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Water-Quality Requirements, Tolerances, and Preferences of Pallid Sturgeon in the lower Missouri River

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U.S. Department of the Interior
U.S. Geological Survey

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Problem

Water-quality characteristics have been identified as potential cause for lack of pallid sturgeon recruitment, but few studies have been undertaken

What water quality characteristics are most likely to be problems and what studies are most needed?

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Objectives

1. Literature Review of Water-Quality Requirements, Tolerances, and Preferences of Pallid Sturgeon in the lower Missouri River

2. Identify potential water-quality bottlenecks to pallid sturgeon recruitment

3. Identify data and interpretive gaps

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Categories of Water Quality Effects on Pallid Sturgeon

- Physical Habitat
- Food Web
  - Primary production
  - Respiration/ Metabolism
- Toxicity and Exposure
  - Bioaccumulative Contaminants
  - Hydrophilic contaminants affecting physiology

Physical Habitat: Water Temperature

- Pallid sturgeon have likely evolved to higher water temperatures than other sturgeon species
- Many adverse conditions found in sturgeon on Platte River observed in shovelnose exposed to high water temps (Schwarz and others 2006)
- One small (18 juvenile pallid) study (Chipps and others, 2010) indicates:
  - 28 ^{o}C is optimal for feeding and growth
  - Temperatures from 30-33 ^{o}C stressful
  - Lethality begins at temperatures > 33 ^{o}C
- Egg/larval stages likely more sensitive to high temperatures than juveniles

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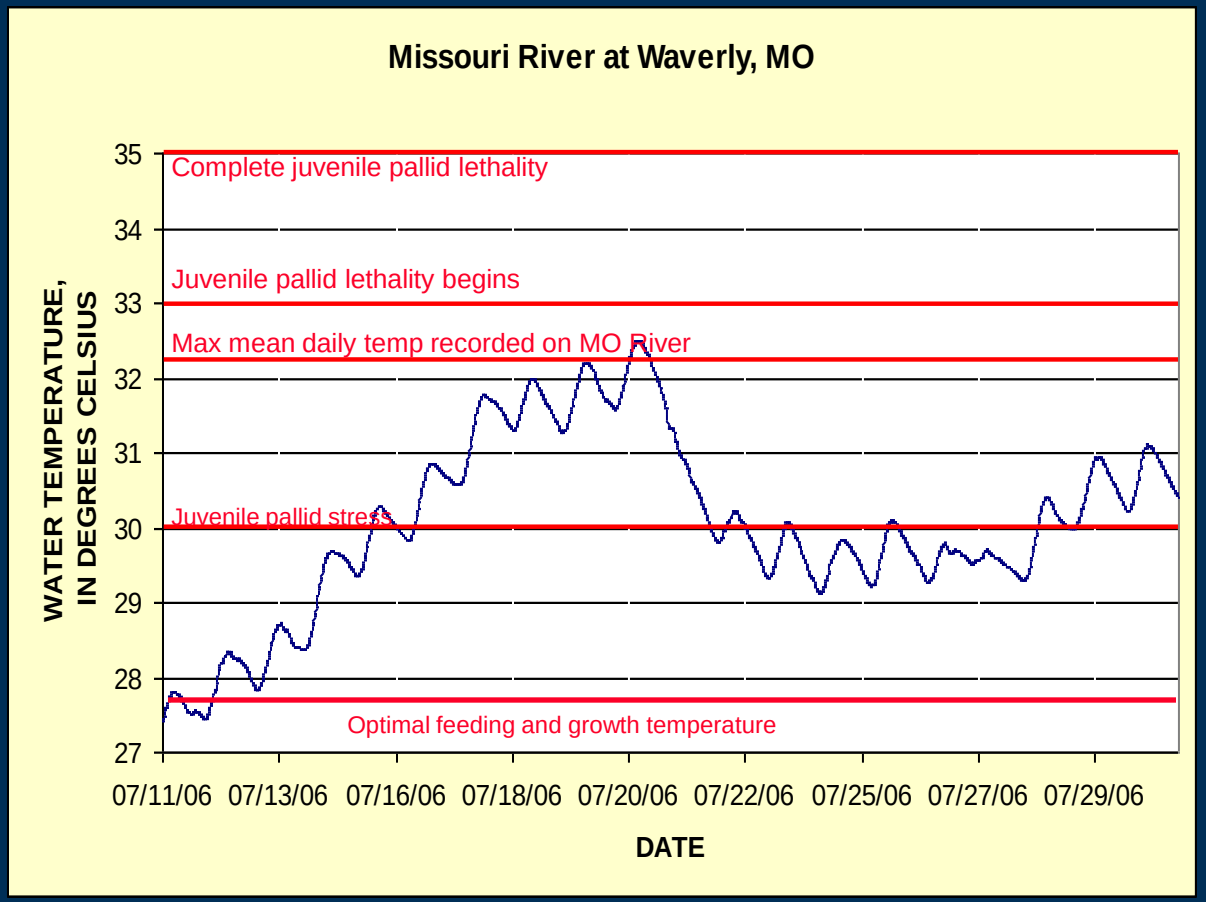
Water Temperature Exposure

