Mercury in Fish - Status Report for the Oak Ridge Reservation

Mark J. Peterson

George Southworth

Teresa Mathews

Environmental Sciences Division

Oak Ridge National Laboratory

Sponsoring organizations:
Y-12 Environment, Safety and Health Organization
ORNL EP&WSD Water Quality Program
ETTP Environmental Compliance and Protection
Water Resources Restoration Program

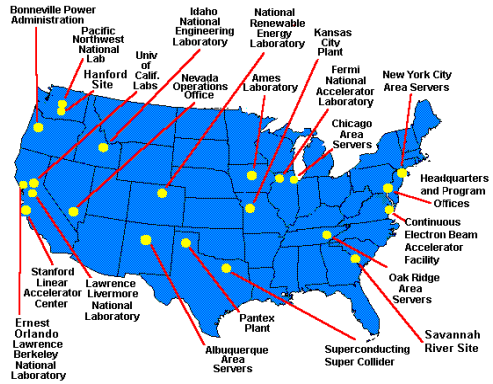
U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Outline

- Background
  - Broad mercury challenges
  - Monitoring History
- Biological Monitoring and Abatement Program (BMAP) sampling
  - Objectives
  - Methods/Approach
  - Sampling locations
- Bioaccumulation Results
  - Oak Ridge Reservation/Regional comparison
  - East Fork Poplar Creek (EFPC) spatial and temporal trends
  - Effectiveness of remedial actions
- DOE programs addressing the mercury problem

Mercury Challenges



DOE Sites

Global/National:

- Complex chemistry/speciation/methylation processes
- Highly bioaccumulative
- Global pollutant readily transported and re-emitted
- Hg a waste issue at all DOE sites; environmental issues at many
- Increased concern for human and ecological risks; more rigorous regulatory limits
- Conventional removal options limited

Oak Ridge:

- TN recently lowered level that triggers a fish advisory (0.3 ug/g)
- Some improvement, but many ORR fish populations > 0.3 ug/g
- Impact of OR remediation on fish levels uncertain
- State of TN developing an East Fork Poplar Creek TMDL (goal: fish reduction)
- Modernization of facilities could impact releases

History of EFPC fish monitoring for mercury

- **1953:** Fish in EFPC first exposed to industrial losses of mercury at Y-12
- **1974:** ORNL conducted first regional survey of mercury levels in fish
- **1982:** Joint ORNL/TVA study of Hg in EFPC fish. EFPC mercury issues go public.
- **1985:** Annual monitoring of Hg in EFPC fish begins
- **1992-1994**. LEFPC Remedial Investigation uses fish data
- **1995-1996**. Lower EFPC soil remediation
- **1996-1998.** Lower East Fork Poplar Creek post-action studies include forage fish monitoring
- **2009.** Monitoring of EFPC fish continued to present as part of Y-12 Biological Monitoring and Abatement Program (BMAP).

Biological Monitoring and Abatement Program

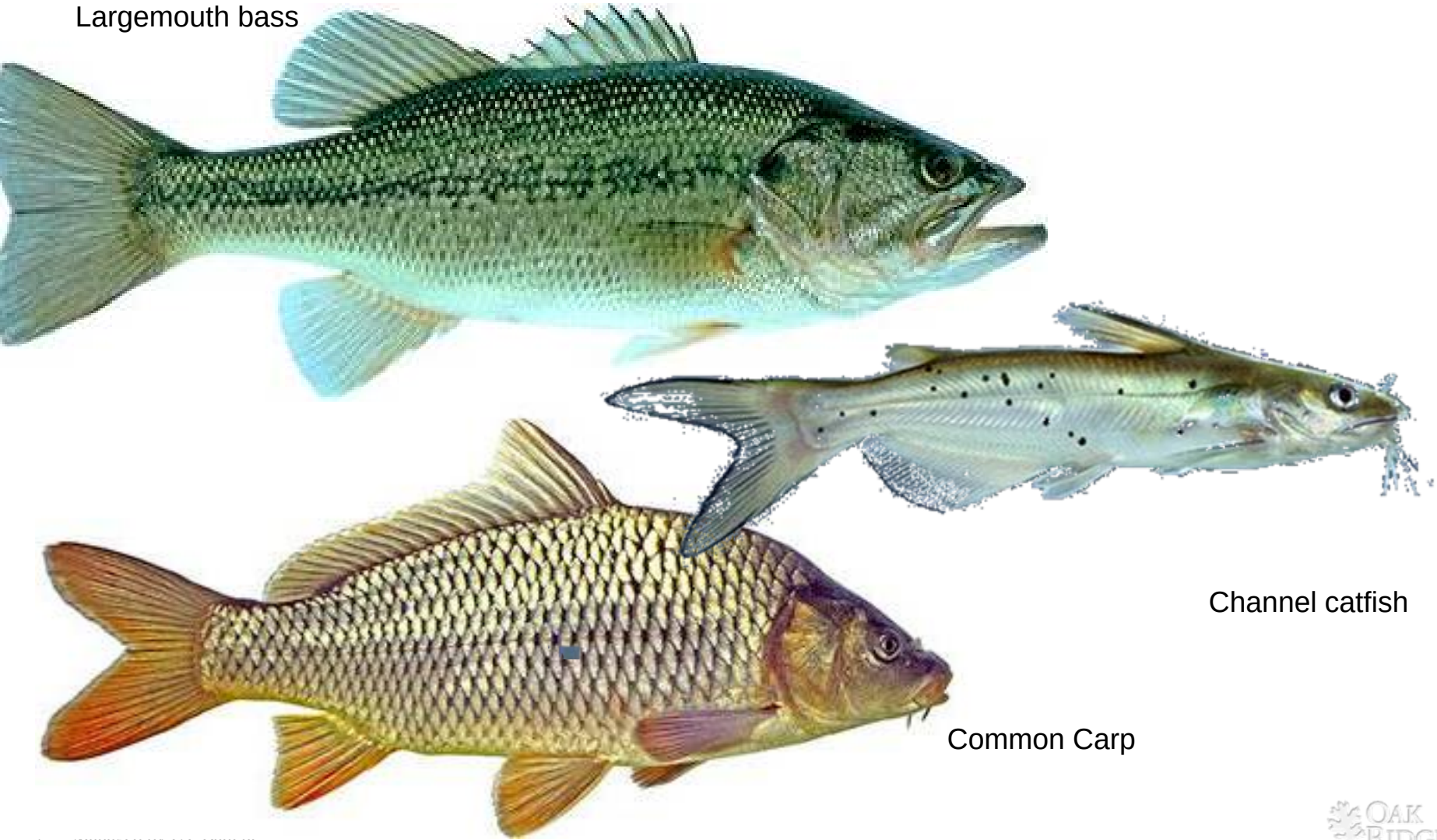
- EPA and the State of Tennessee ensure protection of state waters via Clean Water Act and the TN Water Quality Control Act, as well as CERCLA
- Biological monitoring required in Oak Ridge, including bioaccumulation
- Bioaccumulation objectives
  - Address regulatory requirements by ensuring effluent limits protect the uses of the receiving stream (e.g., recreation - fish safe to eat?)
  - Provide data for human and ecological risk assessments
  - Assess the impact of plant operations and identify sources (spatial patterns)
  - Monitor recovery and assess the effectiveness of remedial actions (temporal patterns)

