



# Supporting the Development of Mercury Fish Tissue and Water Quality Criteria for the Navajo Nation

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The report for the Navajo Nation Lake Fish and Water Quality Study is available at:  
[www.fws.gov/southwest/es/newmexico/documents/Final\\_NNLFWQI\\_Report.pdf](http://www.fws.gov/southwest/es/newmexico/documents/Final_NNLFWQI_Report.pdf)

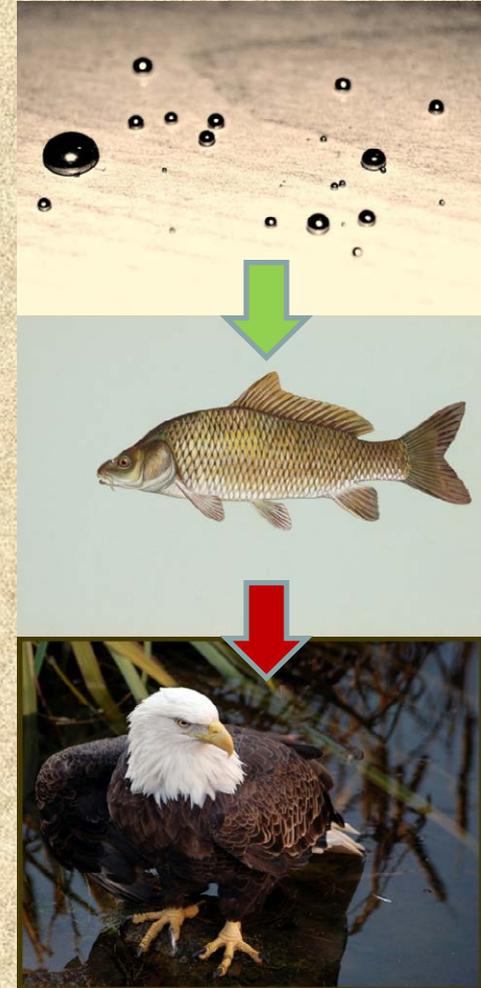


US Fish and Wildlife Service, Region 2  
Environmental Contaminants Program



# Timeline of Arizona and Navajo Nation Mercury Criteria Consultations

- 1977-1985: Fish and bird monitoring identifies elevated mercury in Arizona fish and in bald eagle eggs of concern.
- 1994: EPA approves of Arizona water quality standards and suggests adoption of mercury criteria for fish tissue in AZ.
- 1999-2006: EPA approves of Navajo Nation water quality standards with requirement to adopt human health criteria and monitor mercury in fish collected from bald eagle habitat.



# Sources of Mercury Deposition

- **Natural (31%):**

- Volcanoes
- Forest fires volatilize Hg (=re-emission; Hg is a grasshopper pollutant)



- **North America (30%)**

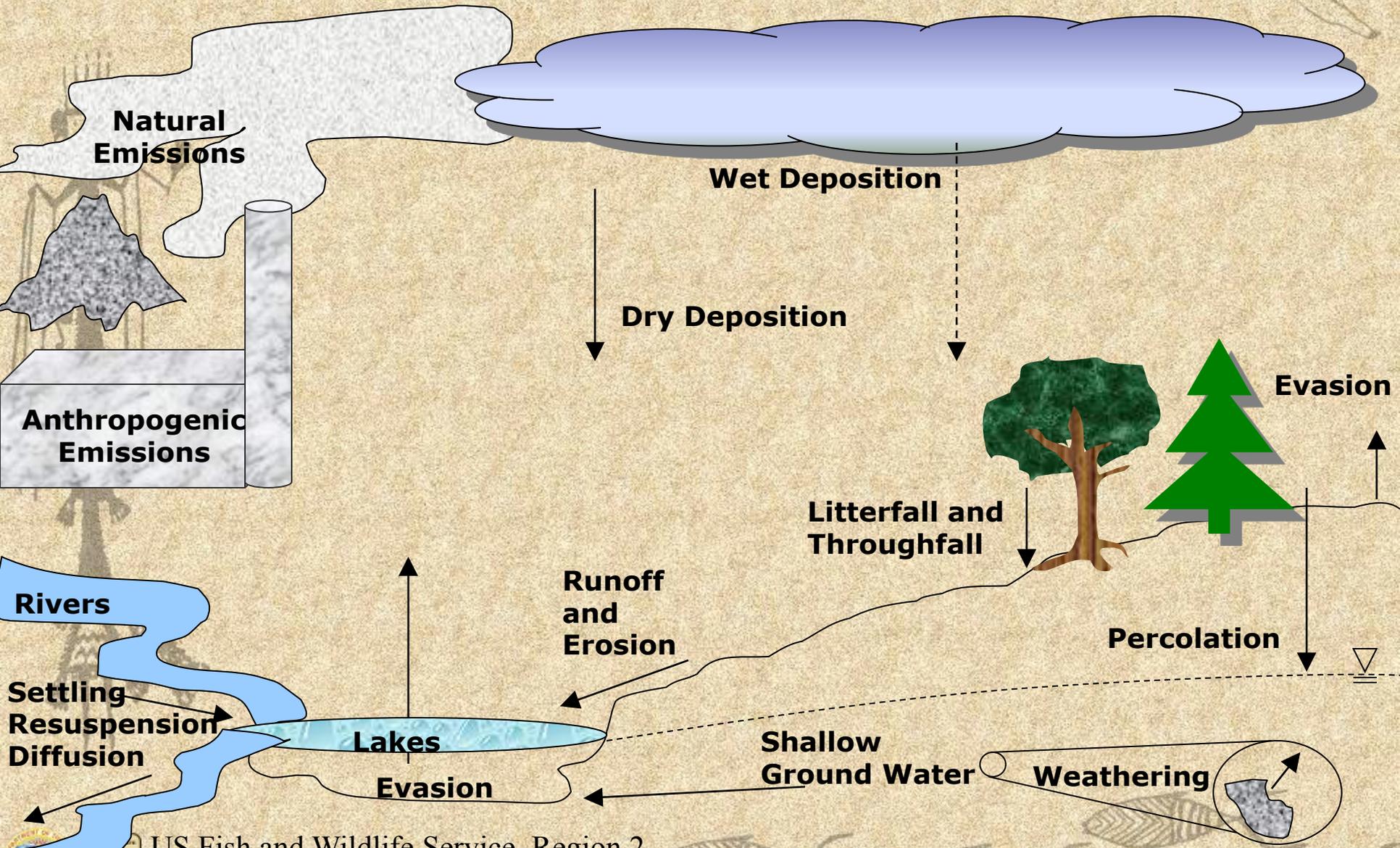
- Burning activities
  - Coal-fired power plants
  - Incinerators, crematoria