- Highest daily mean ever measured = 32.2 ºC in 1955
- 18 consecutive days > 30 oC at Waverly in 2006
- Water temp gradient from Gavins to KC. Little gradient from KC to St. Louis.
- Summer spawns most vulnerable to high temperatures (USFWS 2006)



Water Temperature (continued)

- Water temp increases of even 1 or 2 ^{o}C resulting from climate change could have negative effects
- Temperature refugia?
  - Tributaries usually even warmer
  - In channel pockets possible, but not much relief
  - Can swim upstream above St. Joseph, MO
- Need studies on lower Missouri River egg/larval pallid temperature tolerance

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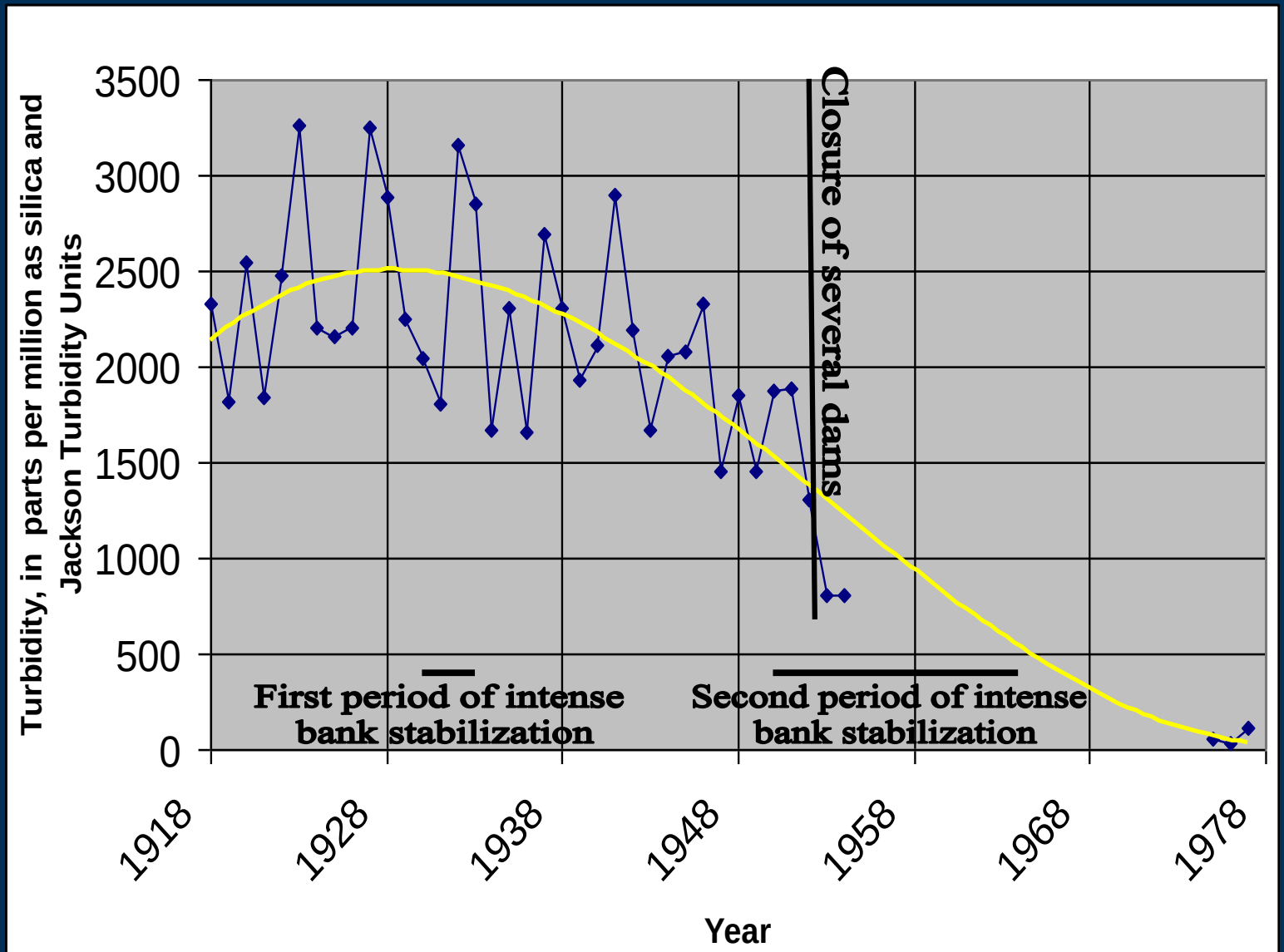
Physical Habitat: Turbidity - Impoundment effects



