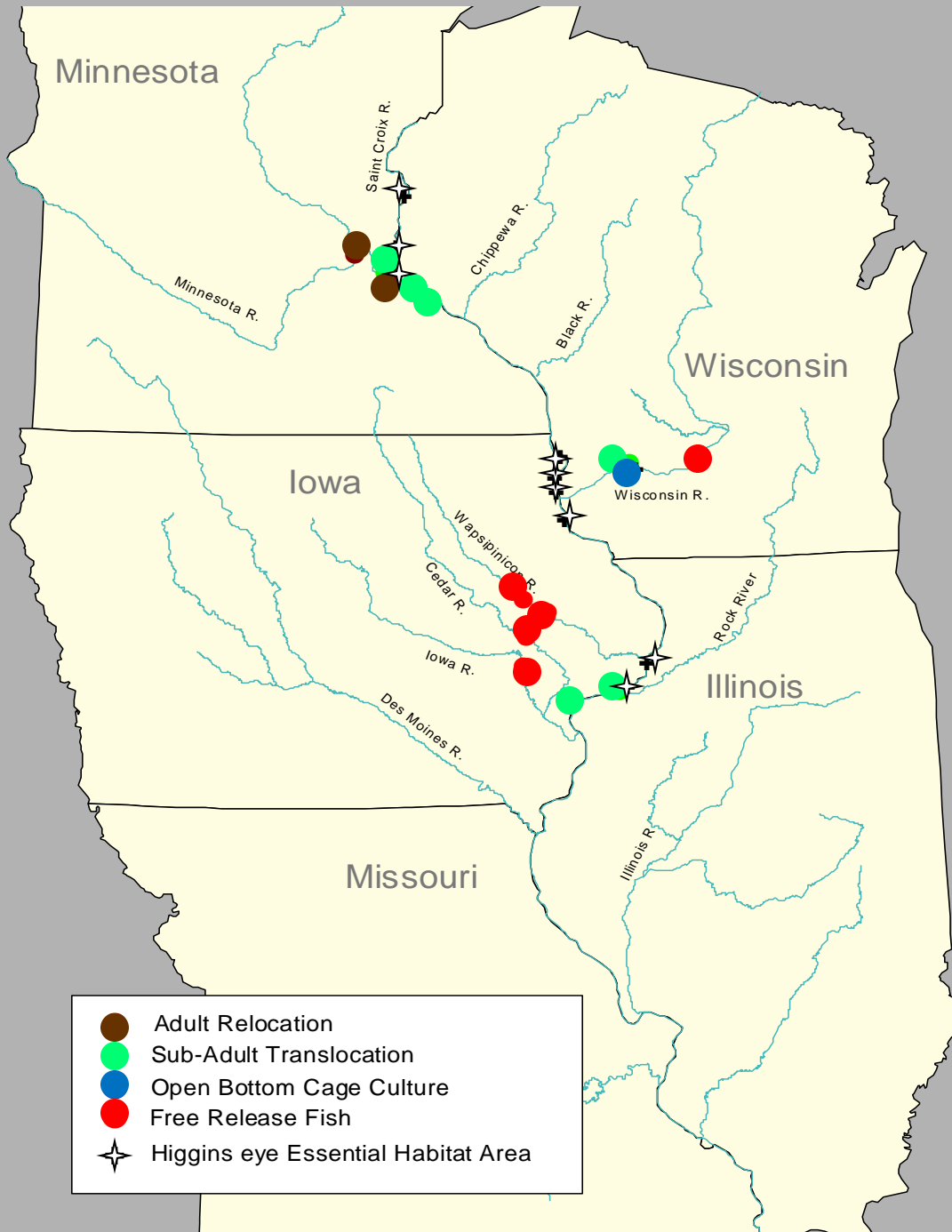




**Gill chamber full of gloch
September 2005**

**Juvenile propagated in 2001