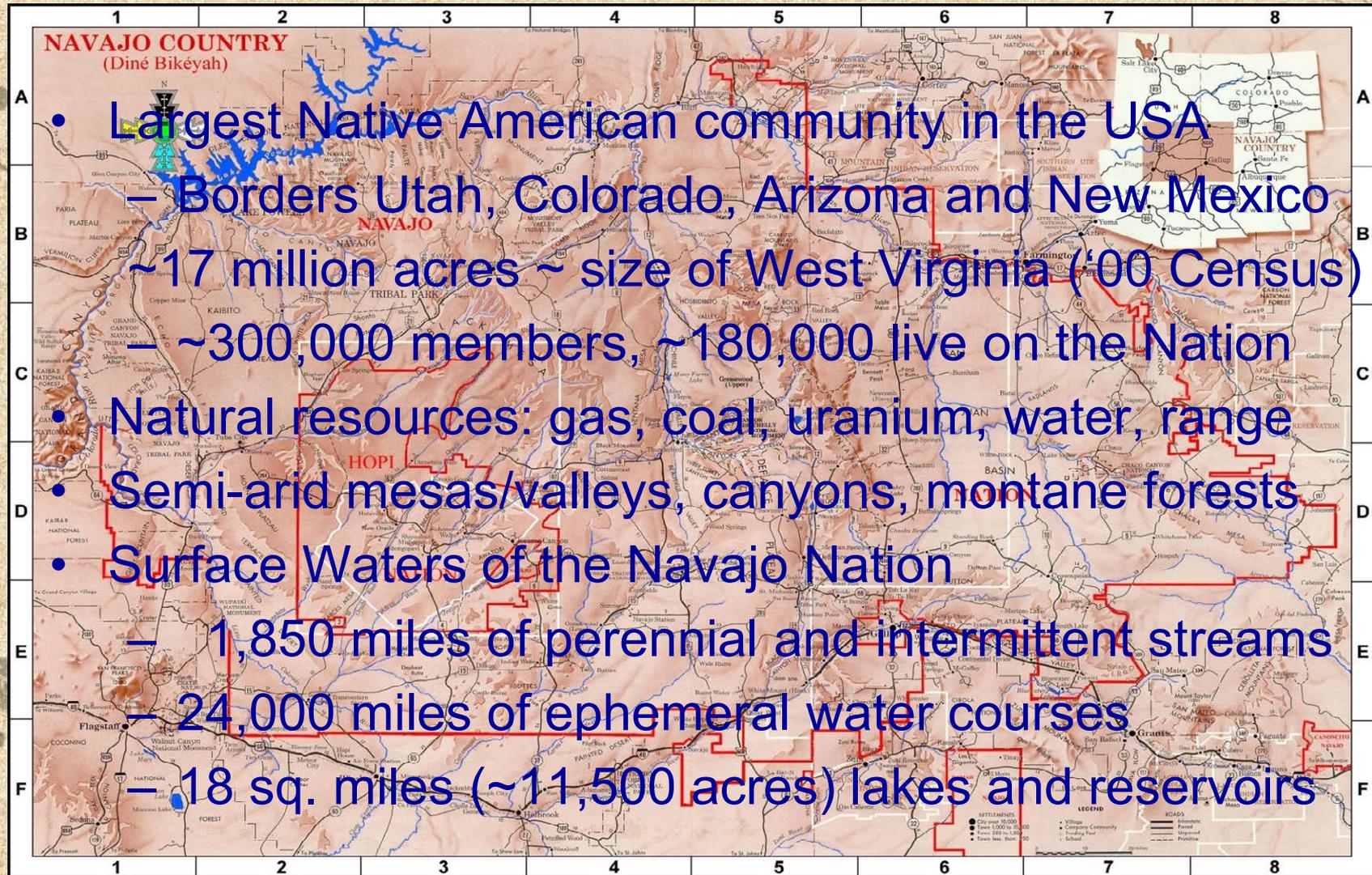
- Hg devices, home wastes
- Gold-mining activities
- **Sources in Asia (~21%)**



# Watershed Mercury Processes



# Navajo Nation Information



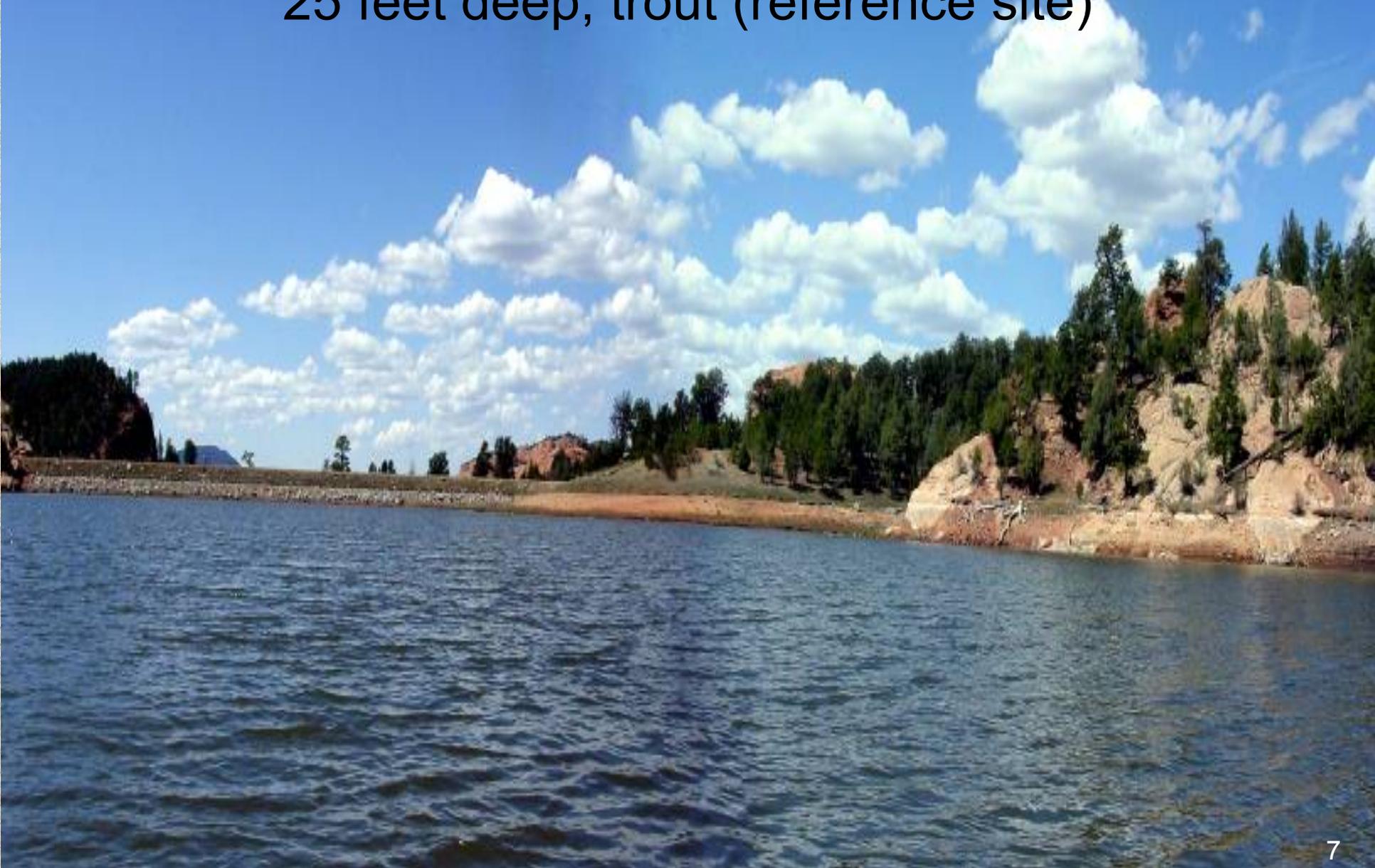
# Timeline of the Navajo Nation Lake Fish and Water Quality Study

- 2002: EPA funds Navajo Nation for Lake Fish Study lead by NNEPA and USFWS
- 2003: Sampling and Analysis Plan, QAPP
- 2004: Navajo Nation EPA, Fish and Wildlife Department, and USFWS collect samples
- 2005: Final report issued
- 2007: Fish advisories posted
- 2008: Water quality standards



# Assayi Lake

36-acre, coldwater reservoir, 7,500 feet elevation,  
25 feet deep, trout (reference site)



