



# Green Bay NRDA: Why No HEA?

NOAA-ARD, Monthly Meeting

David Allen & Doug Beltman  
Stratus Consulting Inc.  
Marquette, MI & Boulder, CO

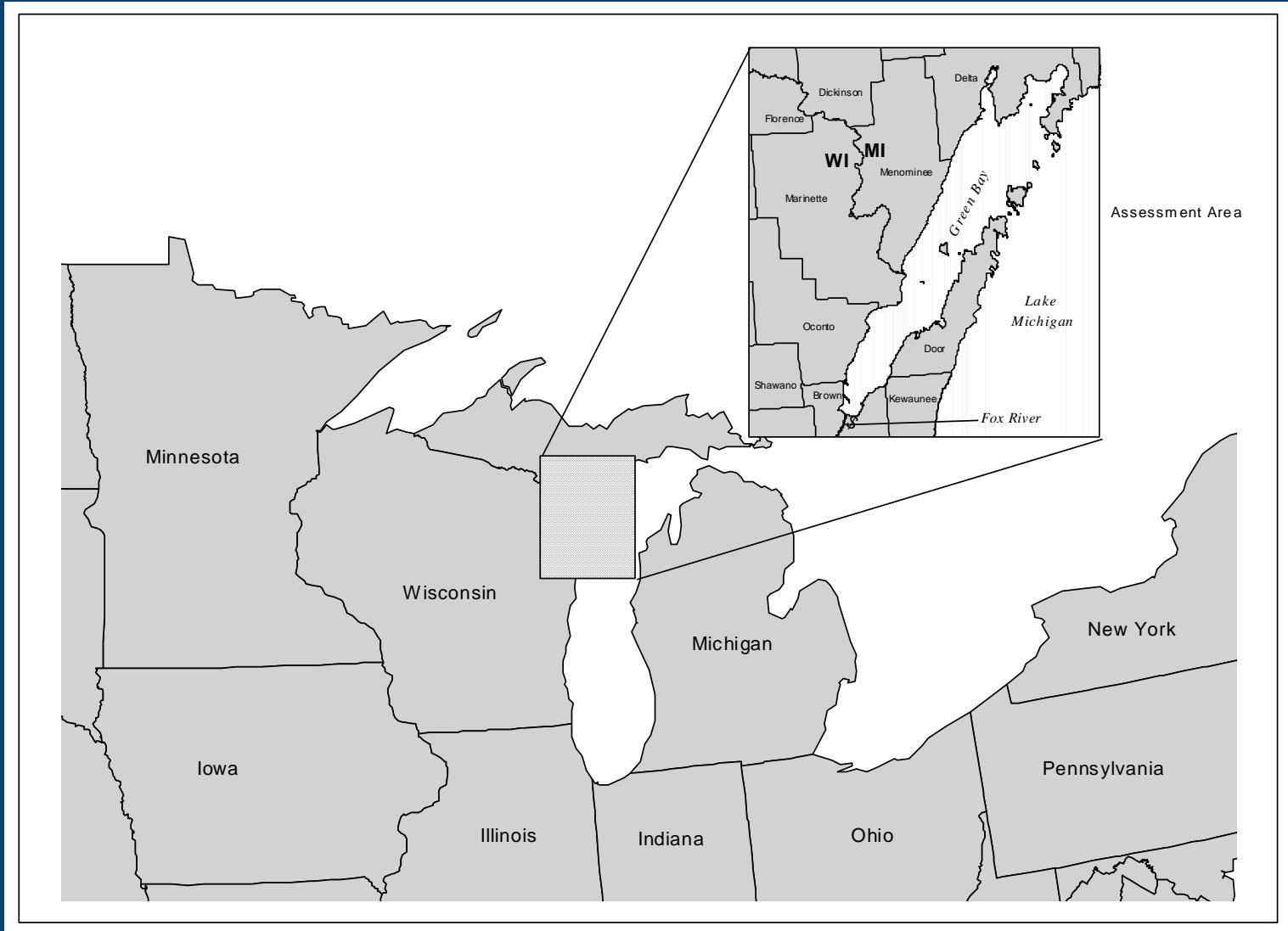
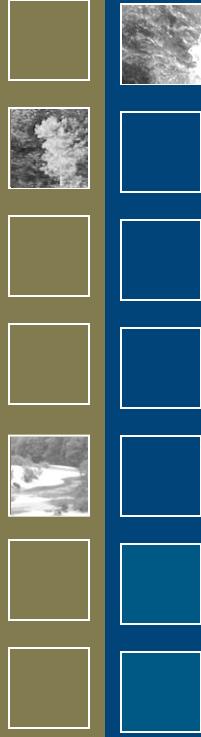
March 18, 2010



# Agenda

- Why so much historical “injury” work in GB?
- How the NRDA added to and synthesized the injury information
- Why no service-based HEA?
- How the NRDA scaled injury information to restoration

# Fox River/Green Bay Site



Why so much historical  
“injury” work in GB?



# Organochlorines discovered early

- 1962-1965: U.S. FWS, National Contaminant Biomonitoring Program (Patuxent)
- Highest O-Cs from entire U.S. program found in herring gull eggs from Sister Island in Green Bay
- Unable to discern which O-Cs, unable to tell source – complete surprise



# Deformities discovered in birds

- 1970s: Major banding efforts, particularly for double-crested cormorants in upper Green Bay (Michigan and Wisconsin islands)
- Deformities (crossed bills) widespread
  - Severe (bills often twist in opposite directions, or around head)
  - Long lasting (continued at least until the 1990s)
  - Extremely high rates (approx. 5% on Hat Island, WI in 1994)



# Lamprey control surprisingly ineffective

- 1950s: lake trout population crash, mostly attributable to sea lamprey invasion
- 1950s: Massive and successful lamprey program control launched
- 1960s and 1970s: Lake Michigan lake trout recovery unsustainable even with large stocking efforts (Why?)



# Contaminants Research

- 1960s-1970s: the O-C are dominated by PCBs
- 1970s-1980s: high concentrations of PCBs in all Green Bay biota
  - 25 species of birds
  - Many dozens of fish species (FCAs issued on almost all sport fish)
  - PCBs in sediment, water, biota throughout WI & MI waters of GB



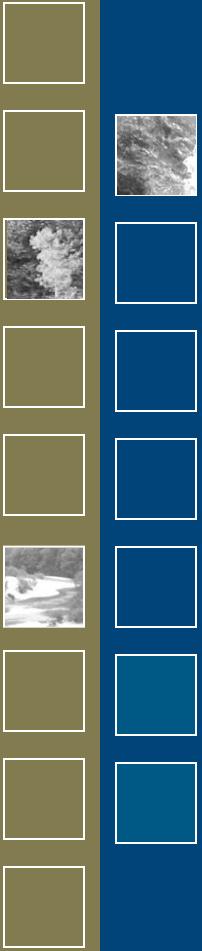
# Contaminants Research (cont.)