Reintroduced to river in 2003**

✓ Higgins eye Relocation Sites and Methods



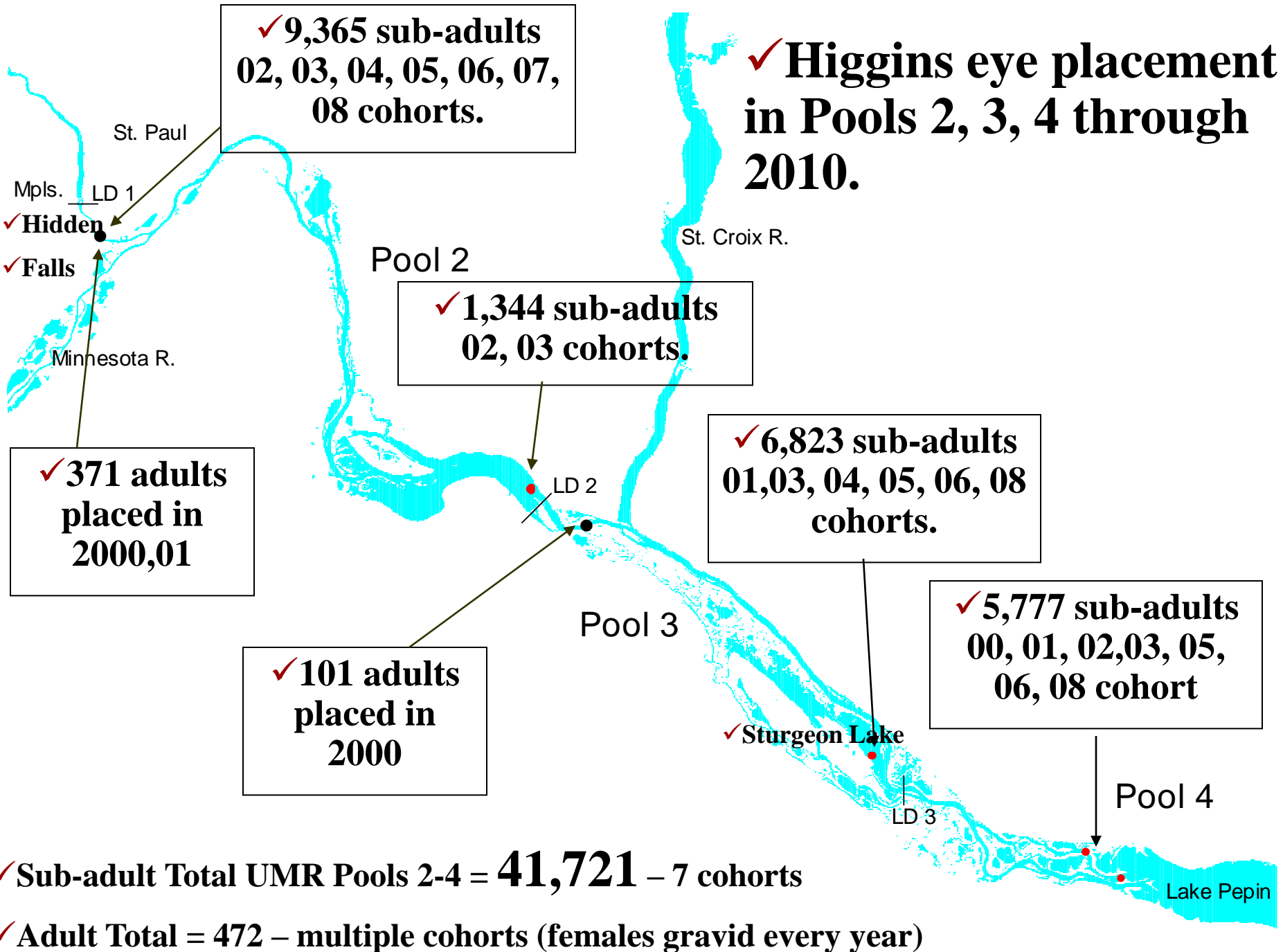