# Morgan Lake

1,287-acres, power plant cooling reservoir, 5,300 feet elevation, 100 feet deep, catfish and bass



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# Red Lake

611-acre, warm water reservoir, 7,150 feet elevation, 5 feet deep, catfish



# Wheatfields Lake

226-acre, coldwater reservoir, 7,300 feet elevation,  
18 feet deep, stocked trout



# Methods

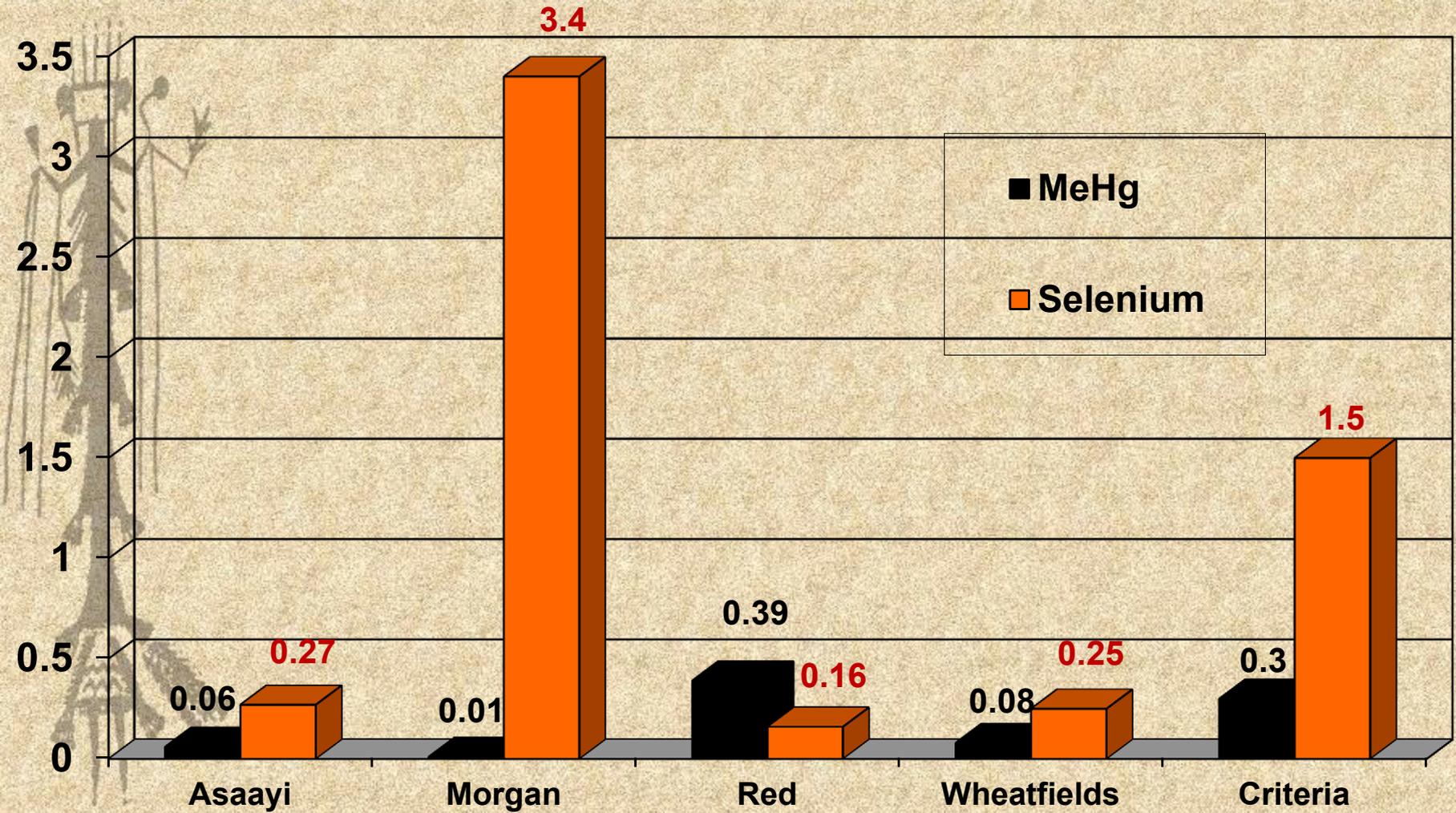
- Collection and Analyses
  - Water
    - Total mercury
    - Methyl mercury
    - Metal scan, ions
    - General water quality
    - Blanks
  - Fish fillets and remainders (offal)
    - Total mercury
    - Methyl mercury
    - Metal scan
    - Length, weight
  - Risk Assessment
    - Bald Eagle
    - Human health



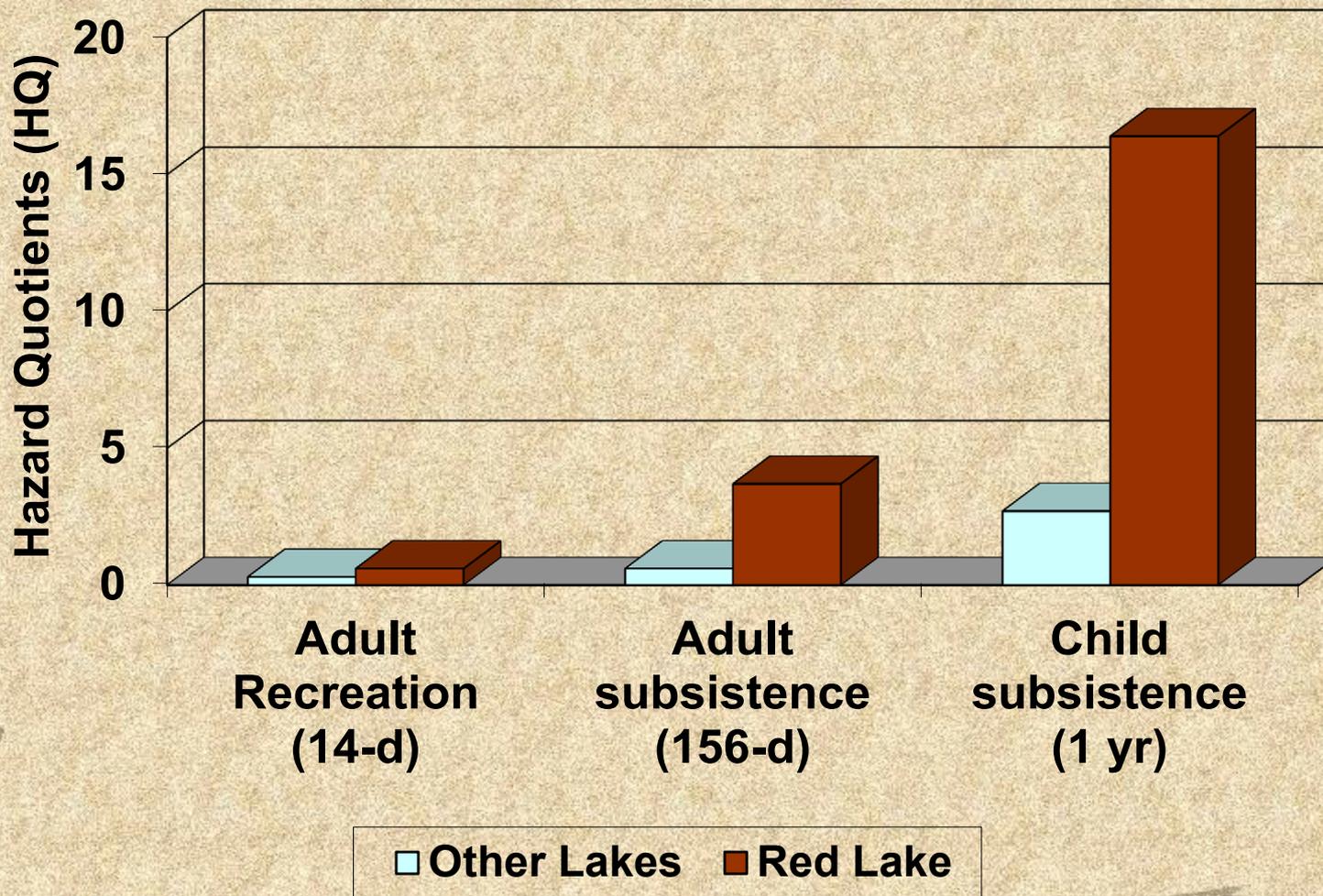
$$\text{Intake} = \frac{C_f \times FF \times FIR \times EF \times ED}{BM \times AT}$$