Bioaccumulation approach

- Monitoring of resident fish
- Watershed scale
- Annual or twice-a-year sampling; long-term
- Human health assessment:
  - Muscle tissue from game fish
  - 6-8 individual fish/site
  - standardized sizes, age, sex for comparability
- Ecological risk assessment:
  - Typically 3 10-fish composites (forage fish)

Large game fish used for bioaccumulation studies

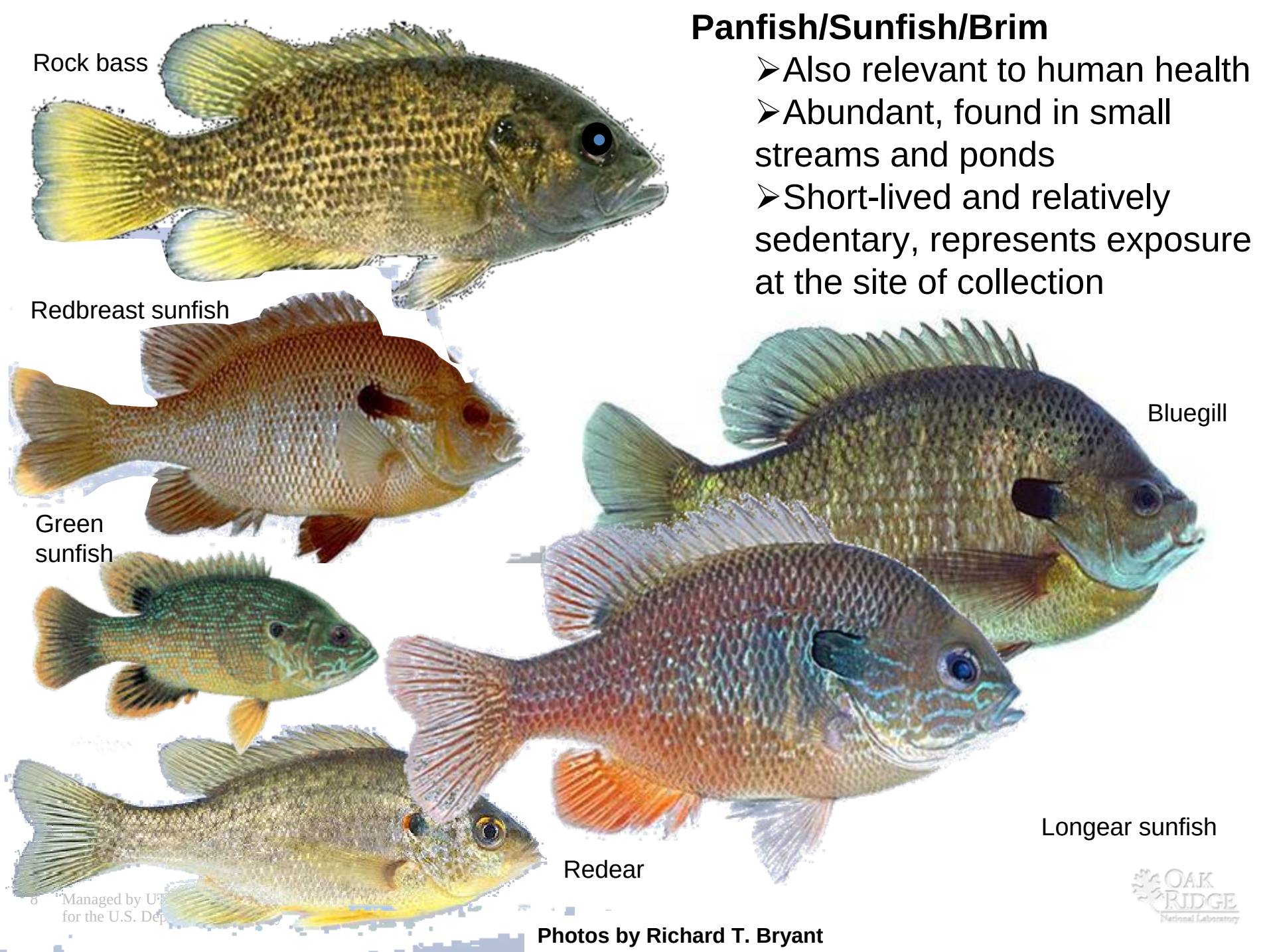
- Represent maximum risks (larger, older, top of food chain)
- However, highly mobile, only found in big waters



Photos by Richard T. Bryant

Panfish/Sunfish/Brim

- Also relevant to human health
- Abundant, found in small streams and ponds
- Short-lived and relatively sedentary, represents exposure at the site of collection



Photos by Richard T. Bryant

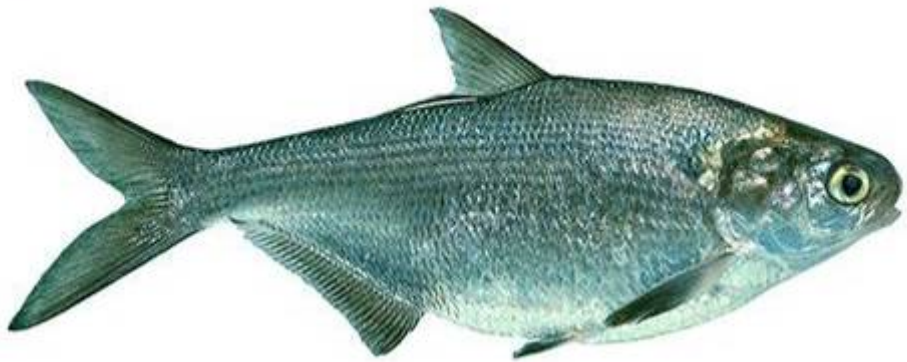
Forage fish used for ecological risk assessment

- Abundant, can obtain large numbers for compositing
- Can accumulate high levels of some contaminants like PCBs