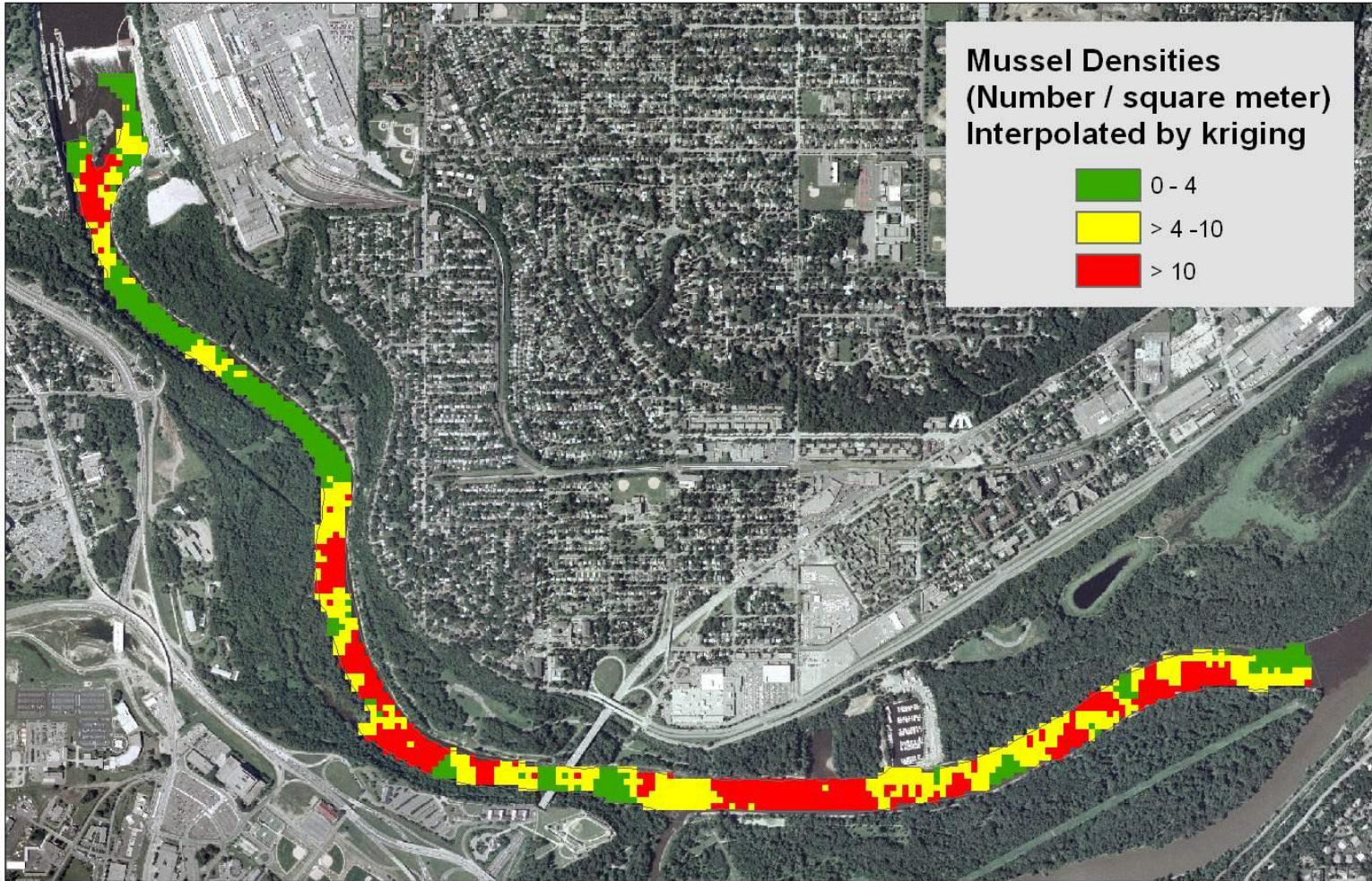


Figure 1. Mississippi River relocation area, Hidden Falls Park, St. Paul, MN.