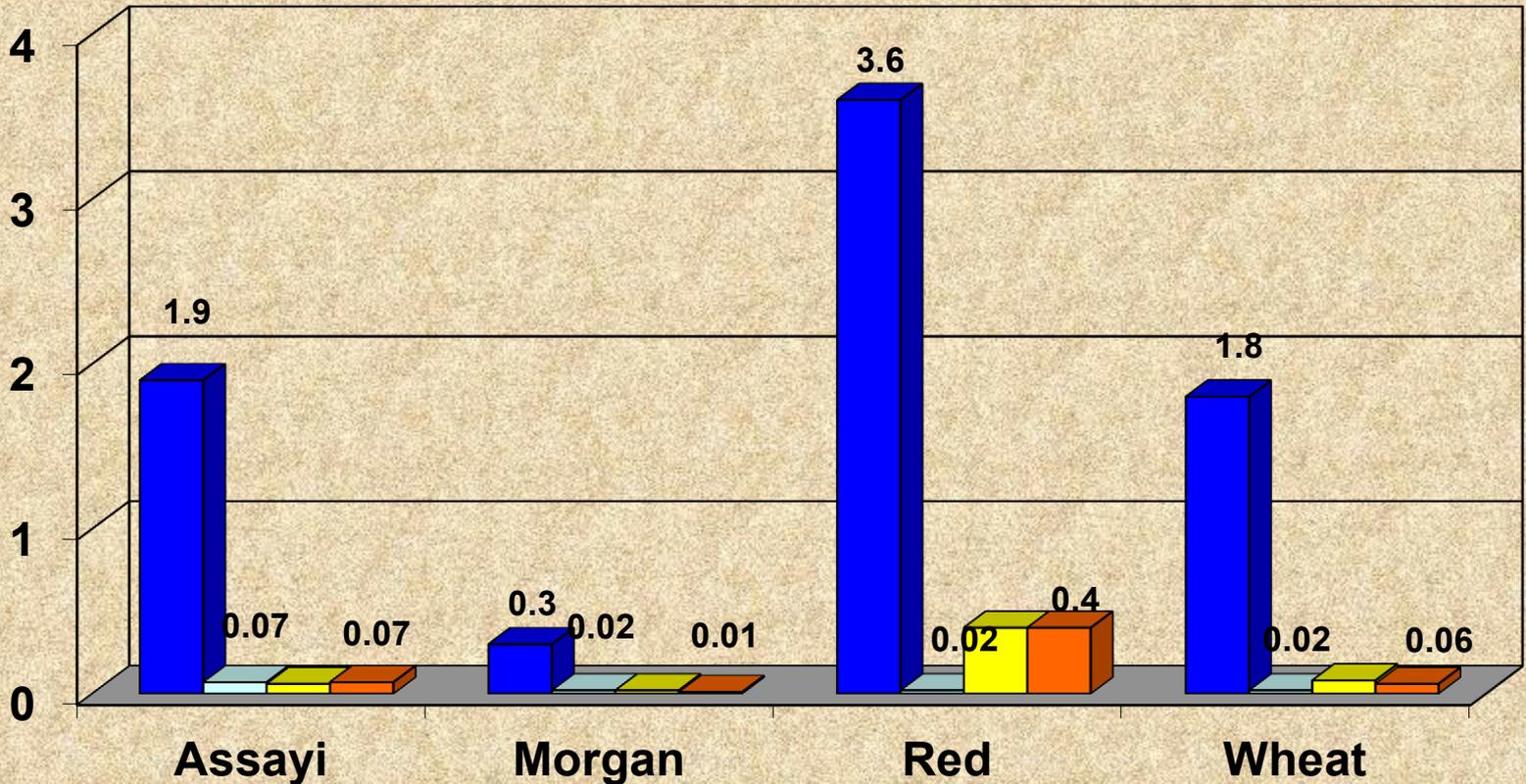
# Fish Fillet Results ( $\mu\text{g/g}$ wet weight)



# Mercury Risk – Human Health



# All Mercury and MeHg Results (geometric means)



■ Water THg (ng/L)

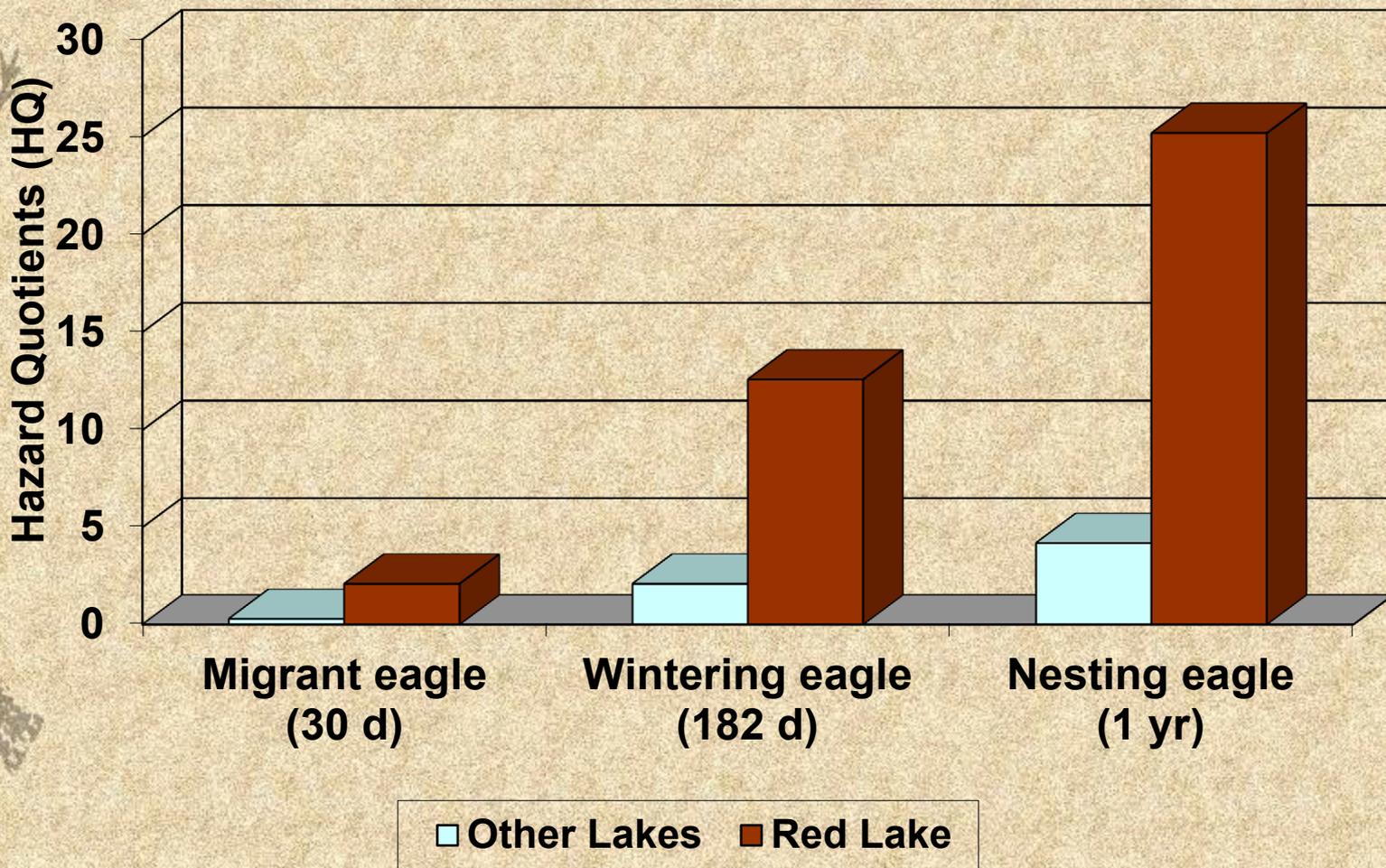
■ Water MeHg (ng/L)