Striped shiner

Largescale stoneroller

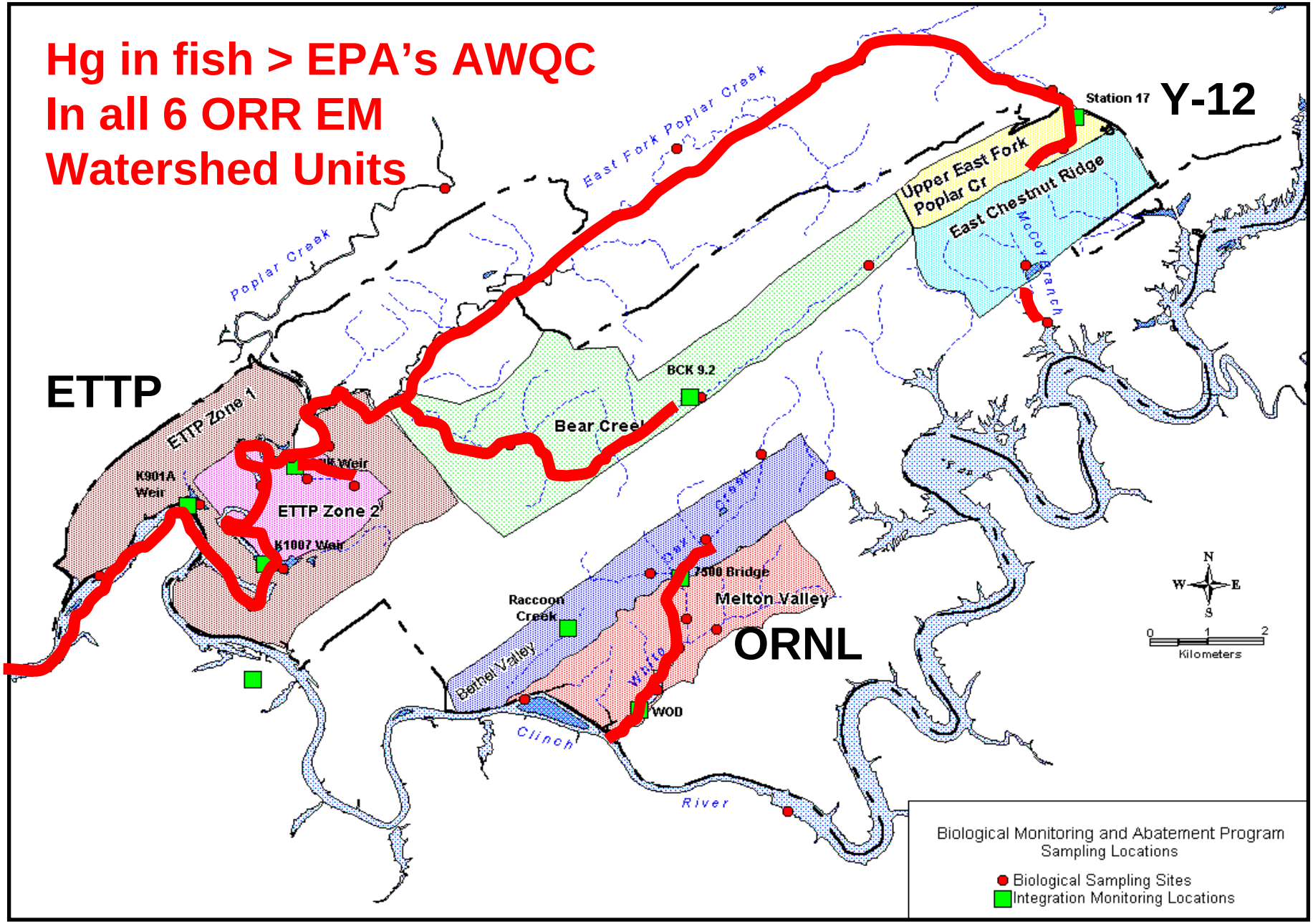
Blacknose dace



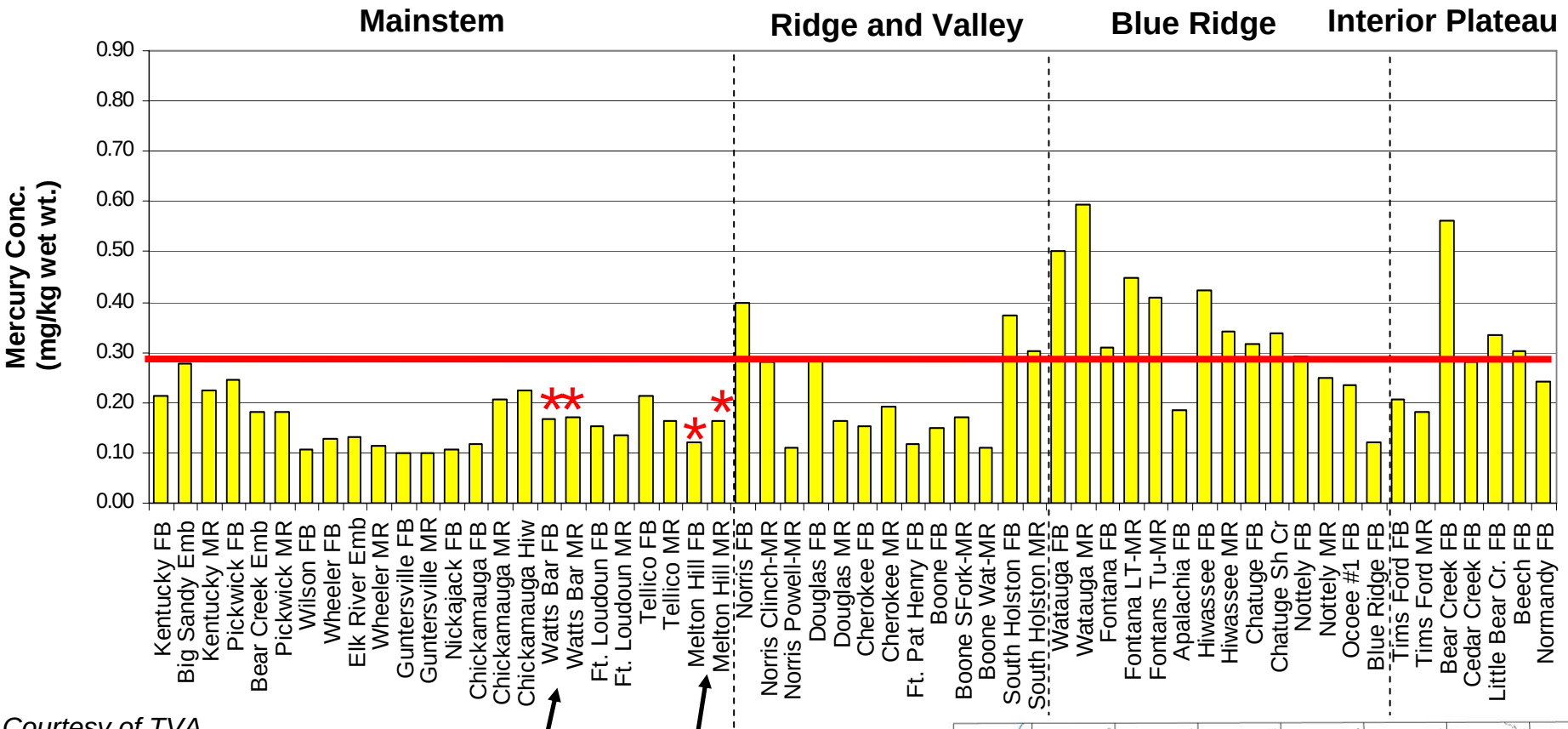
Gizzard Shad

Photos by Richard T. Bryant

Hg in fish > EPA's AWQC In all 6 ORR EM Watershed Units



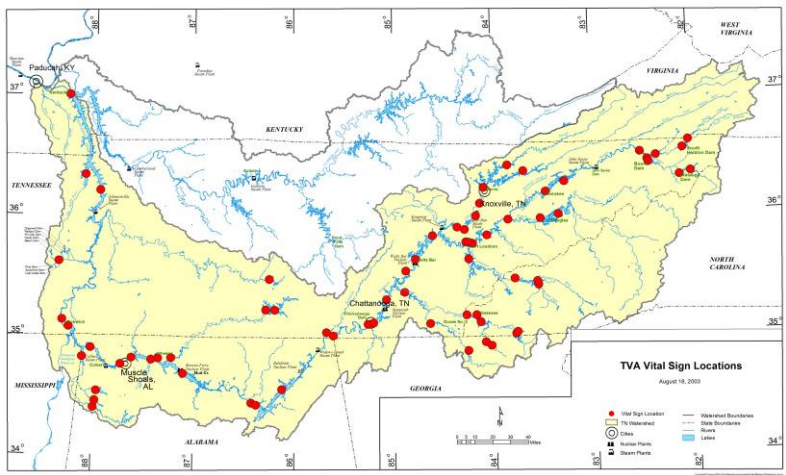