- 1980s: the Bay becomes a focus of multiple lines of PCB research
  - Aroclor & congener patterns by media
  - Attempts to link biological effects with PCBs or particular congeners
  - Attempts to determine PCB sources



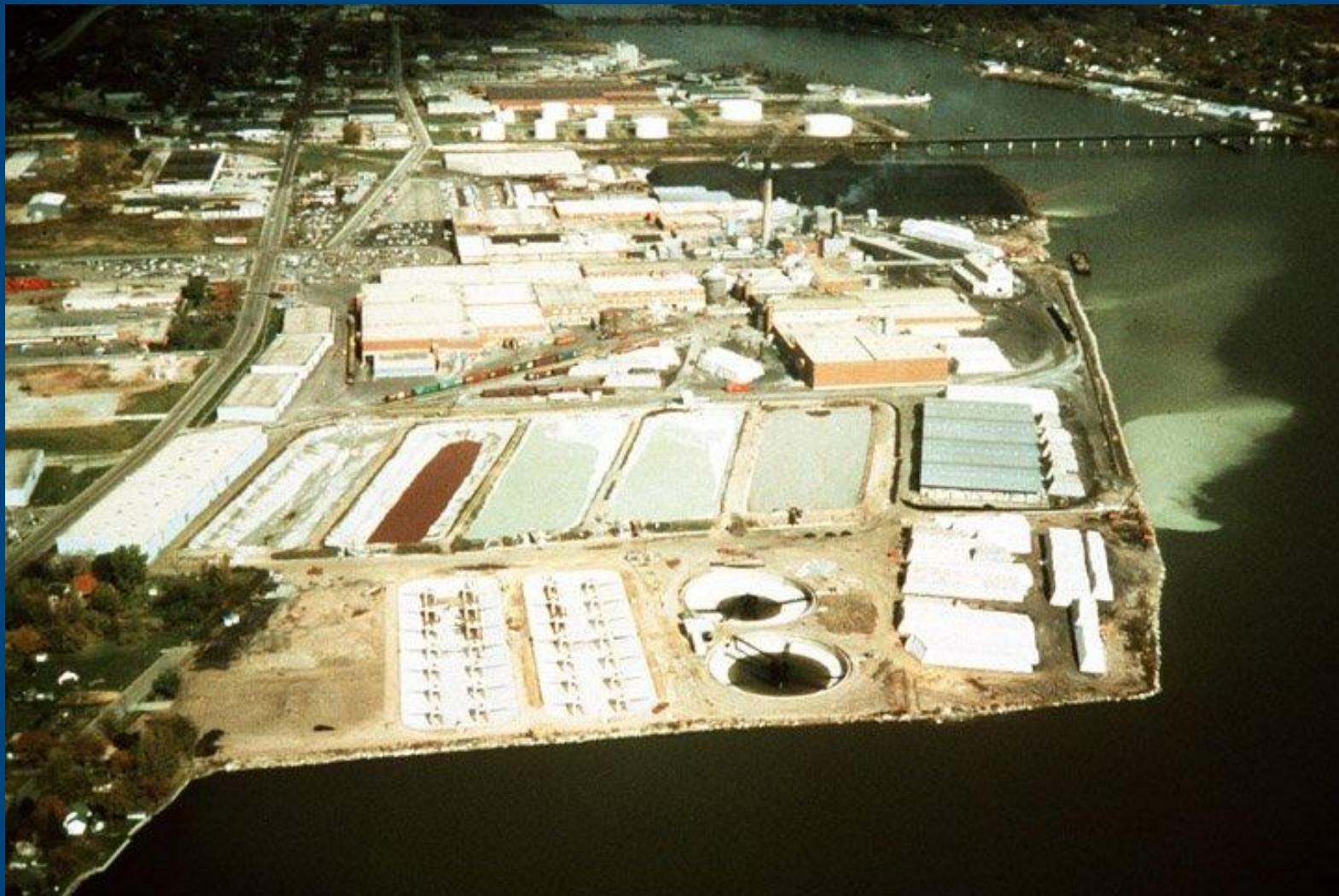
# Contaminants Research (cont.)

- 1990s: controversies and answers
  - The double-crested cormorant wars: PCBs the cause of deformities (etc.) or not?
  - The Green Bay Mass Balance Study: is the Fox River the dominant source or not?
  - What's wrong with the lake trout: PCBs or not?



# How the NRDA added to and synthesized the injury information

# Fox River/Green Bay NRDA Site



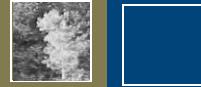
# Fox River/Green Bay NRDA Site (cont.)