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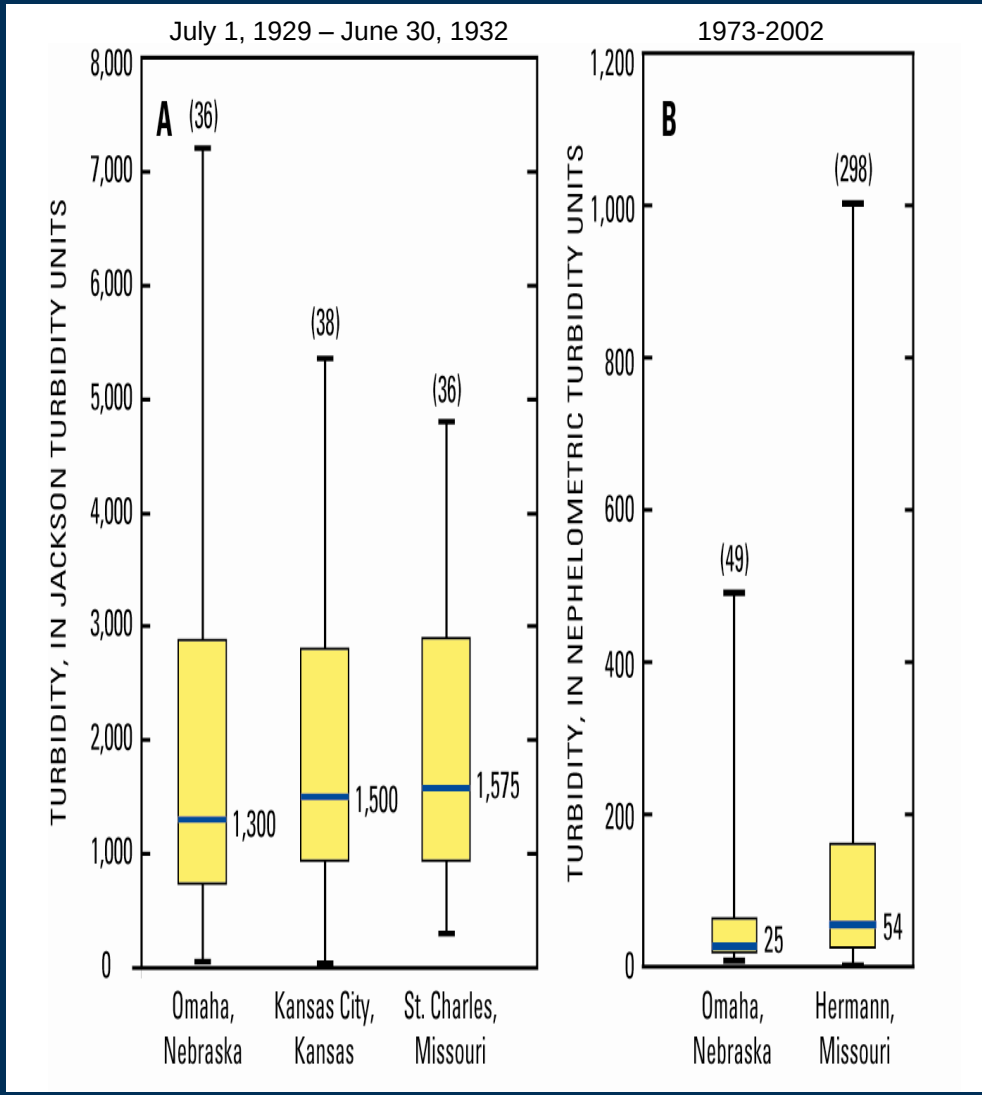
Physical Habitat: Potential ecological effects of decreased turbidity