Average Mercury Concentrations in Largemouth Bass at Vital Signs Monitoring Locations, 1990-2004



Courtesy of TVA

Watts Bar Reservoir
(downstream of major ORR streams)

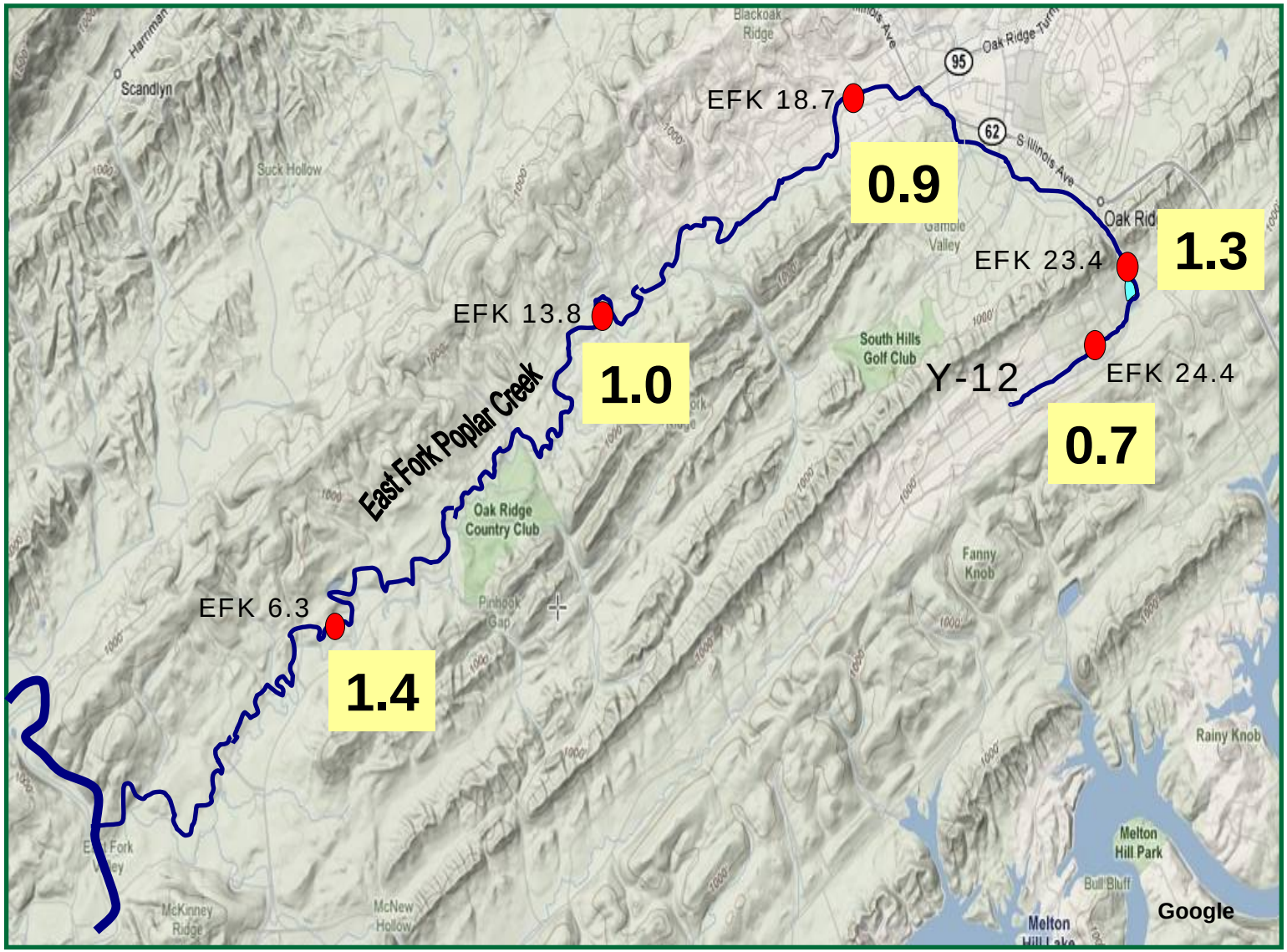
Melton Hill Reservoir
(upstream of major ORR streams)