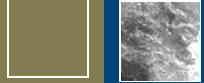
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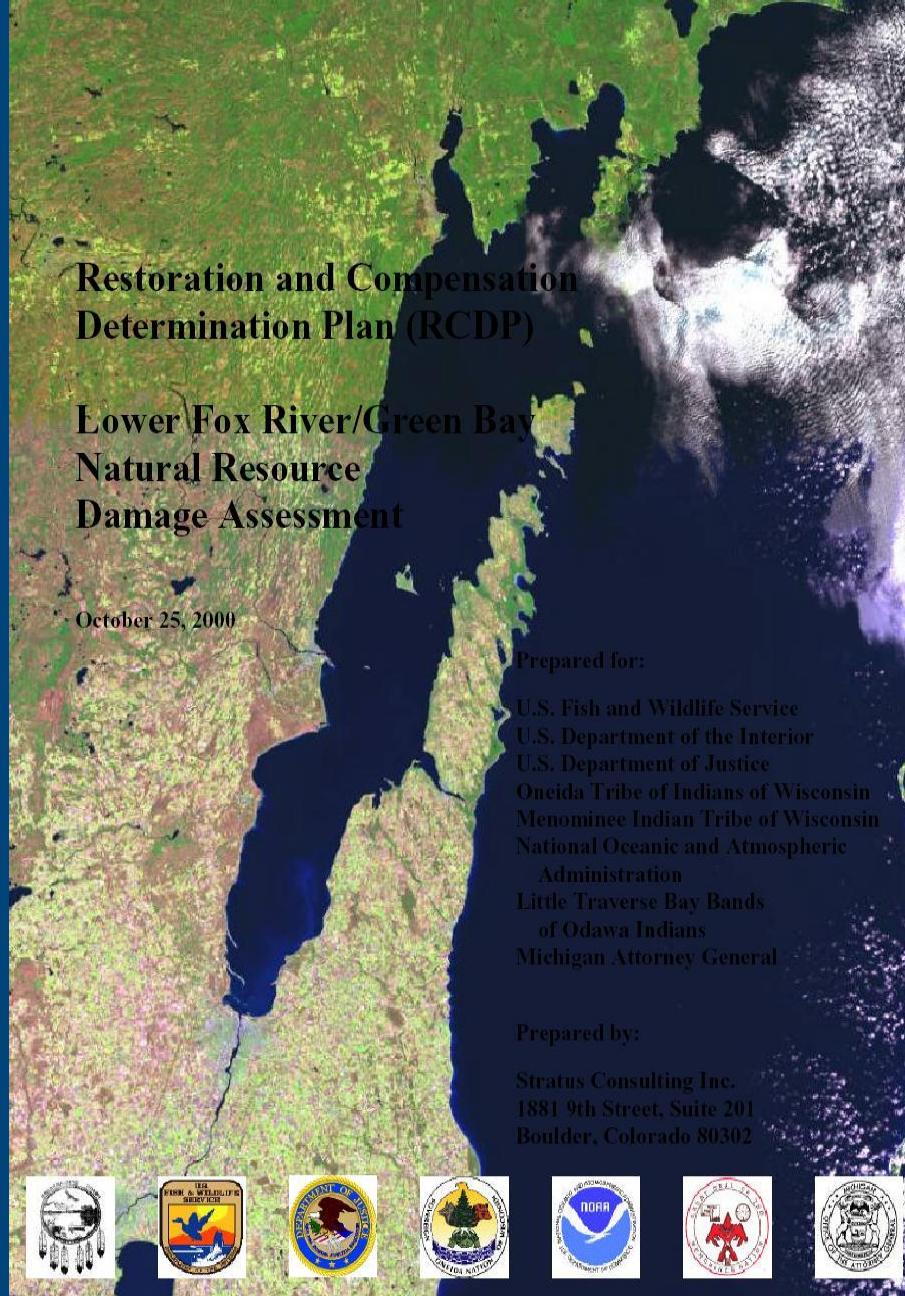
# Injury Assessment

- Original NRDA studies:
  - Game fish pathway (field): confirmation of GBMBS
  - Walleye injury (field): injury discovered
  - Lake trout injury (lab & field): injury ruled out
  - Waterfowl injury (field): consumption advisory triggers confirmed; direct injuries ruled out
  - Double-crested cormorant injury (lab & field): mixed results
  - Tree swallow injury (field): injury ruled out
  - Forster's and common tern injury (lab & field): injury confirmed



# Injury Assessment (cont.)

- Synthesis of site-specific information via formal determinations by Authorized Official
  - Pathway [6 rounds of CERCLA 104(e); existing literature; original analysis of FRMBS & GBMBS data]
  - Surface water injury (existing data)
  - Fish consumption advisories (existing data)
  - Fish toxicological injuries (existing and new studies)
  - Avian injuries (existing and new studies; original analysis of PCBs, DDx, and bald eagle reproduction)





# Pathway: Approach

- PCB release history from paper company facilities
- Water circulation and sediment transport patterns
- Spatial and temporal distribution of PCBs in sediment, water, and biota
- Evaluation of PCB congener patterns in sediment
- Application of the Green Bay Mass Balance Study to pathway determination



# Pathway: Conclusions

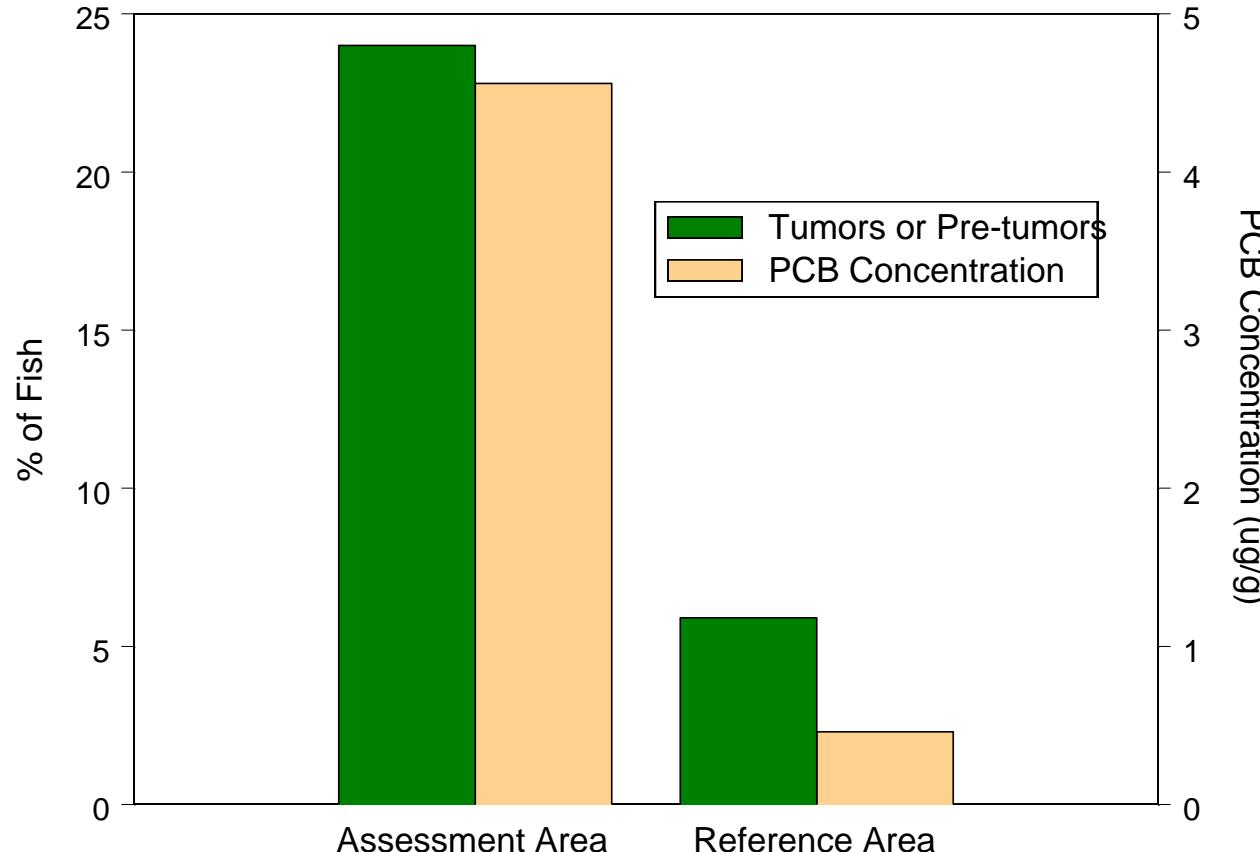
- Fox River dominant source of PCBs to Green Bay
- Surface water is the primary pathway by which PCBs are transported within the system
- Fox River PCBs transported throughout Green Bay
- Green Bay PCBs have declined since 1970s, but remain elevated
- PCBs transported from Green Bay to Lake Michigan