■ Fillet MeHG (ug/g ww)

■ Whole fish (ug/g ww)



# Mercury Risk Assessment – Bald Eagle



# Deriving Water Criteria for Methylmercury

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- MeHg Water Criteria = 
$$\frac{(TD \times UF \times BW)}{(D + (FF \times BAF^*))}$$
    - TD = toxicity reference dose = (0.021 mg/kg-day)
    - UF = uncertainty factor = (0.33 unitless)
    - BW = bald eagle body weight = (5.25 kg)
    - D = eagle drinking water intake = (0.16 L/day)
    - FF = fraction of the eagle's diet that is fish = (0.14)
    - *BAF\** = meHg water-to-fish bioaccumulation factor  
(\*BAFs were derived from the Lake Fish Study data)



# Use BAF to Derive of MeHg Criteria

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- Bioaccumulation Factor =  $\frac{\text{Total Hg in Fish}}{\text{Total MeHg in Water}}$
- Assayi Lake BAF =  $4.2 \times 10^6$
  - Morgan Lake BAF =  $1.3 \times 10^6$
  - Red Lake BAF =  $7.5 \times 10^6$
  - Wheatfields Lake BAF =  $1.6 \times 10^6$



# Derive Mercury Criteria

- Convert MeHg Criteria to Mercury Criteria
  - $WC_{Hg} = WC_{MeHg} / (\text{Total MeHg/dissolved Hg})$
  - Assayi Lake =  $0.00011 / 0.039 = 0.003 \mu\text{g/L}$
  - Morgan Lake = below minimum detection level
  - Red Lake =  $0.0006 / 0.059 = 0.001 \mu\text{g/L}$
  - Wheatfields Lake =  $0.00027 / 0.084 = 0.003 \mu\text{g/L}$
- Mercury criteria calculated using BAF of  $7.5 \times 10^6$  results in  $0.001 \mu\text{g/l}$  total Hg, or  $0.11 \text{ ng/L}$  MeHg, in water, to protect bald eagles and other wildlife



# Navajo Nation Lake Fish Study

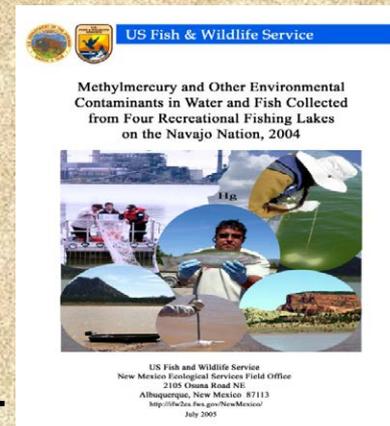
## Conclusions

- Are the fish safe to eat? Yes, on a recreational basis, but people that eat a lot of fish from Red Lake should contact the Navajo Nation Health Agency. Fish consumption advisories have been issued.
- Migratory eagles okay, but wintering eagles at Red Lake are at risk. Recommendations made for Red Lake management if nesting eagles occur nearby.
- Wildlife criteria calculated using BAF of  $7.5 \times 10^6$  results in 1 ng/l total mercury, or 0.11 ng/L methylmercury in water to protect nesting bald eagles



# Navajo Nation takes Action to Protect Wildlife and People

- In 2008, the Navajo Nation adopts protective Water Quality Standards :
  - Aquatic and Wildlife Habitat Chronic Mercury Standard of 0.0010 ug/L; and
  - Aquatic and Wildlife Habitat Chronic Methylmercury Standard of 0.00011 ug/L
  - (2004 Aquatic Habitat Chronic Standard 0.012 ug/L)
  - (0.3 µg/g MeHg in fish fillets for human health)



# What are Mercury Effects to Fish?

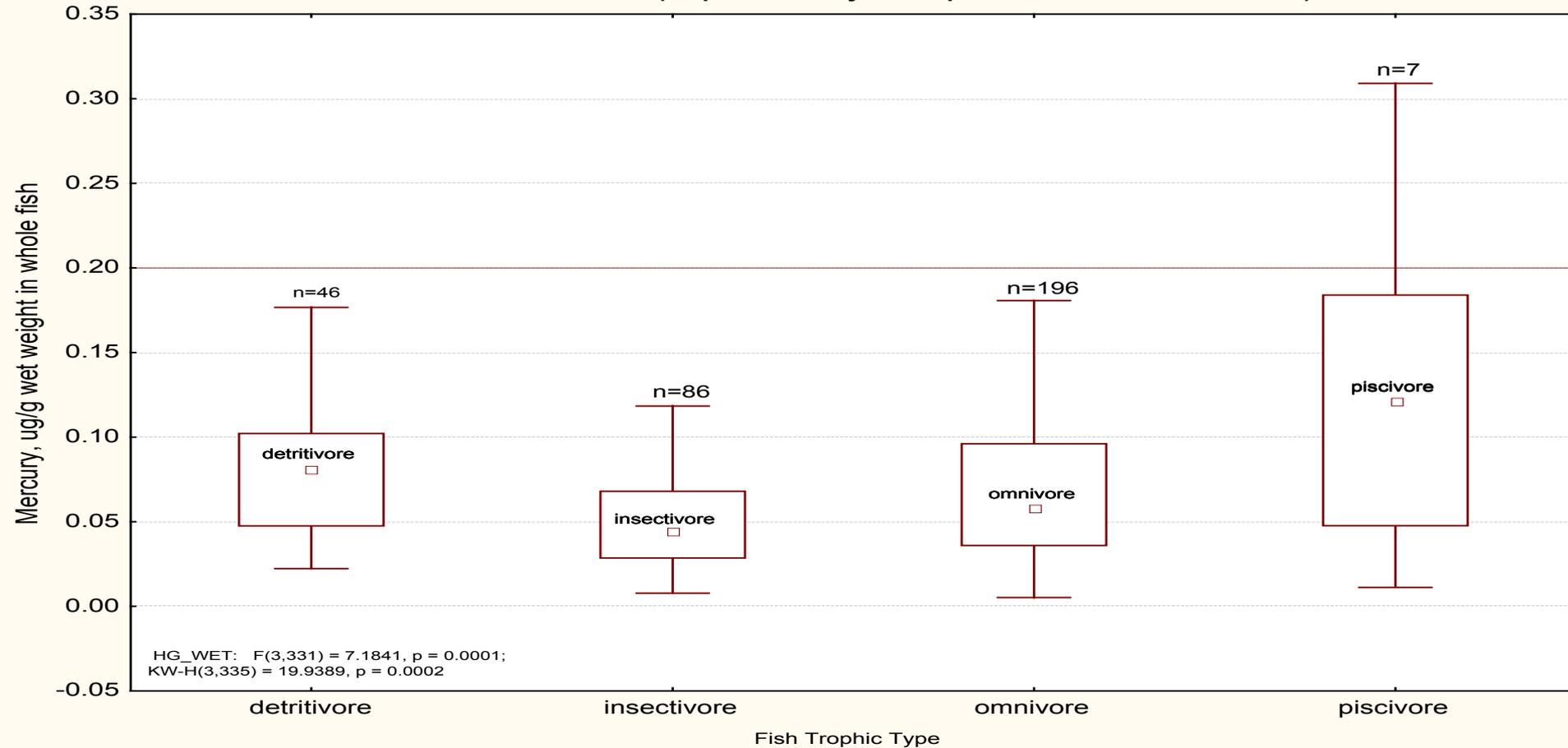
- Potent Neurotoxin
  - Affects central nervous system (reacts w/ brain enzymes, then lesions)
  - Affects hypothalamus and pituitary, affects gonadotropin-secreting cells
  - Altered behaviors: Reduced predator avoidance, reproductive timing fail
  - Reduced ability to feed (emaciation/growth effects)
- Endocrine disruptor
  - Suppressed reproductive hormones in male and female fish
  - Reduce gonad size and function, reduced gamete production,
  - Altered ovarian morphology, delayed oocyte development
  - Reduced reproductive success
  - Transfer of dietary Hg of the female during oogenesis and into developing embryo
- Fish have inability to grow new brain cells or significantly reduce brain Hg