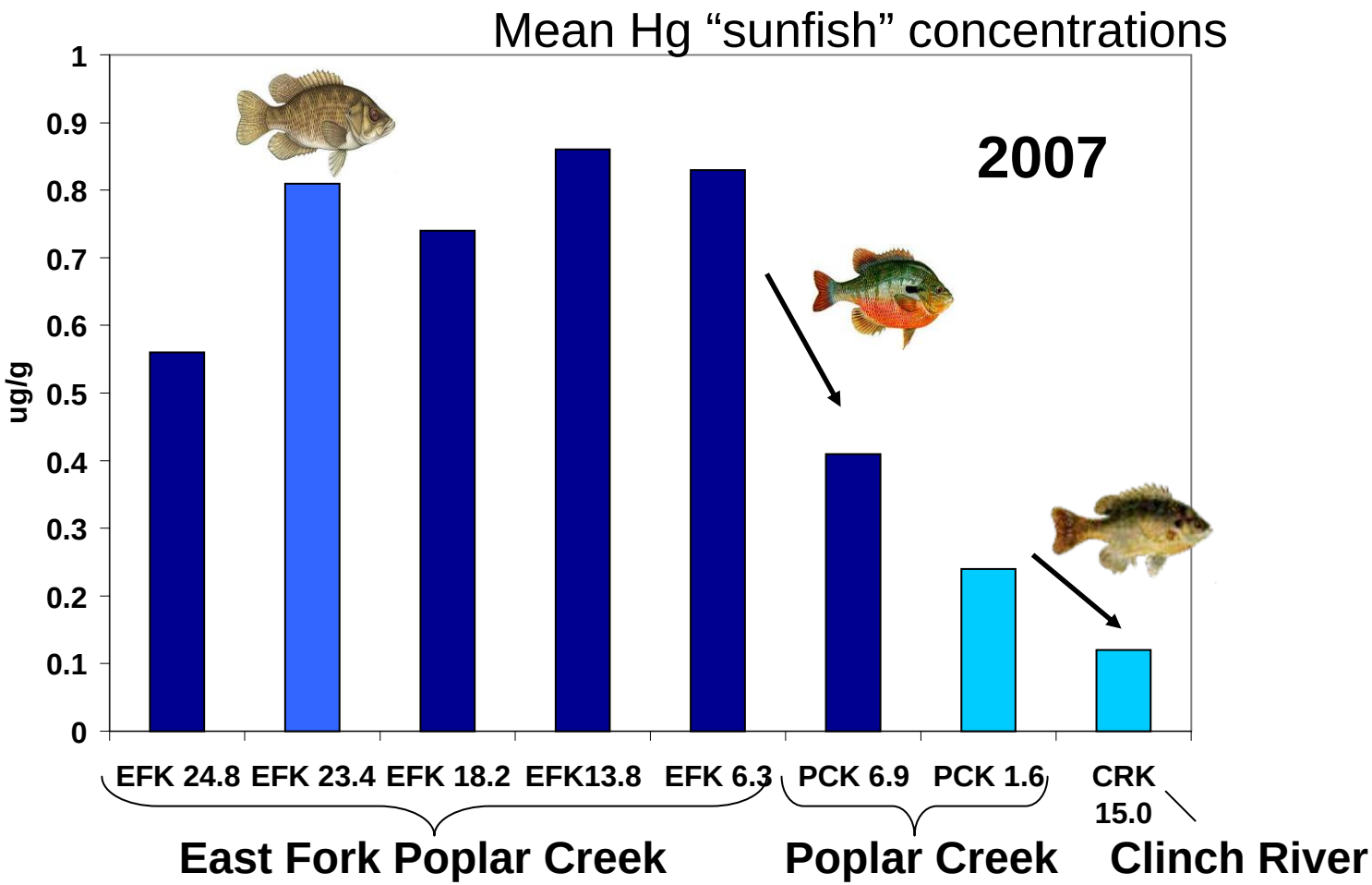
Spatial trends East Fork Poplar Creek, May 2009

-Rockbass all sites except EFK24.4 (Redbreast)

Mean Hg 2-6 fish/site

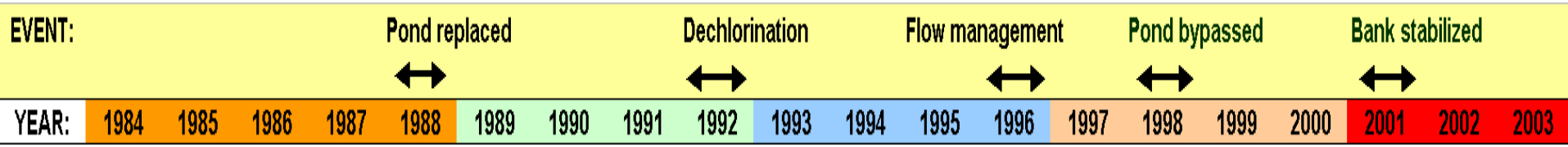


Decrease with distance downstream in Poplar Creek and the Clinch River



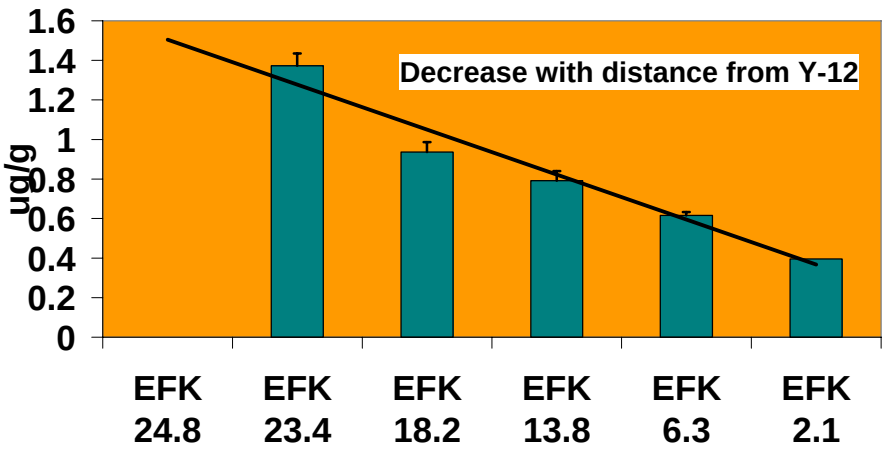
MERCURY TRENDING

(Average seasonal mercury concentrations in redbreast sunfish)