- Decreased turbidity favors sight-feeding fish
- Effects on spawning behavior
- Decreased prey species
- Decreases cover for eggs and juveniles
- Few experiments designed to isolate effects of turbidity on pallid survival and foraging
- Analysis of pallid tracking data during high turbidity events could provide insight



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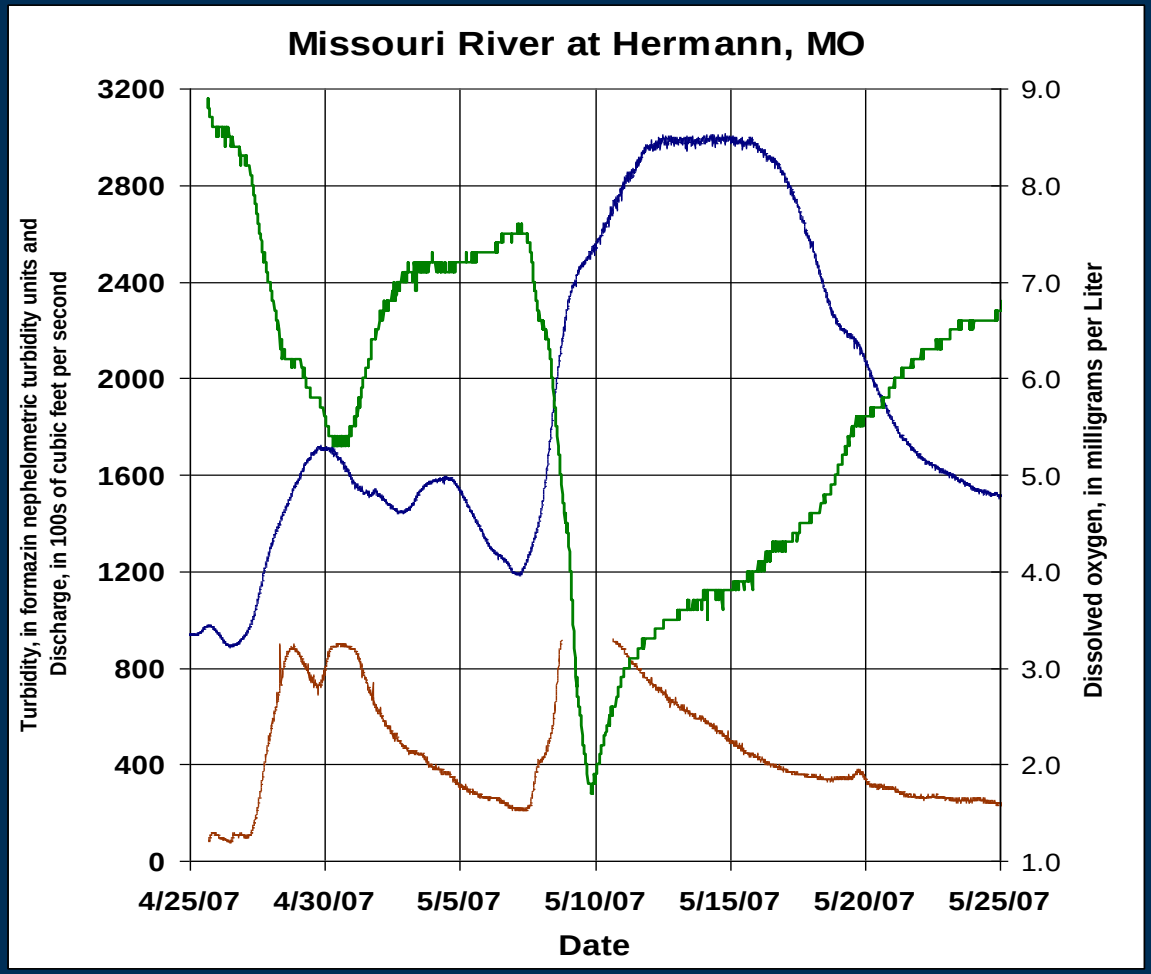
Food web: Impacts of decreased turbidity and increased algal populations