- Beckvar (2005)-survival, growth, reproduction, behavior at **0.2ug/g in whole fish**
- Yearley (1998)- Hg > **0.1 mg/kg WW** likely harmful to piscivorous mammals
- USEPA (2000)- Hg > **0.3 mg/kg WW** likely harmful to certain people that eat fish



# 1990-96 Mercury in San Juan River Fish

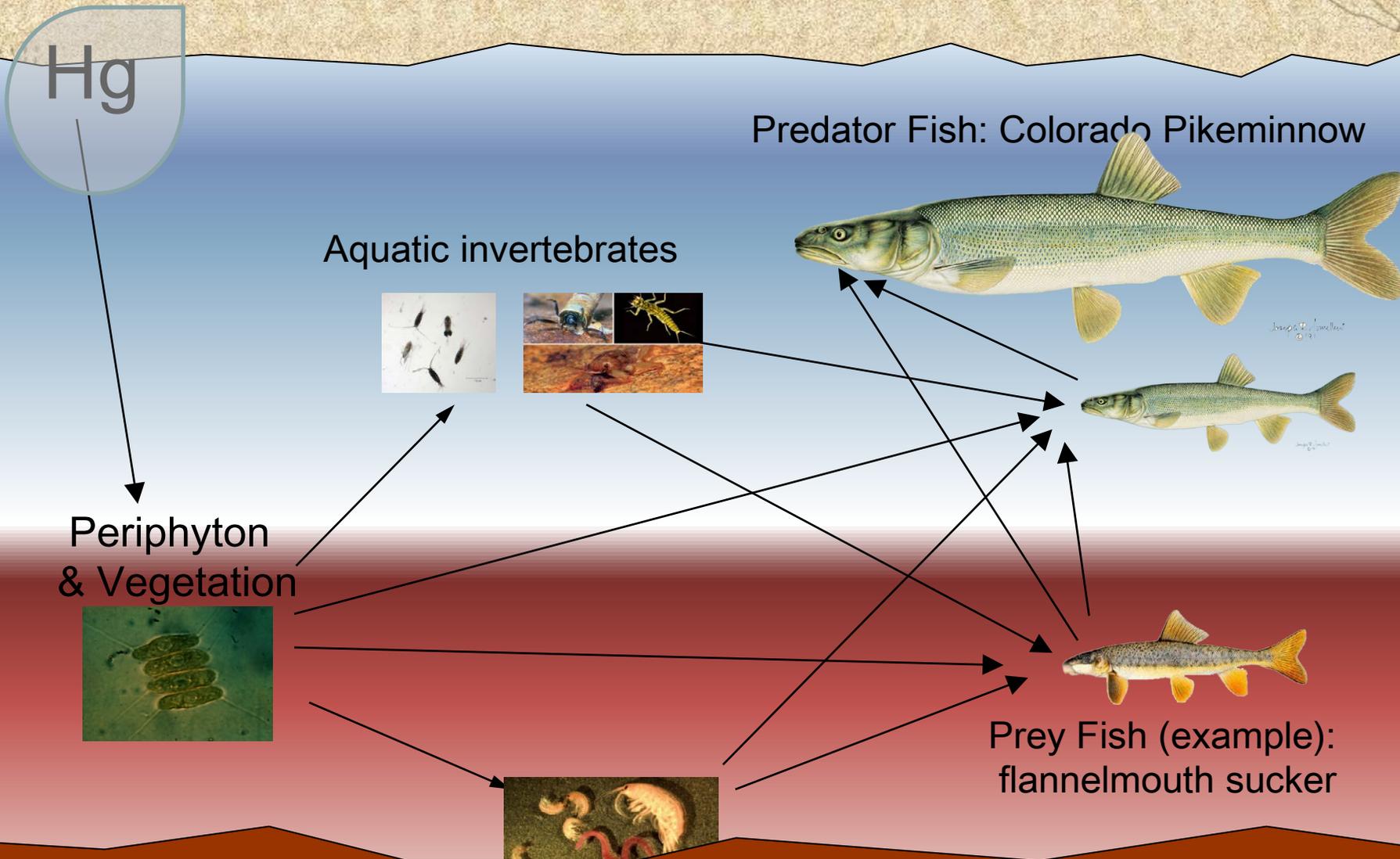
Boxplot of mercury (ug/g ww) in whole fish from the San Juan River (reported by Simpson and Lusk 1999)



- Few fish Hg data relevant to piscivorous pikeminnow – more data needed. . .