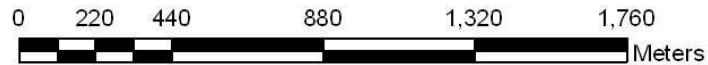


| | Area (m ²) (Millions) | # of samples | # of samples with live mussels | # of live mussels collected | Mean Density (#mussels/m ²) | Populatio n Mean (millions) | Lower 95% confidence interval (millions) | Upper 95% confidence interval (millions) | # of live species |
|------------------|--------------------------------------|-----------------|---|-----------------------------------|--|-----------------------------------|---|---|-------------------------|
| Pool 2 | | | | | | | | | |
| All sites | 570,975 | 219 | 162 (73.9%) | 494 | 9.02 | 5,150,000 | 4,410,000 | 5,890,000 | 16 |





Pool 2 Relocation Area



FRESHWATER MUSSELS OF MINNESOTA:

A PLAN FOR CONTROLLED PROPAGATION, REINTRODUCTION AND AUGMENTATION WITHIN THE MISSISSIPPI RIVER FROM ST. ANTHONY FALLS TO LAKE PEPIN.



Mike Davis, MN DNR
Minnesota Department of Natural Resources

March 2005

SITE REINTRODUCTION PLAN

for

Actinonaias ligamentina (mucket) and *Epioblasma triquetra* (snuffbox) at St. Paul, MN
(Mississippi River at Hidden Falls)



Site Coordinator:


- Mike Davis, Minnesota Department of Natural Resources, 1801 South Oak St, Lake City, MN 55041. 651/345-3331 ext 227, fax 651/345-3975, mike.davis@dnr.state.mn.us









The background of the entire page is a close-up photograph of numerous mussel shells. The shells are densely packed and show a variety of colors, including shades of green, brown, and tan, with distinct concentric growth lines. The lighting creates highlights and shadows, giving the shells a three-dimensional appearance.

| MN T&E Mussel Species Released into Gorge | 2007 | 2008 | 2009 | 2010 | 2011 | Total |
|--|-------------|-------------|-------------|--------------|--------------|---------------|
| <i>Epioblasma triquetra</i> (snuffbox) | 94 | 74 | 954 | 580 | 428 | 2,130 |
| <i>Actinonaias ligamentina</i> (mucket) | 61 | 0 | 0 | 1,826 | 1,577 | 3,464 |
| <i>Lampsilis higginsii</i> (Higgins' eye) | | | | | | 41,721 |

✓ Moving on –

- ✓ opportunities for other mussel species
- ✓ reintroductions!



- ✓ *Quadrula fragosa* – winged maple leaf
- ✓ Propagation efforts are underway now



- ✓ Fish hosts –
- ✓ blue catfish
- ✓ channel catfish



0623





**Hidden Falls Park, Pool 2 Mississippi River – 2050?
Mussel Redemption 42 species back in the River –
HALLELUJAH!!!!**

A scenic landscape painting of a river with a waterfall. The scene is bathed in a warm, golden light, suggesting a sunset or sunrise. In the foreground, a person stands on a rocky bank, looking out over the water. The river flows from the background, where a waterfall cascades down, towards the viewer. The water is turbulent, with white foam from the rapids. The sky is a mix of orange, yellow, and brown tones. The overall mood is serene and contemplative.