# Injury: Surface Water

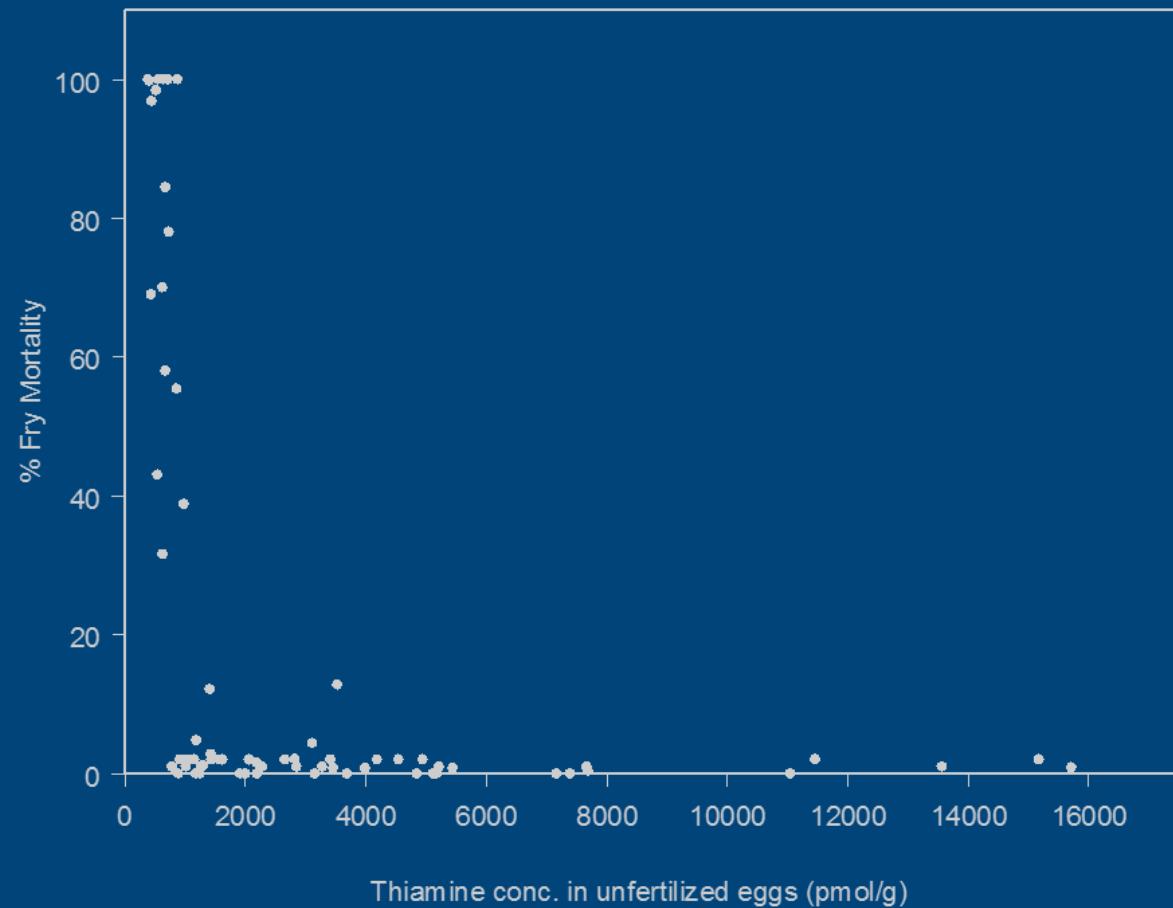
- Surface water throughout Lower Fox River and Green Bay contaminated with PCBs
- Fish are exposed to PCBs in the surface water
- PCBs in surface water greatly exceed criteria and standards for protection of biota