- **Photosynthesis/respiration effect**

N and P concentrations well above those that limit phytoplankton

Consequently, algae respond to light/turbidity fluctuations

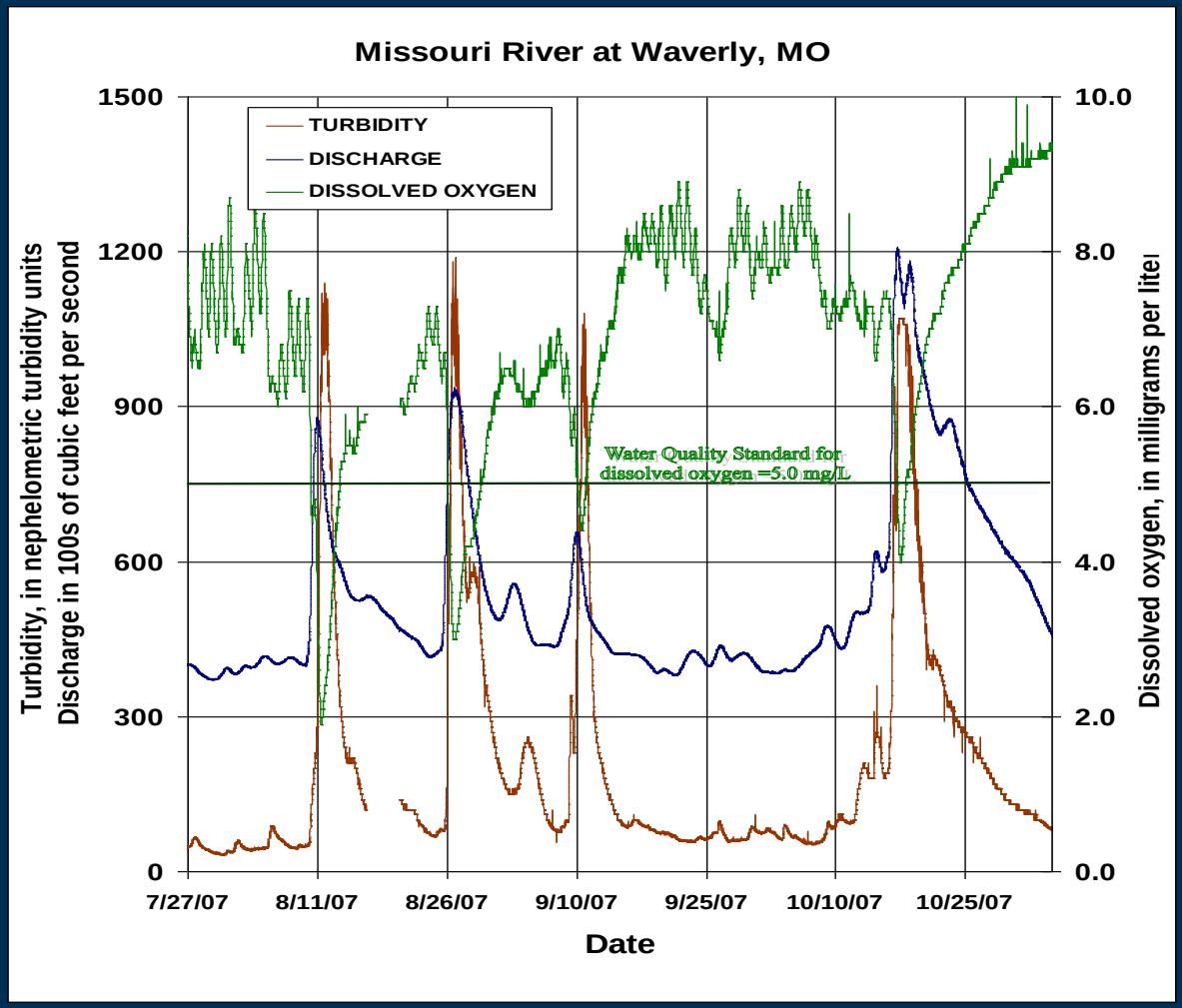
Likely not as extreme in pre-dam river



Food Web:
Relation between Dissolved Oxygen and Turbidity

Diurnal fluctuations of 1-2 mg/L indicate persistent algal population

- D.O. frequently < 2 mg/L during rises in summer and spring at downstream stations (5 mg/L standard)
- Other sturgeon species susceptible to D.O. < 3.0 mg/L
- Egg/larval fish likely most susceptible to "D.O. sags"