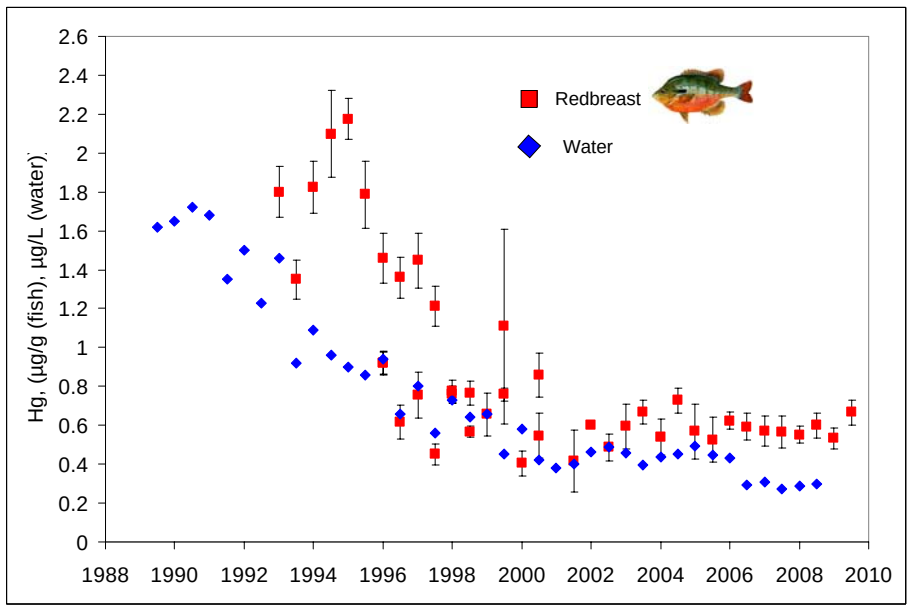


Early years

-Downstream decrease consistent with point source dilution



-Fish concentrations initially decreased commensurate with water at uppermost site (EFK 24.2)



Interim remediation goal: 200 ng/L; initially 0.5 ug/g in fish

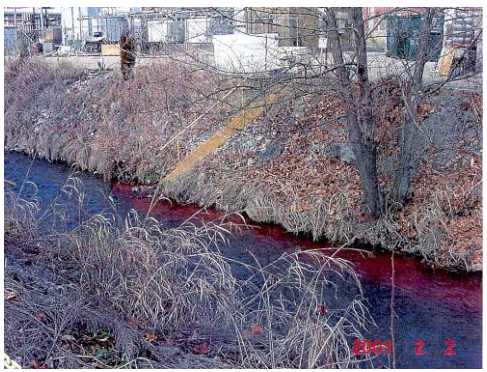
Y-12 Complex Remedial Actions and Abatement

- Sewer relining (1986-1987)
- Pipe rerouting (1993-1995)
- LEFPC floodplain soil removal (1996-1997)
- Bank stabilization (2001)
- Big Spring Water Treatment System (2005-2006)

Actions successful at decreasing Hg in UEFPC water, or removing soil Hg

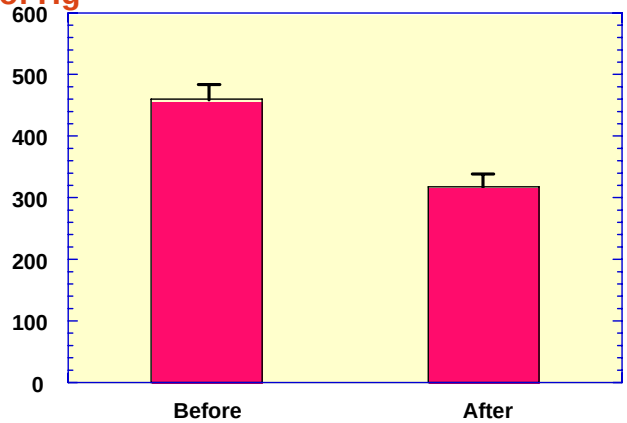
- Planned: soil capping, storm drain cleaning, sediment removal