A STORY OF RIVER REDEMPTION

**Potential future feature
restoration?**

Modern Day Pool 1 Gorge

Looking Upstream

Lake Street

Marshall Street

Ford Parkway

Lock and
Dam 1



Treasures of the Lost Gorge

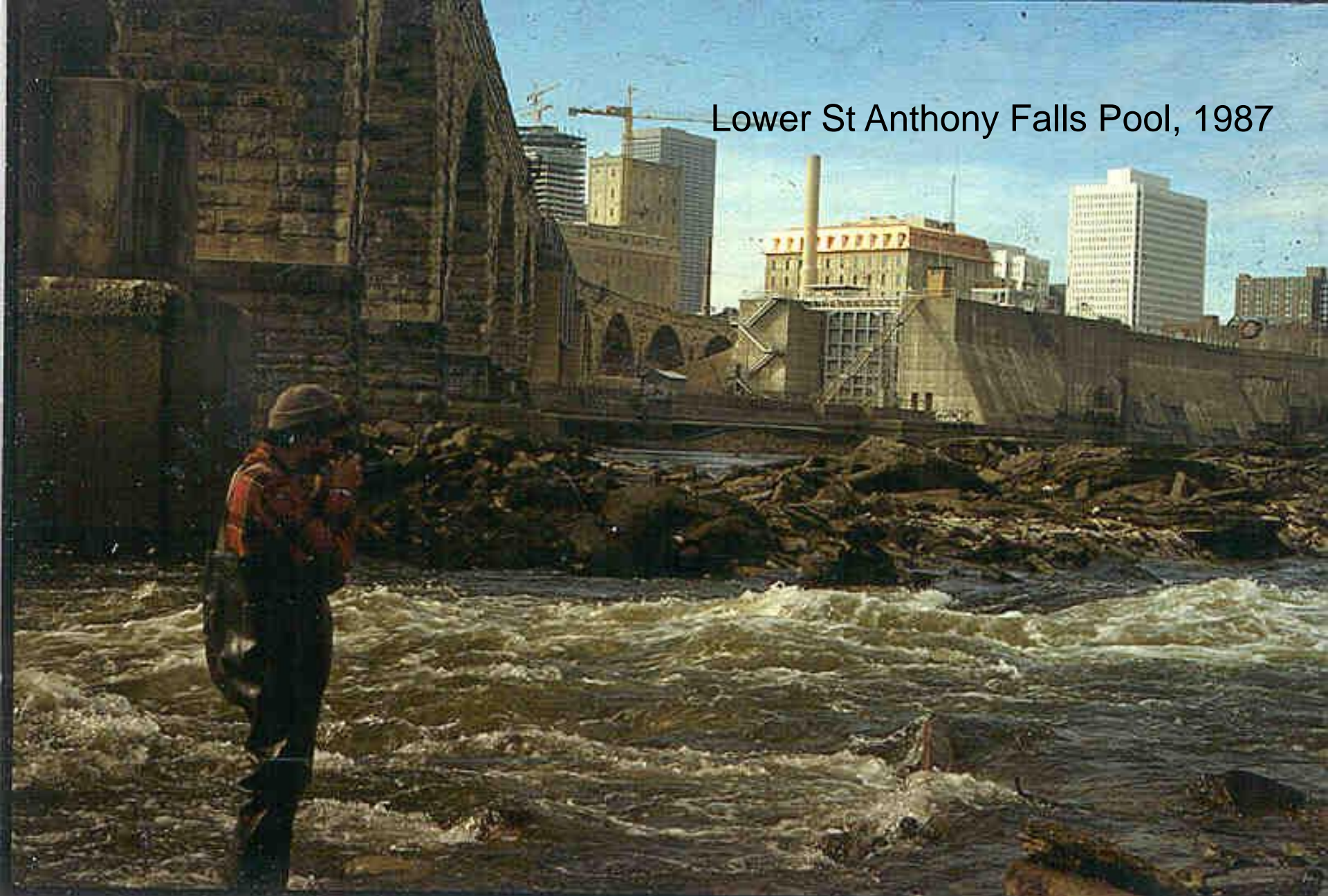


Changes in the Pool 1 Gorge of the Upper Mississippi River