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Food Web: Trophic changes

- Impoundment caused profound effects on food web
  - Increased productivity – algae -> zooplankton -> Asian carp
  - Less influence of microbial loop
- Lower Missouri River now often hypereutrophic
  (Havel and others 2009)
- Little information on pallid sturgeon, but plankton are important food source for most larval fish

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Food Web: Zooplankton changes

- **Large alterations of zooplankton community caused by impoundment** (Dickinson and others 2009)
  - Large lentic species dominate below dams (cladocerans, copepods), but decrease exponentially downstream (Williams, 1966)
  - Farther downstream smaller rotifers dominate – world-class densities (Williams, 1966)
  - Even farther downstream (below KC), rotifers still dominate, but turbidity limits densities (Williams, 1966)
  - Consequently, turbid, preimpoundment river likely had even fewer rotifers, although were still the most abundant zooper (Berner, 1951)
  - Decreases in density, size, or preferred zooplankton species could impair pallid recruitment

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Food Web: Trophic changes

- Large populations of Asian carp may be taking advantage of increased plankton densities in post-impoundment period
  - Predation may limit phyto/zooplankton densities below light-limited capacity

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Food Web: Needed studies in Lower Missouri River

- Hypoxic tolerance of pallid sturgeon, especially at egg and larval stages
- Hypoxic refugia of juveniles and adults
- Planktonic food preferences of larval pallid sturgeon
- How have changes in food web affected first-feeding pallid?
- Characterizations of phyto and zooplankton populations since intro of Asian carp

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Toxicity: Bioaccumulative Contaminants of Concern for Pallid Sturgeon

- Generally hydrophobic - Likely correlated with suspended sediment and turbidity
- Piscivorous diet and long life span make pallid sturgeon more susceptible to bioaccumulative compounds (Quist 2004)
- SPMD extracts from Missouri River induced vitagellin production in males indicating an estrogenic effect on male trout (Petty and others, 1998)
- Three categories of bioaccumulants have shown evidence of deleterious effects on sturgeon
  - Persistent organochlorine pesticides
  - Polychlorinated Biphenyls
  - Metals

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Toxicity: Persistent organochlorine pesticides

- DDT still present in Missouri River from pre 1972 applications & atmospheric deposition from other countries (Schmitt 2002)
- Injections into rainbow trout induced vitagellin production in male trout (estrogenic effect) (Petty and others 1998)
  - DDT metabolites, p,p'-DDE found in pallid tissue (3 fish - 1983-1988) (Ruelle and Keenlyne, 1993)
  - Chlordane (banned), cis-chlordane
    - Detected at high levels in one NE pallid in 1980s
      - Low levels in two upper river pallid
    - Well correlated with PCBs
    - Declining concentrations in shovelnose (Schwarz 2006)
  - Dieldrin detected in all three pallids at low concentrations

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Toxicity: Polychlorinated Biphenyls (PCBs)

- Banned 1977 – long half lives
- SN sturgeon PCB levels stable over last 20 years (MO Dept Conservation 2004)
- Egg concentrations high enough to issue "do not consume" advisory in MO
  - One meal per month on sturgeon fillets
- Detected in pallid ovaries at elevated levels (Ruelle & Keenlyne, 1993)
- PCB concentrations suspected of causing reproductive problems (Ruelle & Keenlyne, 1993)
- SN tissue concentrations exceed several toxicity thresholds in NE & MO (Schwarz and others, 2006 and MO Dept of Health, 2009)

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Toxicity: Metals

- **Selenium exceeded levels for reproductive impairment in Platte River sturgeon**
  (Schwarz and others, 2006)

- **Hg exceeded action level for edible tissues in 9 of 11 pallid in upper MO River**