Tracer dye emerges from spring

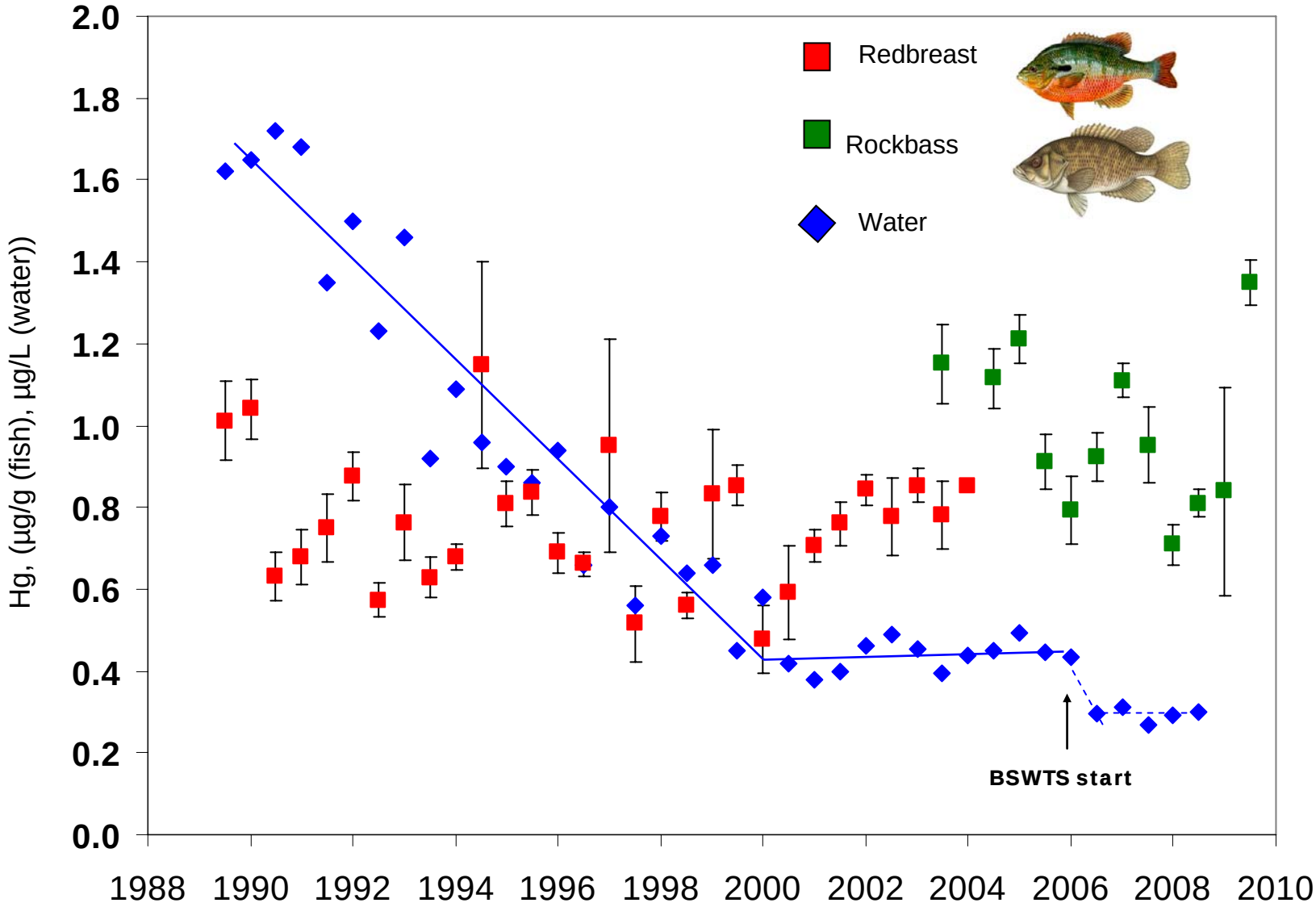


Activated charcoal treatment removes > 99% of Hg

BSWTS: 30% reduction in creek

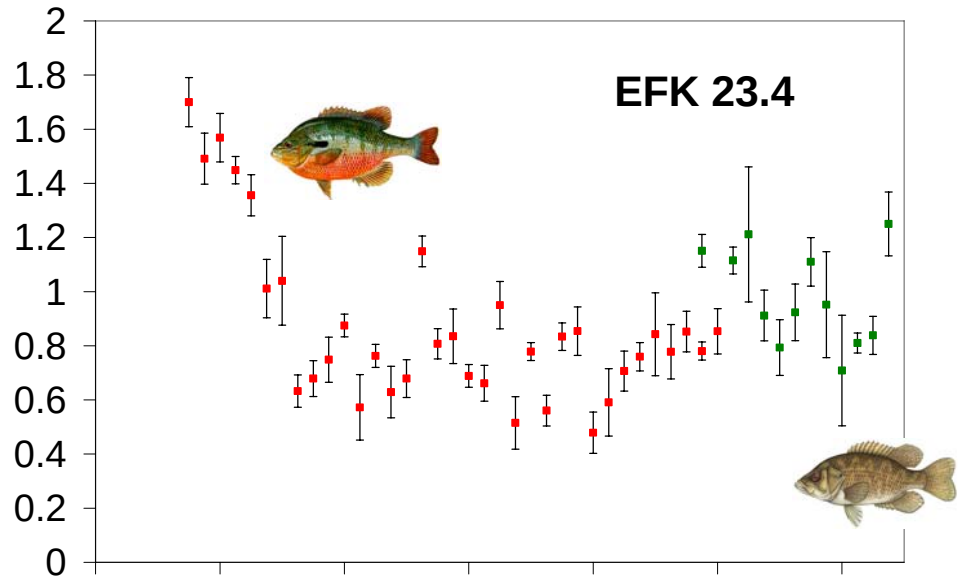


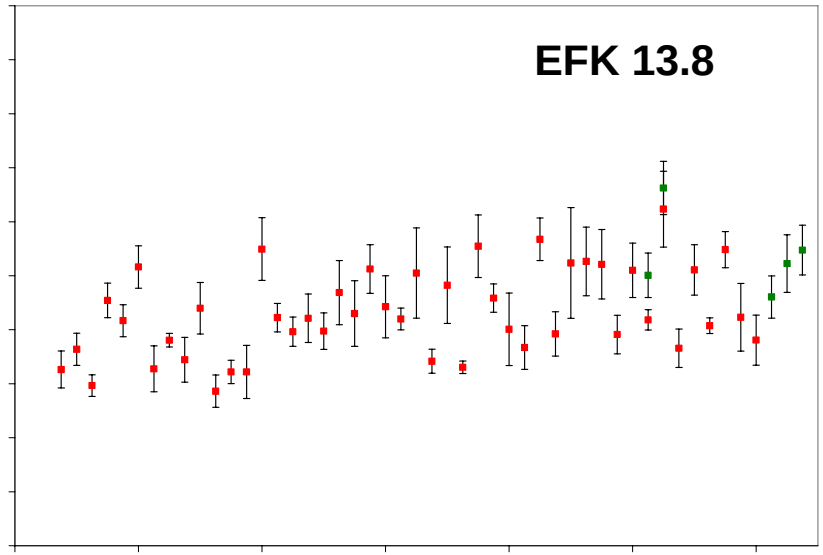
..but mercury concentrations in EFK 23.4 fish remain elevated

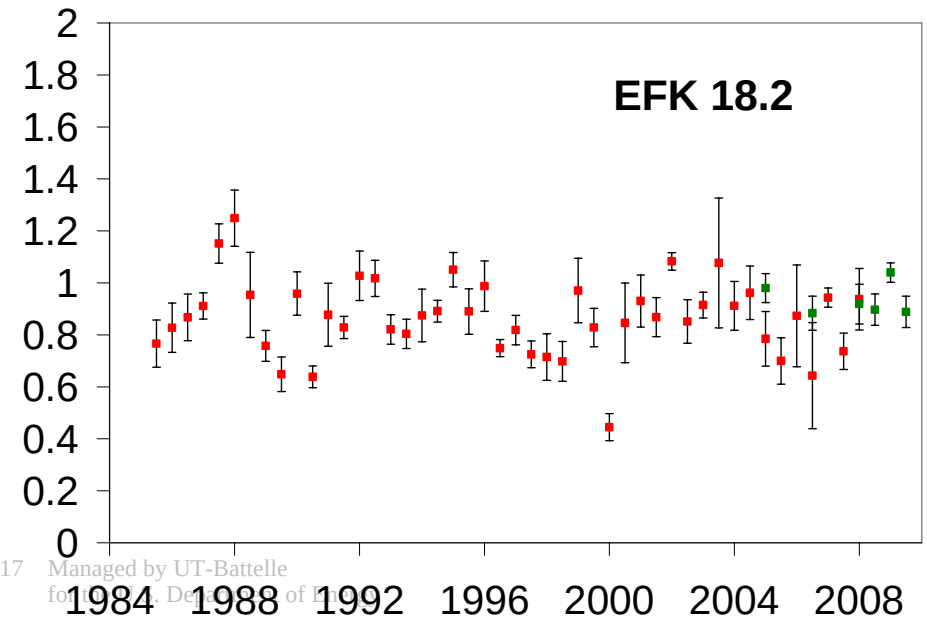


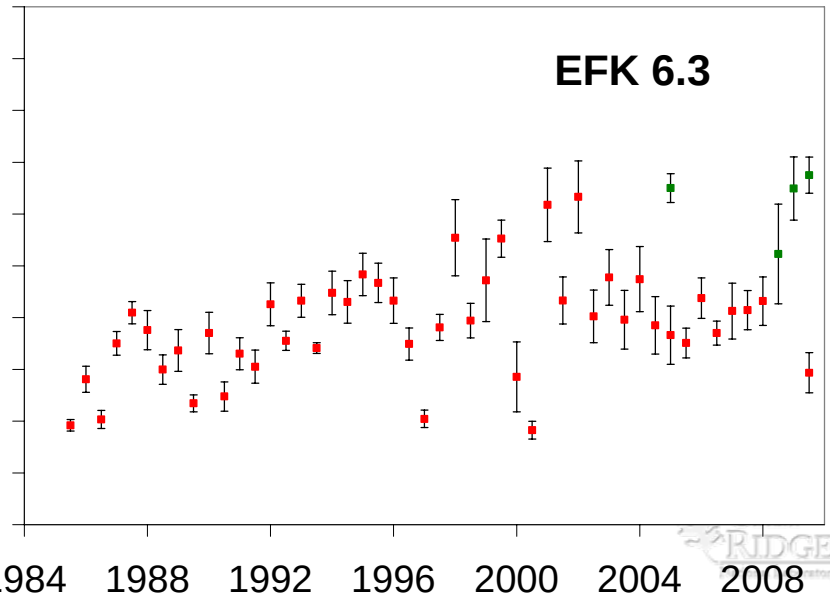
Mean of 6 fish/season
6-month average water concentrations