# Injury: Walleye (Liver Tumors)

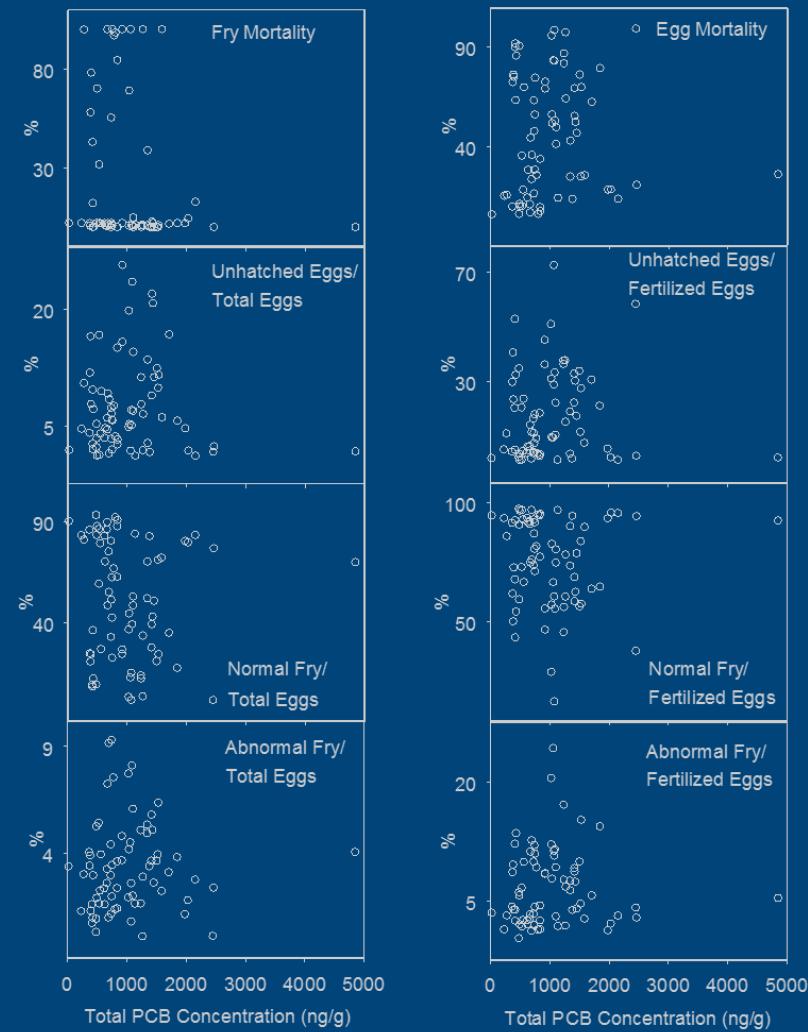




# Injury: Lake Trout (Reproduction) Thiamine Deficiency



# Injury: Lake Trout (Reproduction) PCBs

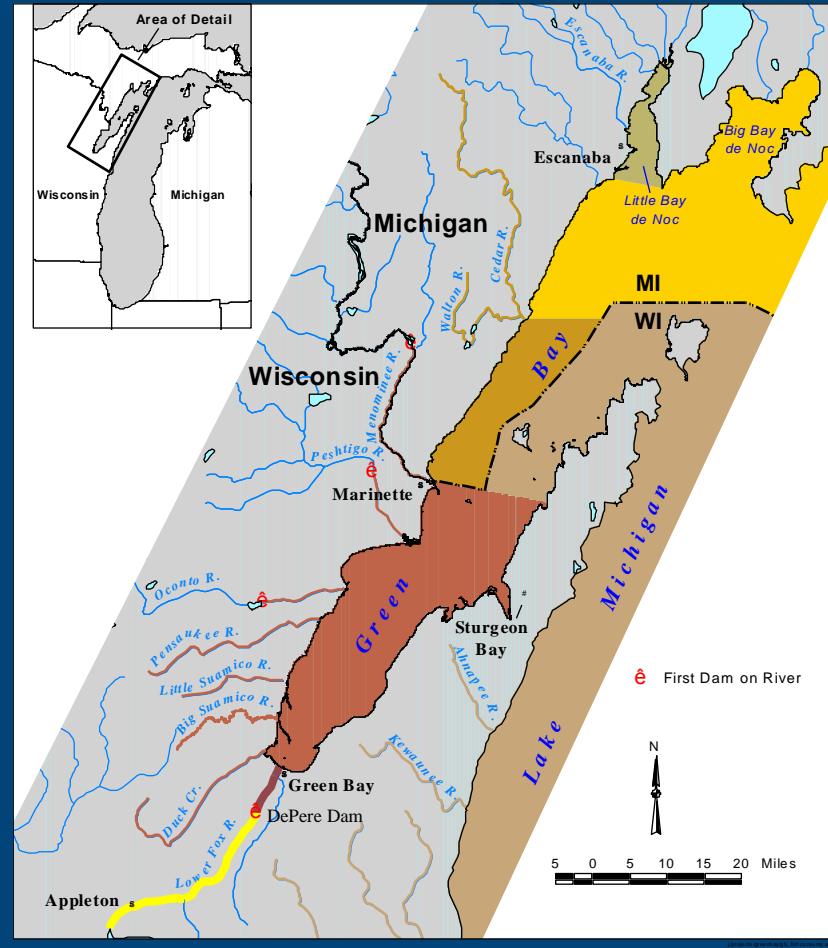




# Injury: Fish Species With Advisories

- Black crappie; bluegill; brook trout; brown trout; burbot; carp; channel catfish; chinook salmon; chubs; coho salmon; lake trout; longnose sucker; northern pike; rainbow trout; rock bass; sheepshead; smallmouth bass; smelt; splake; sturgeon; walleye; white bass; whitefish; white perch; white sucker; yellow perch