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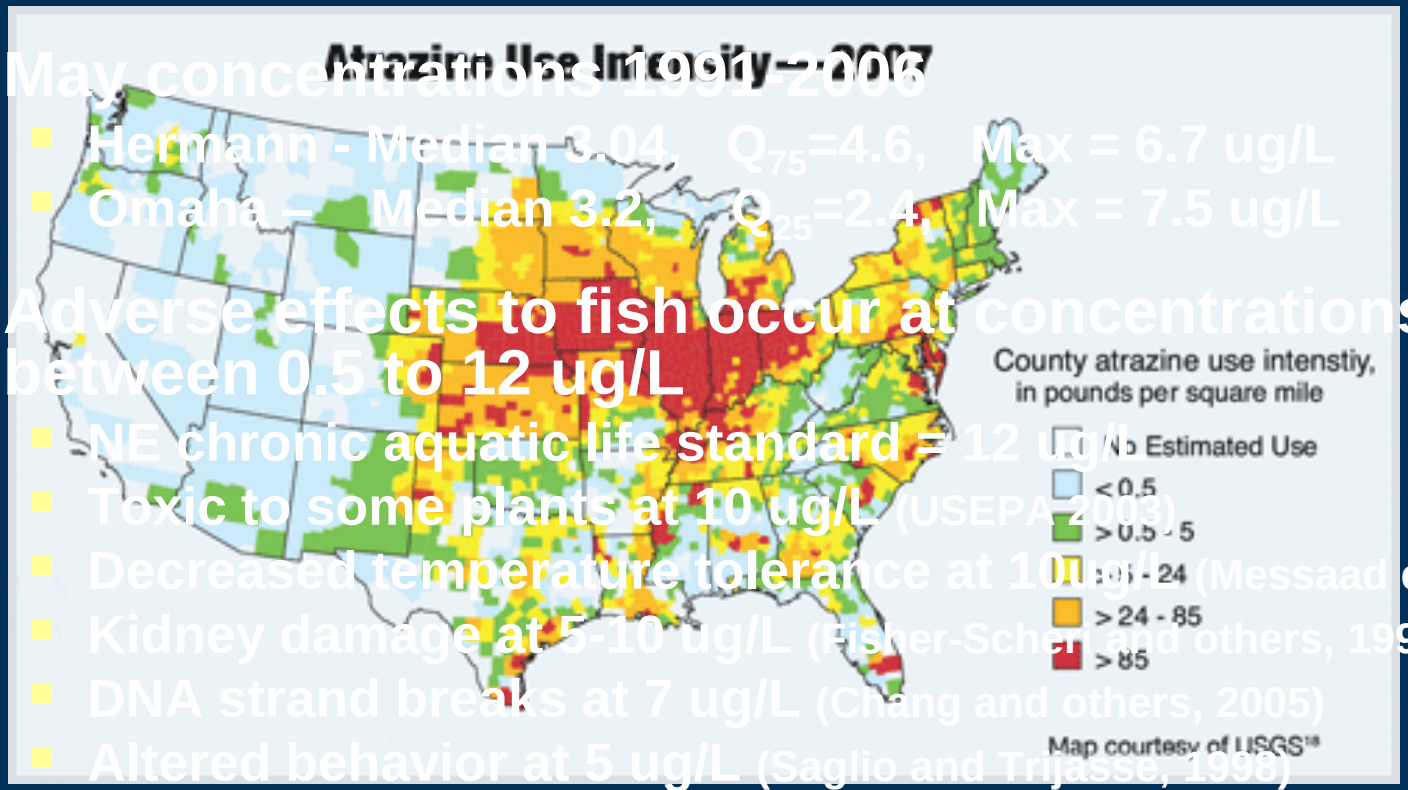
Toxicity: Atrazine

- Concentrations in blood follow concentrations in water (Schwarz and others 2006)
- May concentrations 1991 - 2006
  - Hermann - Median 3.04, Q_{75}=4.6, Max = 6.7 ug/L
  - Omaha – Median 3.2, Q_{25}=2.4, Max = 7.5 ug/L
- Adverse effects to fish occur at concentrations between 0.5 to 12 ug/L
  - NE chronic aquatic life standard = 12 ug/L
  - Toxic to some plants at 10 ug/L (USEPA, 2003)
  - Decreased temperature tolerance at 10 ug/L (Messaad et al. 2000)
  - Kidney damage at 5-10 ug/L (Fisher-Scherl and others, 1991)
  - DNA strand breaks at 7 ug/L (Chang and others, 2005)
  - Altered behavior at 5 ug/L (Saglio and Trijasse, 1998)
  - Endocrine effects on some fish at < 3 ug/L (Moore and others)
  - Egg production decreased in fathead minnows at 0.5 ug/L (Tillet and others, 2010)



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Toxicity: Hormones, pharmaceuticals, and wastewater compounds