Temporal trends in East Fork Poplar Creek





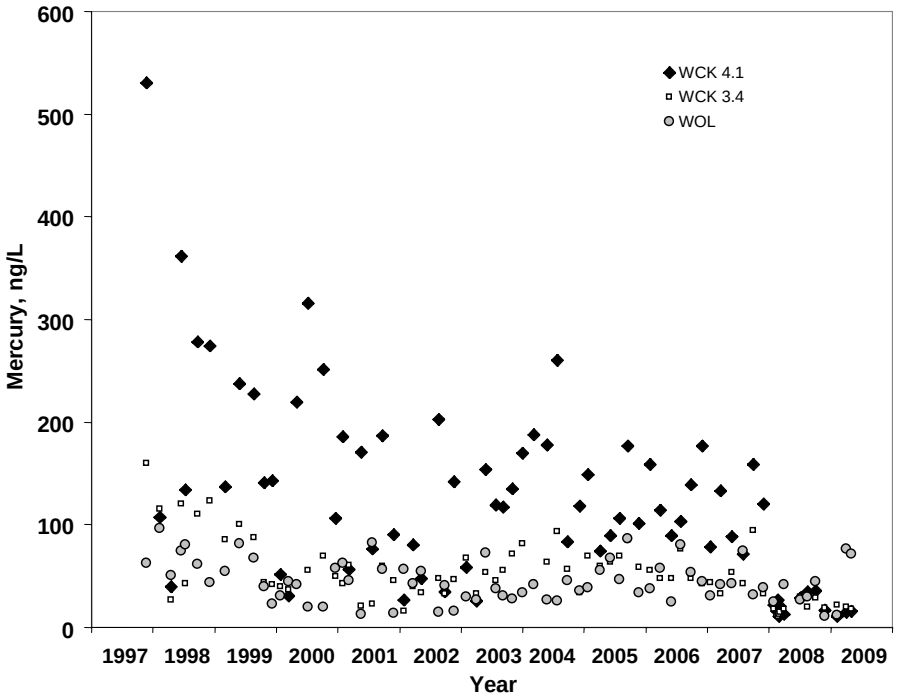




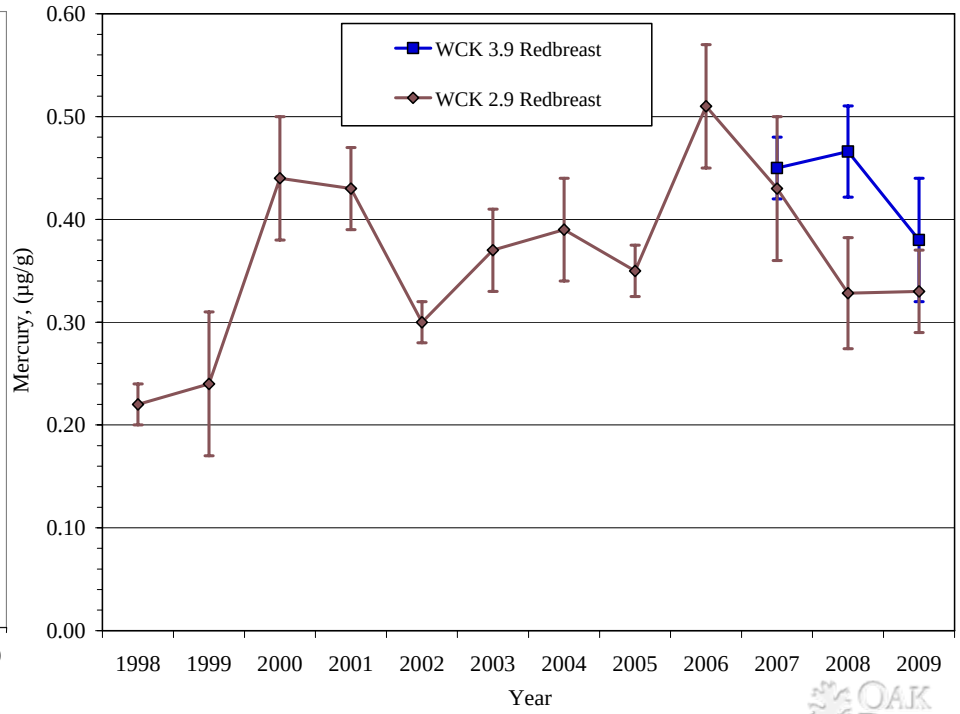
How low does total mercury in water need to go to achieve the 0.3 ug/g goal in fish?

White Oak Creek comparison

Three to five fold decrease in water, to ~ 20 ng/L



Mean concentrations of mercury in muscle tissue, remains 0.3-0.5 ug/g



DOE Programs Addressing Mercury Issues

- Clean Water Act (CWA) Compliance
  - BMAP fish monitoring
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
  - Water monitoring
  - Planned actions: soil capping, sediment removal
- Integrated Facilities Disposition Project (IFDP)
  - Recovery Act actions (scrapyard, storm drain repairs)
  - Decontamination and Decommissioning (D&D) of buildings
  - Soil remediation
- Groundwater and Soil Remediation Program (EM-22)
  - Applied Science: development of new technologies and strategies for mercury remediation
- ORNL Science Focus Area (SFA)
  - Basic Science: Mechanisms Controlling Contaminant Transformation in the Environment

For more information:

- ORNL: http://www.ornl.gov/
- Y-12 Complex: http://www.y12.doe.gov/
- ORNL Environmental Sciences Division: http://www.esd.ornl.gov/index.shtml
- BMAP: http://www.esd.ornl.gov/BMAP/
- Technical Reports at the DOE Information Bridge: http://www.osti.gov/bridge/
- Open literature publications
- My Contact Info: 865-576-3461; petersonmj@ornl.gov