# Injury: Spatial Extent of Advisories

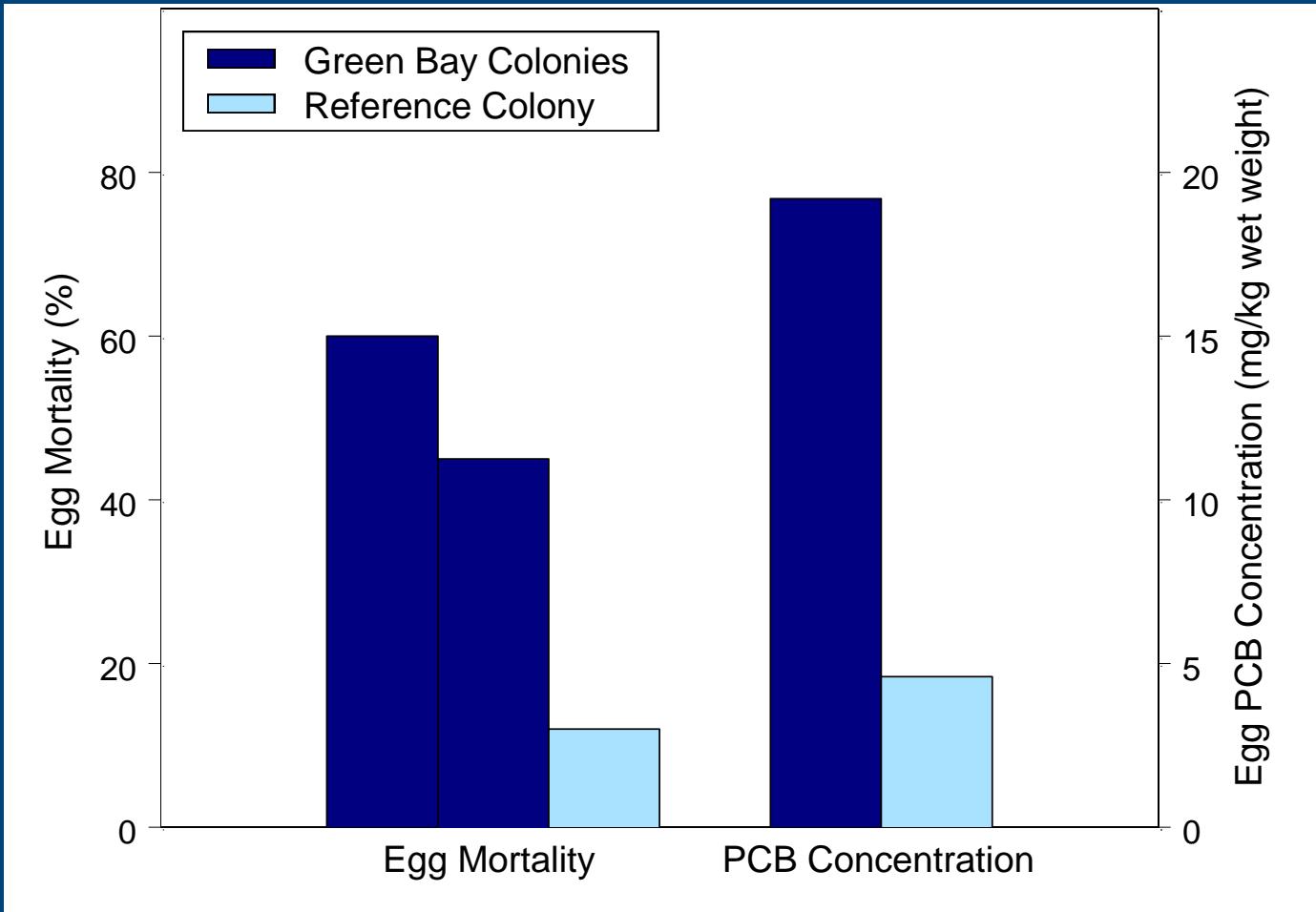


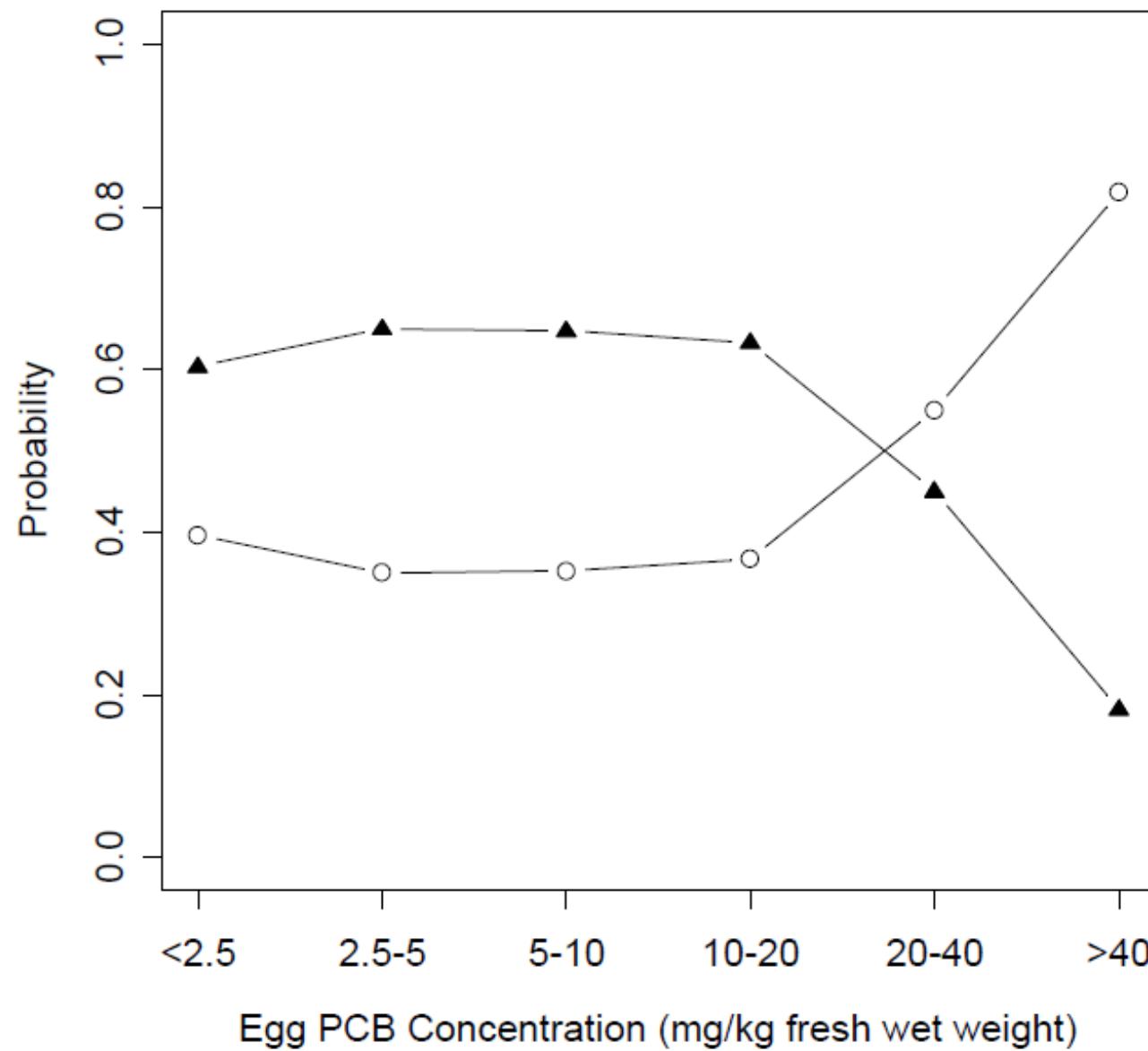


# Injuries: Birds

- Waterfowl also have PCB consumption advisories
- Forster's terns, common terns, and bald eagles have decreased reproduction, maybe also double-crested cormorants
- Common terns have increased deformities

# Injuries: Forster's Tern (Reproduction)





~flegprob.ssc

**Figure 5-13. Probability of bald eagles in inland Michigan and Wisconsin and Green Bay producing no young (open circles) or one or more young (triangles) in relation to egg PCB concentrations.**



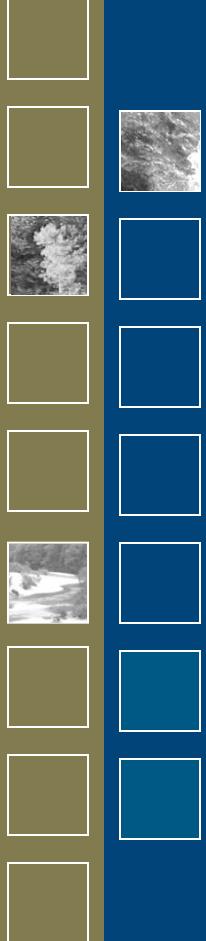
# Injury: Conclusions

- WQS to protect aquatic life & wildlife greatly exceeded
- Severe fish consumptive advisories
- Waterfowl consumption advisories
- Walleye liver tumors (no obvious population effects)
- About 1/5 of avian species tested showed injuries (reduced reproduction and deformities but without obvious population effects)