# Mercury in Colorado Pikeminnow food web

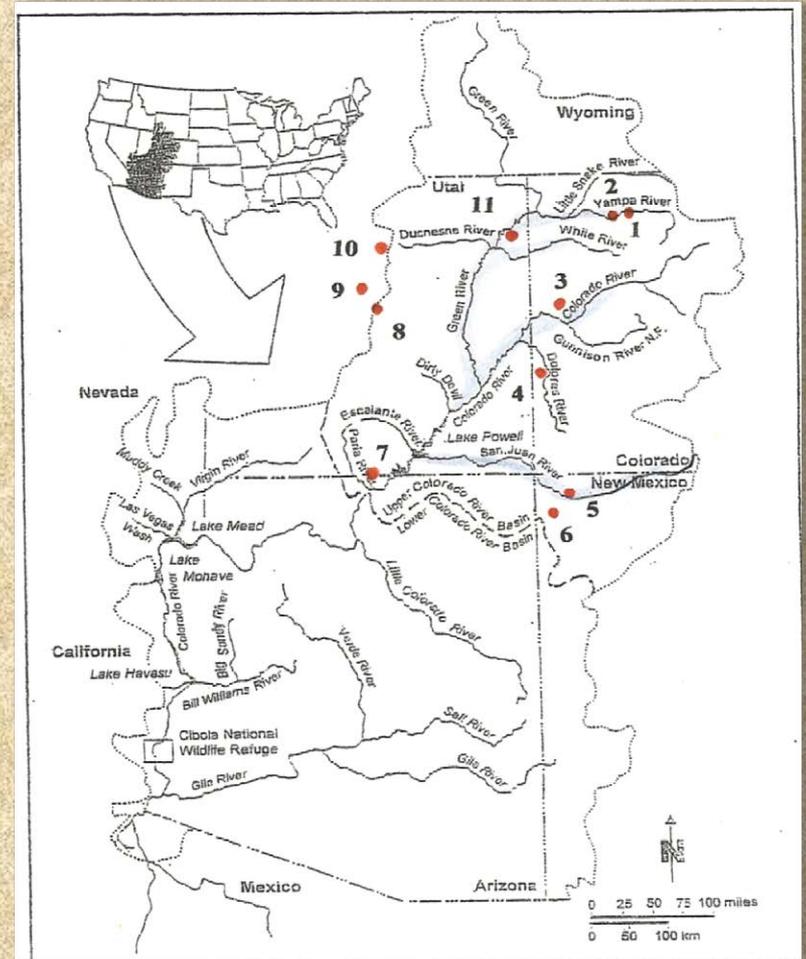


# 2007-11: Colorado Pikeminnow Study

- Determine Hg concentrations in Colorado pikeminnow throughout critical habitat using muscle plugs

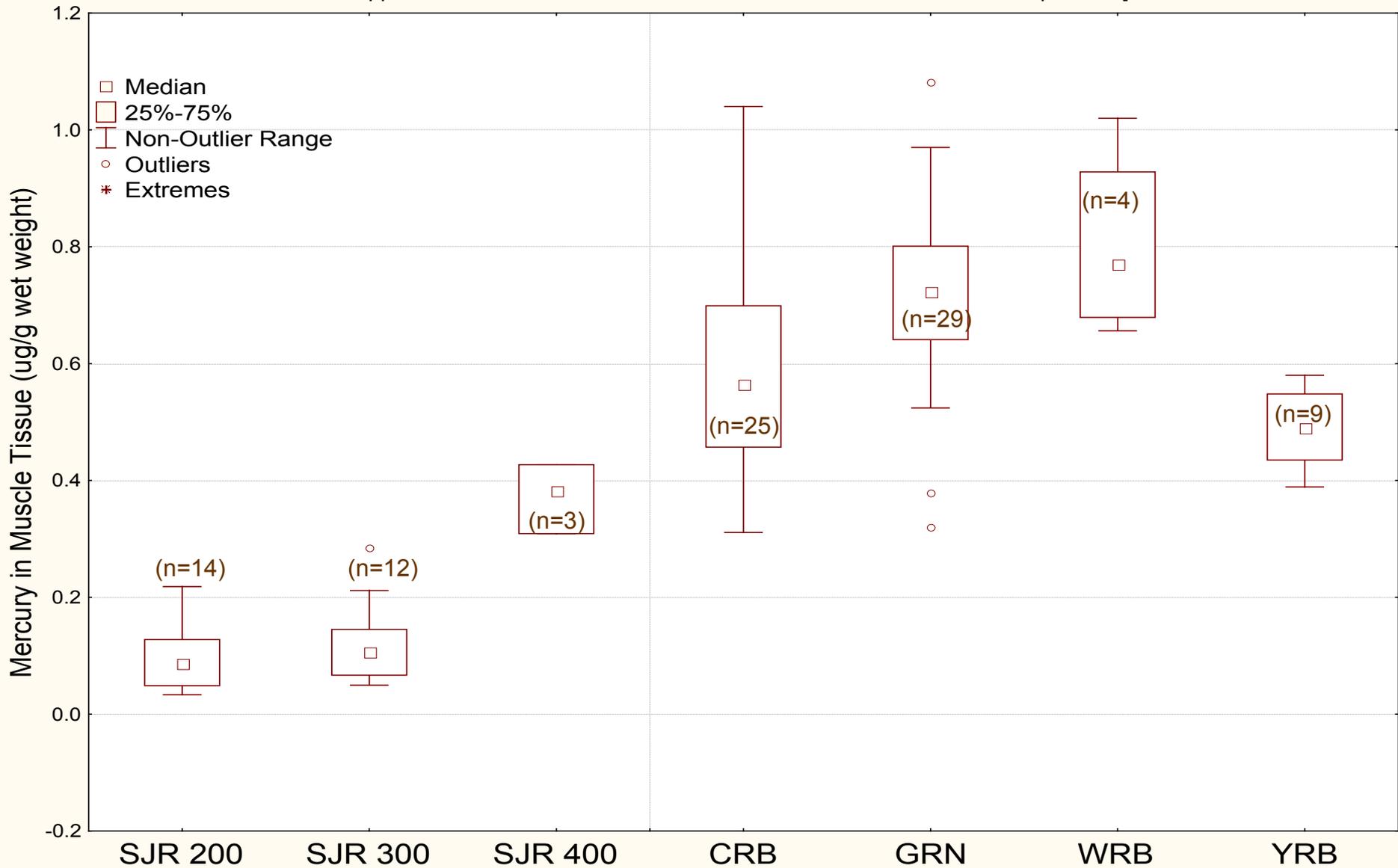


- Assess health risks to Colorado pikeminnow from Hg exposure



# BoxPlot of Mercury (ug/g ww) in Colorado Pikeminnow muscle by Watershed and San Juan River (by Size)

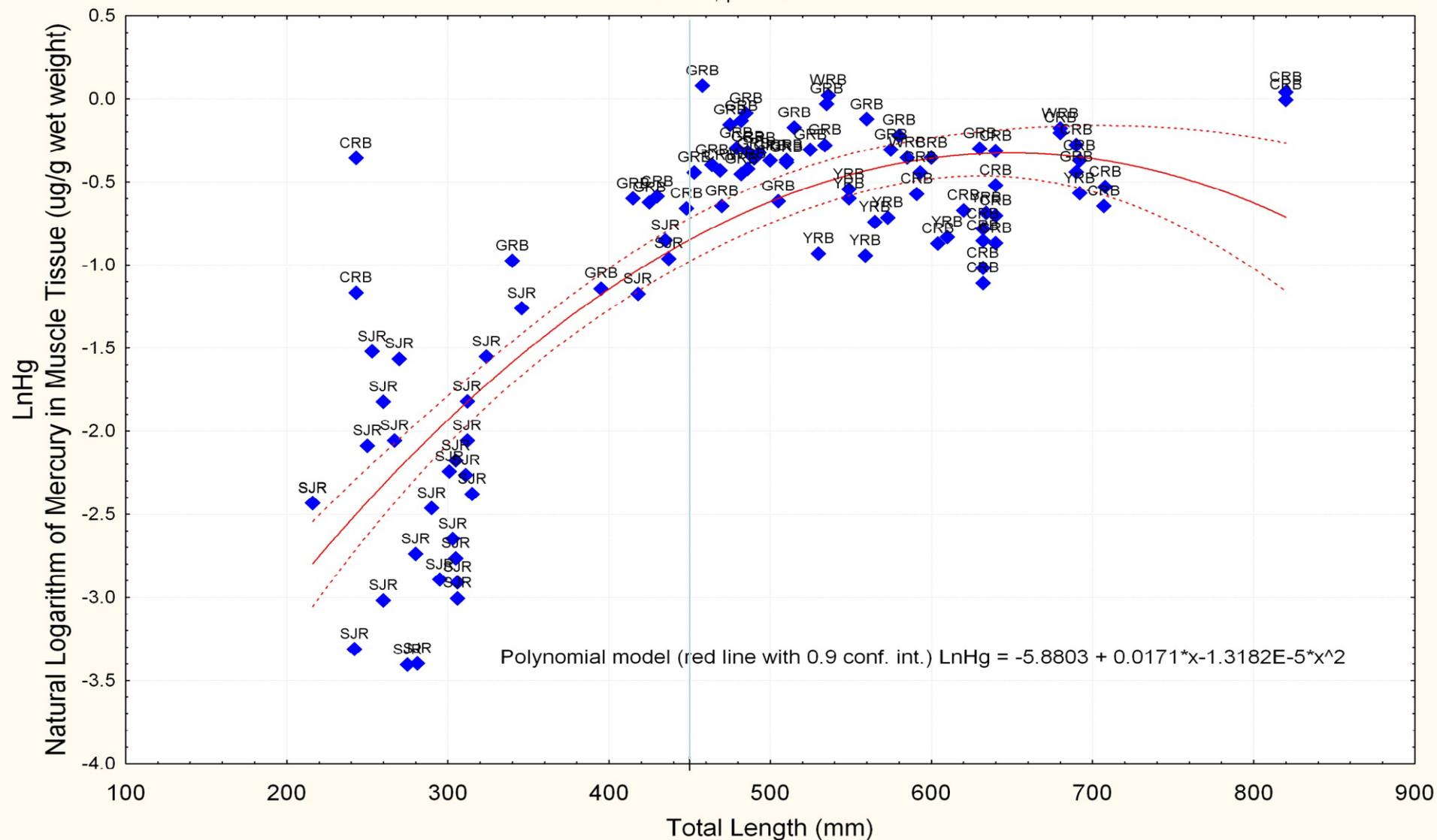
[Watershed: SJR 200-San Juan River 200mm; SJR 300-San Juan River 300mm; SJR 400-San Juan River 400mm; CRB-Upper Colorado River; GRN-Gren River; WRB-White River; YRB-Yampa River]