A Preliminary Hydrologic Analysis



Lower St Anthony Falls Pool, 1987



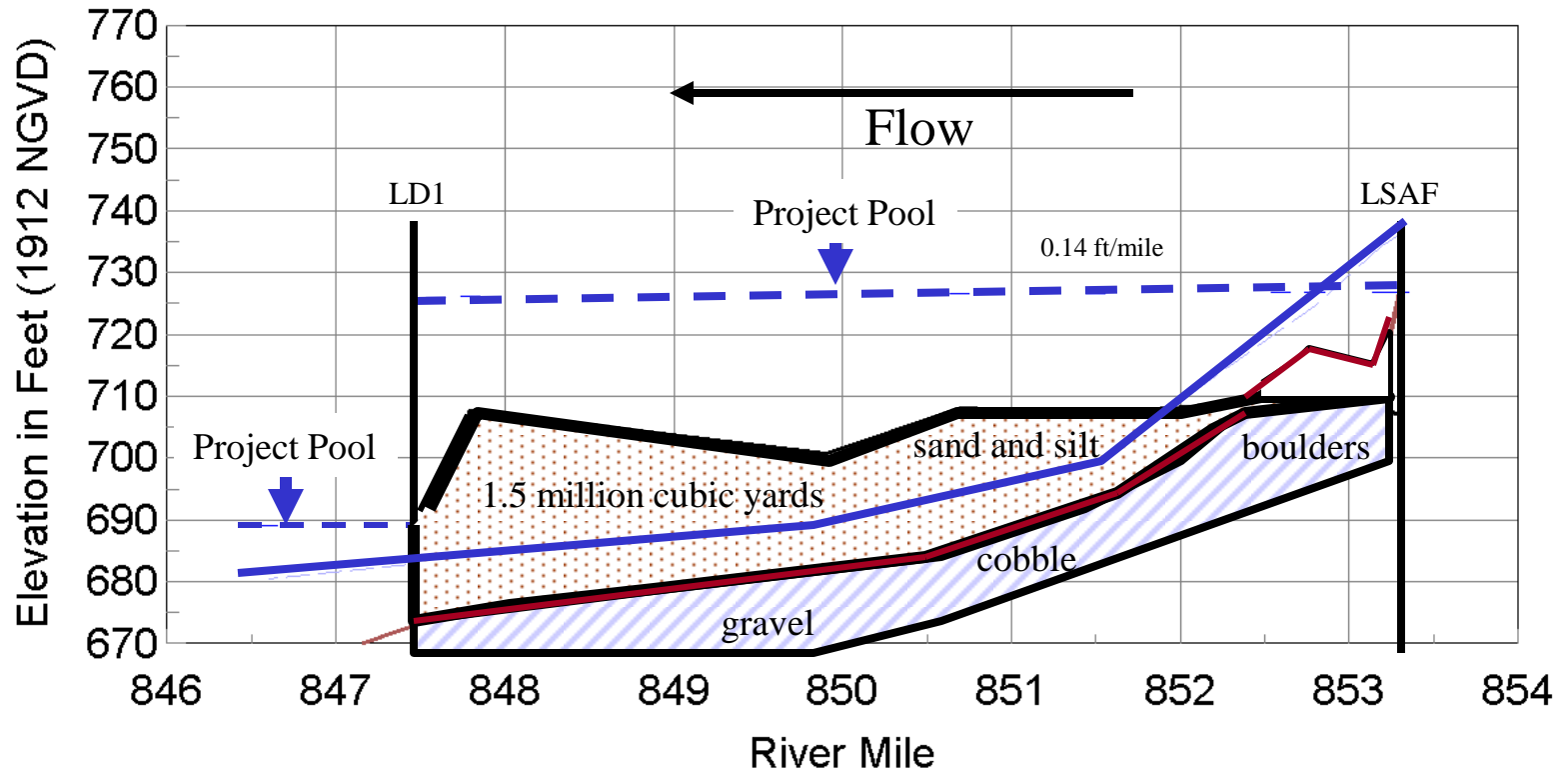
The ancient rapids was briefly exposed in 1987



Cap rock excavated from the rapids still line the shores of the gorge – putting them back could recreate whitewater features.