## Injury: Conclusions (cont.)

- Late trout reproductive failure (including obvious population effects) not linked to PCBs after 1970s
- Dramatic deformities in double-crested cormorants not linked to PCBs



# Why No Service-based HEA?



# HEA Issues for Green Bay

- All of Green Bay has PCBs and injuries (100+ miles x ~20 miles)
- Green Bay habitats are mostly distinct from both Lake Michigan habitats and inland habitats
- Restoration to improve habitat quality within Green Bay would probably also increase measurable injuries
- Many of the best restoration opportunities are inland



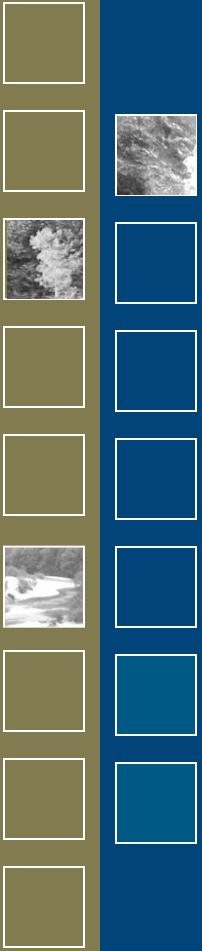
## HEA Issues for Green Bay (cont.)

- Injury levels subtle, but over very large areas for very long time
- Needed methods to trade dissimilar resources and habitats between debit and credit
- Needed methods that did not rely on numbers of organisms lost & gained
- Needed methods that did not require ecological conversions from subtle injuries to habitat acreage



# HEA Issues for Green Bay

- Needed methods that would prevail against hostile PRPs (and State)
- High stakes with pronounced “grossly disproportionate” issues
- PED
  - ~\$  $\frac{3}{4}$  billion cost for sediment restoration (cleanup authorities explicitly excluded at beginning)
  - ~\$  $\frac{3}{4}$  billion for residual compensatory value
- Needed to know relationship of values and costs for realistic restoration options



# How the NRDA scaled injury information to restoration



# Original Recreational Fishing Study

- Wisconsin and Michigan waters of Green Bay
- Addresses only anglers from nearby counties who currently fish in Green Bay
- Addresses only impacts of FCAs
- Conjoint analysis of original SP data (boat ramp fees, catch rate, FCA level)
- About \$100 million (about 2/3 in past)



## All the Rest

- Biological and ecological losses not addressed by recreational fishing study
- General public not included in the recreational fishing study



## All the Rest (cont.)

- How much restoration to address:
  - Subtle PCB injuries for decades (past and future) over thousands of square miles
  - PCB cleanup should speed recovery but cannot address most of the PCBs (>\$100 billion to clean up Green Bay)
  - Restoration beyond cleanup should improve environmental quality of the Fox River and Green Bay to compensate for PCB injuries



# Restoration

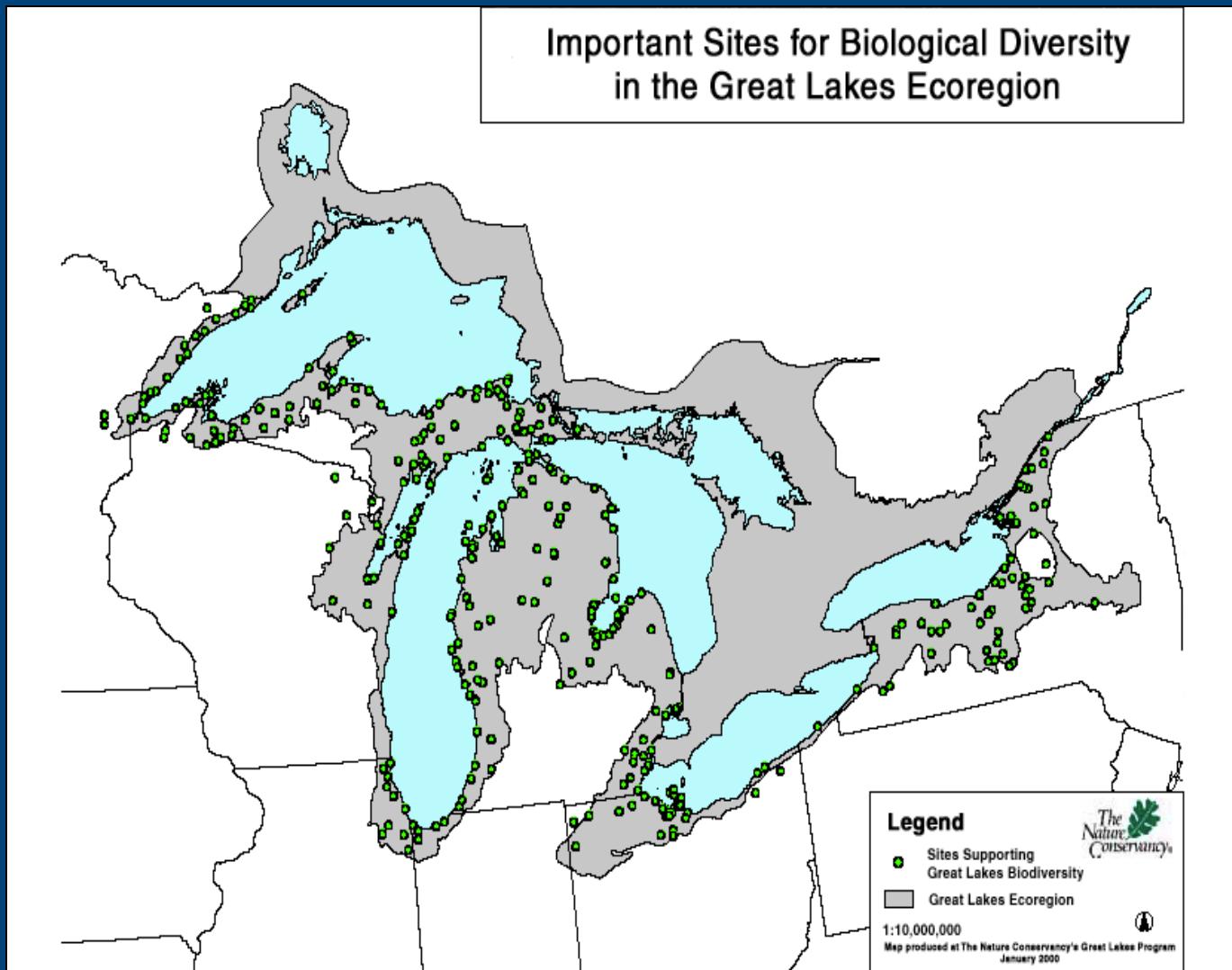
- Formal criteria developed first
- Project selection
  - 621 projects compiled
  - 564 projects after NRDA criteria
  - Categorize and rank
  - Select projects
  - Develop strategy for implementation



# Restoration (cont.)

- Preferred alternatives
  - Wetland preservation
  - Wetland restoration
  - Reduce agricultural runoff into Green Bay
    - Stream buffer strips
    - Conservation tillage on cropland
  - Improve recreational opportunities
    - Less important, but part of the mix

# Restoration: Preservation





# Restoration: Scaling

- How much is enough?
- How should the different project types be combined into an overall approach?
- What are the public's preferences and attitudes?
- How do values compare to costs?