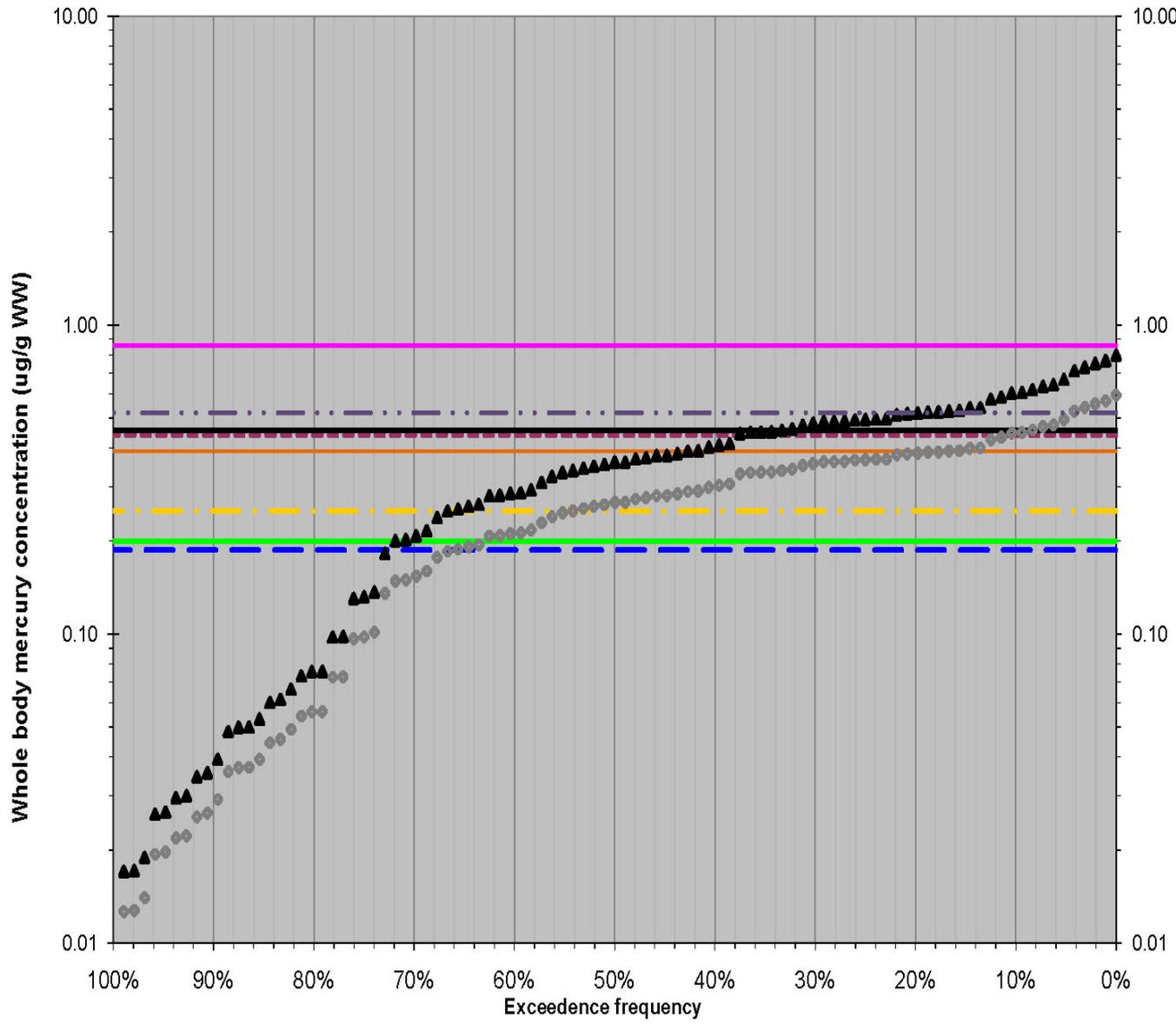
# Scatterplot of the natural logarithm of mercury in muscle tissue (ug/g wet weight) and total length (mm)

Pikeminnow tissues collected from the Colorado (CRB), Green (GRB), San Juan (SJR), White (WRB), and Yampa (YRB) River Basins.

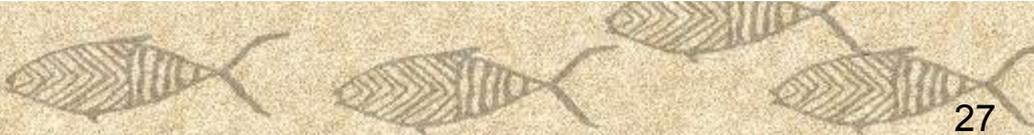
Linear Model:  $\text{LnHg (muscle)} = -3.2054 + 0.0046 * \text{Total Length}$   
 $r = 0.7447, p = 0.0000$



Current and expected future(35.5 % increase by 2020) whole-body mercury concentrations in Colorado Pikeminnow along with reproductive, behavioral, and lethal effects concentrations for surrogate species described by Beckvar et al. (2005).



- ◆ Current upper Colo. River Basin pikeminnow whole body Hg
- ▲ 2020 Future (35.5% increase) pikeminnow whole body Hg
- Proposed whole body fish threshold effect level (0.2 mg/kg)
- Possible threshold for steroidogenesis effects in male White Sturgeon (Hg in muscle)
- Gonadal atrophy in males (walleye)
- 16% reduction in spawning success (fathead minnow)
- 47.7% reduction in survival of males (mummichog)
- Severe brain lesions (vacuolation) and high lipid peroxidation (Atlantic salmon parr)
- Significant effects on dispersal behavior (golden shiner)
- 63% reduction in spawning success (fathead minnow)



# The USFWS appreciates working with the Navajo Nation EPA and FWD



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