- Hormonally active compounds likely responsible for adverse reproductive effects in Platte River sturgeon (Schwarz and others 2006)
  - Testosterone, estradiol, progesterone, estrone, estriol, stanolone, equilin, etc
  - Extremely small concentrations can effect fish reproduction (including fathead minnows)
- Concentrations and persistence in Missouri River unknown
  - Lab methods at environmentally-relevant concentrations only recently available

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Conclusions: Data and study gaps

1. Comprehensive studies of egg and larval pallid temperature tolerance in light of climate change
2. Water temperature refugia
3. Effects of decreased turbidity on spawning behavior, piscivory, and predation at egg and larval stages and environmentally relevant turbidities
4. Field studies on preference of pallids for turbid reaches

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Conclusions: Data and study gaps

5. Pallid tolerance of hypoxia at egg and larval stages
6. Hypoxic refugia

7. Habitat specific characterization of modern plankton populations
8. How plankton populations effect first feeding pallids

9. New analyses of pallid tissue for bioaccumulants
10. Toxic tolerance of bioaccumulants by pallids

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Conclusions: Data and study gaps

11. Toxicological studies of atrazine on pallids

12. Exposure and tolerance of hormones and endocrine disruptors

13. Add bioaccumulants, hormones, and endocrine disruptors to monitoring programs

14. Use of Semipermeable membrane devices to assess exposure to many toxic compounds

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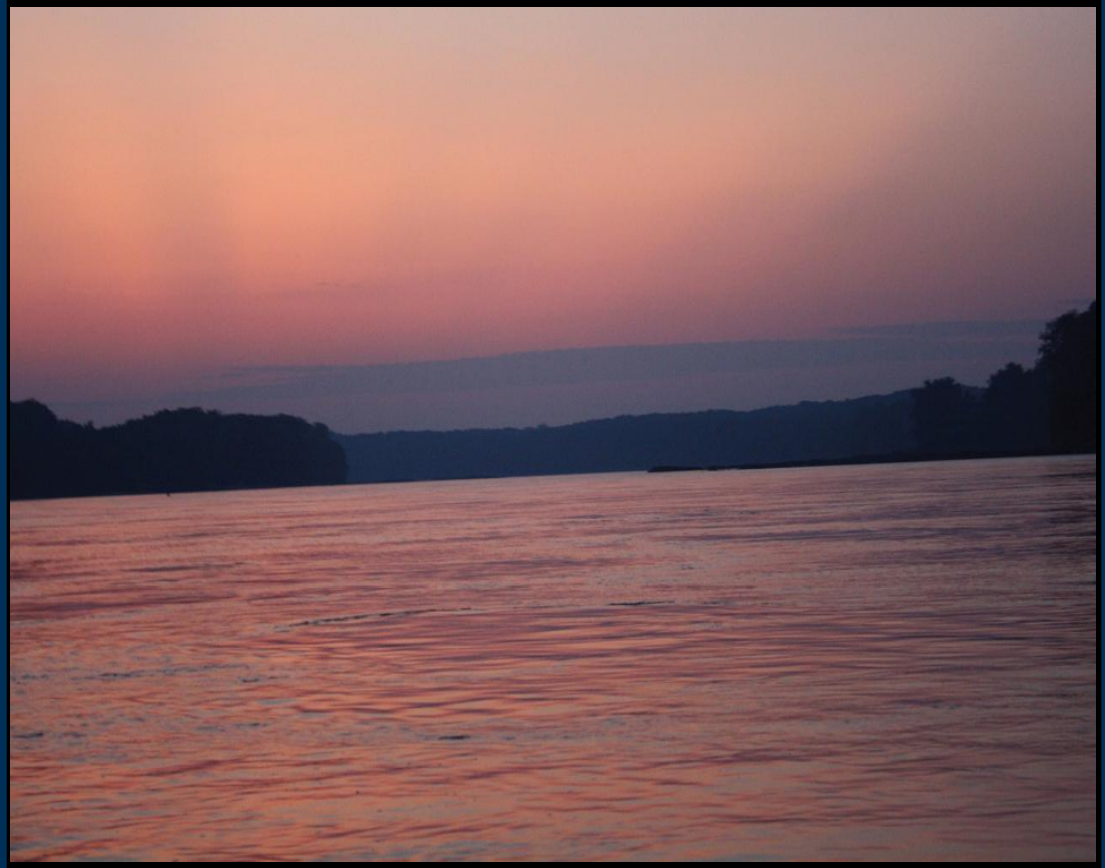

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