# Restoration: Scaling

- “HEA” with the value terms measured
  - Original SP data with conjoint analysis (“total value equivalency”): “VEA?”
  - Value to public gained from environmental quality through restoration is balanced against the value lost from continuing PCB injuries
  - Determines “how much is enough,” with the flexibility to consider different project mixes
  - Empirical measurement of the value terms for different restoration types and injuries, rather than modeled ecological service losses & gains



# Restoration: Scaling (cont.)

- Written survey, conducted in 10 counties in Green Bay area
- Conducted using rigorous survey and economic methods
- Designed to quantify how the public balances ongoing PCB injuries against improved environmental quality via restoration

**16** If you had to choose, would you prefer Alternative A or Alternative B? Check one box at the bottom.



|  | <b>Alternative A</b>               | <b>Alternative B</b>                |
|--|------------------------------------|-------------------------------------|
| Wetlands   |                                    |                                     |
| Acres . . . . .  | 58,000 acres<br>(current)          | 58,000 acres<br>(current)           |
| PCBs   |                                    |                                     |
| Years until safe for nearly all<br>fish and wildlife . . . . . | 100+ years until safe<br>(current) | 40 years until safe<br>(60% faster) |
| Outdoor Recreation   |                                    |                                     |
| Facilities at existing parks . . . . .                         | 10% more                           | 0% more                             |
| Acres in new parks . . . . .                                   | 0 acres<br>(current)               | 0 acres<br>(current)                |
| Runoff   |                                    |                                     |
| Average water clarity in the<br>southern Bay . . . . .         | 34 inches<br>(70% deeper)          | 20 inches<br>(current)              |
| Excess algae days in lower Bay .                               | 40 days or less<br>(50% fewer)     | 80 days or less<br>(current)        |
| Added cost to your household                                   |                                    |                                     |
| Each year for 10 years . . . . .                               | \$50 more                          | \$50 more                           |

Check (✓) the box for the alternative you prefer →



# Restoration: Scaling (cont.)

| Action  | Mean Importance Ranking |
|---|-------------------------|
| Reduce PCB risks to wildlife                  | 4.3                     |
| Remove PCB consumption advisories             | 4.3                     |
| Reduce runoff to improve water clarity        | 4.0                     |
| Increase wetland habitat for wildlife         | 3.9                     |
| Reduce runoff to reduce algae blooms          | 3.8                     |
| Improve existing parks                        | 3.6                     |
| Add new parks                                 | 3.3                     |
| 1 = not at all important, 5 = very important. |                         |

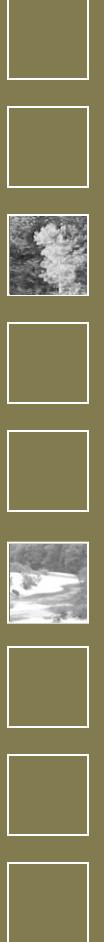


# Restoration: Scaling (cont.)

- Economic model constructed from survey results
- Various mixes of restoration types can compensate for ongoing PCB injuries
  - Wetland preservation and restoration
  - Nonpoint source runoff control
  - Park improvements
  - Not adding new parks
- Under scenarios of less PCB remediation, more restoration is required

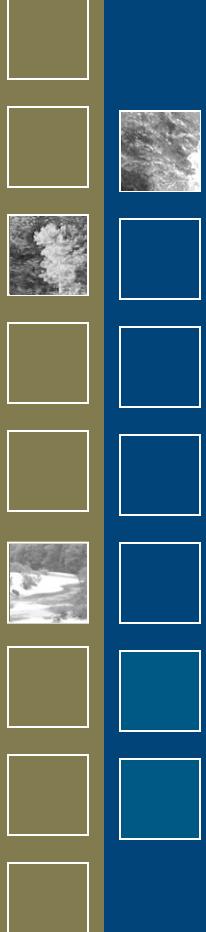
# Restoration: Scaling (cont.)

| PCB cleanup scenario                     | Wetlands        |                | Increase in bay water clarity from runoff control | Improvement in existing parks |
|--|-----------------|----------------|---|-------------------------------|
|  | Acres preserved | Acres restored |   |                               |
| Intensive (injuries gone in 20 years)    | 8,700           | 2,900          | +2"   | 10%                           |
|  | 6,900           | 2,300          | +6"   | 5%                            |
| Intermediate (injuries gone in 40 years) | 9,900           | 3,300          | +4"   | 10%                           |
|  | 8,700           | 2,900          | +8"   | 10%                           |



# Restoration: Cost

- Reasonable cost estimates for the preferred restoration alternative
  - Standard cost estimating methods
  - Detailed analysis of land costs
  - Information on distribution of different restoration opportunities in the area
  - Experiences of other agencies/programs doing similar work
  - Modeling of the relationship between restoration, runoff, and water clarity



# Restoration: Cost

- Final claim follows selection of PCB remedy
- Final claim includes:
  - Value of past recreational fishing losses
  - Cost of restoration to address future PCB injuries
  - Assessment costs
- Total \$200-\$300 million
  - Depends on cleanup
  - Depends on exact project mix and locations

# Gross Disproportionality

## Cost > Value

Sediment removal  
in GB by trustees

Cost  
\$111 billion

Value  
\$610 million

## Cost $\approx$ Value

Habitat restoration  
(trustees)

Cost  
\$111-268 million

Value  
\$254-610 million

## Cost < Value

Recreational  
facilities (PRPs)

Cost  
\$7 million

Value  
\$55 million



# Gross Disproportionality (cont.)

- In theory
  - Trustees could seek \$111 billion to restore sediments of Green Bay (but less authority than cleanup, and cost = 180x value)
  - Popular park could be cheap and valuable (but merry-go-rounds are not NR)
- Therefore: cost-effective, relevant NR restoration, fairly and accurately valued