Mississippi River Pool 1 Gorge

Water Level and Channel Profiles



CITY PAGES

COVER STORY . VOL. 23#1140. PUBLISHED 10/9/02

LET THE RIVER RUN by Mike Mosedale

LET THE RIVER RUN



Many years ago, before the LOCKS & DAMS were built, the MISSISSIPPI RIVER ran wild through the heart of MINNEAPOLIS. Why not again?

Maybe it's time to let the rivers run free

NATURE NUT • GREG MUNSON
mun@poststar.com

Did you know?

The Chattooga River on the border between South Carolina and Georgia, which was featured in the movie Deliverance, is still free roaming with prized fish.

over "bar."

To reach that point, I've concluded that the ultimate step in the plan will be the removal of the 700-foot high Hoover Dam from the canyon that has been

About once a decade we return to the Las Vegas to see the latest in mega hotel construction, to a little



Should the Mississippi River gorge be restored?

by [Lorna Benson](#), Minnesota Public Radio
July 2, 2004

North Star Journal

www.northstarjournal.org • December 2003 • Volume 23, Issue 4 • USPS 095-010 • ISSN No. 0146-1493



Restoring the Flow

Dean Rebuffon

For decades the Corps of Engineers has managed the Mississippi as a barge canal for a very small number of commercial interests. It's time to restore two of the river's most magnificent natural features for the use and enjoyment of all of our people."

—Clyde Hanson, Conservation Chair, North Star Chapter

These magnificent natural features, the Falls of St. Anthony and the whitewater rapids of the Mississippi River Gorge, are in the heart of Minneapolis. But neither can be seen by Minnesotans — or anyone else.

The falls and the rapids have been buried in the forest under concrete, the latter under water — a disaster. This resulted from government and corporate programs that long ago converted the free-flowing Mississippi in Minneapolis into a dammed and dredged industrial stream, and which continue to shrink it today.

The North Star Chapter wants to change that. Its "Let the River Run" campaign, launched in June, calls for restoring the falls and the rapids. It also calls for ending barge traffic on the Mississippi within Minneapolis, where the river's flow is

Water Quality Issue
Winning Elections for Environment
Page 6

Gala Revisited
Page 8

New Tools for Water Quality
Page 10

Please VOTE Election for Chapter Leadership
Page 14-15

restricted by three sets of locks and dams built by the Army Corps of Engineers to facilitate commercial navigation.

St. Anthony Falls, as it is commonly known, is the only major natural waterfall on the 2,350-mile-long Mississippi. Once, the river exceeded more than 20 feet over a wide expanse of limestone ledges, creating a loud, continuous roar and sending clouds of mist and spray.

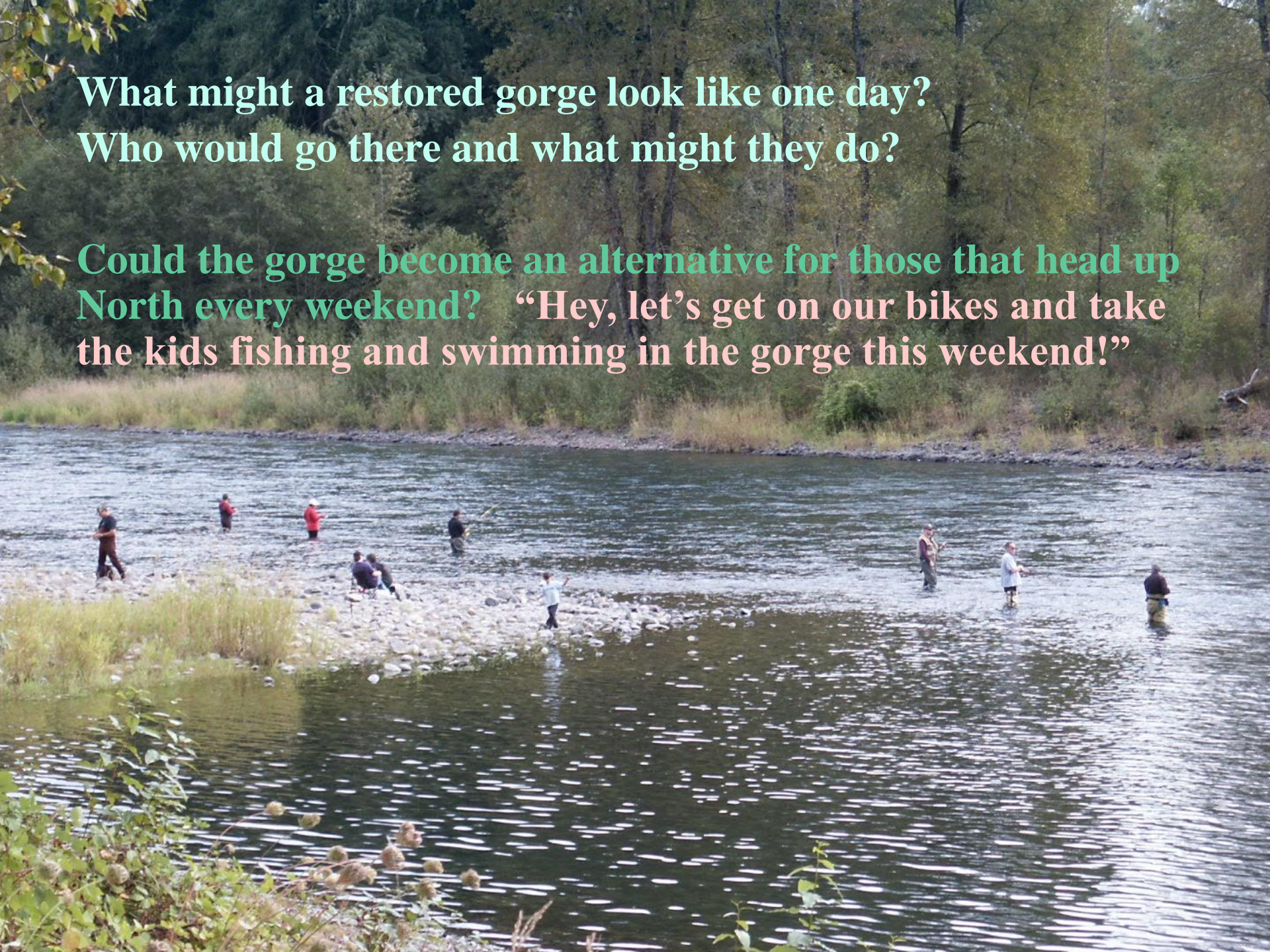
However, for more than 120 years the ledges have been covered by a huge concrete slab, or apron, built by the Corps of Engineers. The apron prevents the ledges, which are sustained by softer sandstone, from deteriorating under the caustic flow of water.

Not coincidentally, the apron and other structures were

Restoring the Flow continues on page 11

**What might a restored gorge look like one day?
Who would go there and what might they do?**

**Could the gorge become an alternative for those that head up
North every weekend? “Hey, let’s get on our bikes and take
the kids fishing and swimming in the gorge this weekend!”**





Seven miles of white-water rapids - might catch on with the kayak crowd

I'd be willing to pay for rafting near home!

Paddleford Rafting

**Mississippi Gorge Regional Park
Beneath the Stone Arch Bridge, 2020**

New challenges in
river management

Mississippi Gorge
International Kayak
Competition – 2025?



Giant spawning sturgeon kill
by reckless kayaker
Below falls
– Mpls trib. *April, 1 2025*





10/04/2005

Our Lost Gorge — a sleeping treasure ready to be awakened

