Upper Mississippi River Water Quality Monitoring Network

Joel Allen[1], William Franz[1], David Hokanson[2], Sri Panguluri[3], John Carson[3]

1. USEPA

2. Upper Mississippi River Basin Association

3. Shaw E&I

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On-Line Toxicity Monitors and Watershed Early Warning Systems

- EWS conceptual framework
- Water Quality Monitoring Tools
- Implementation
- Questions

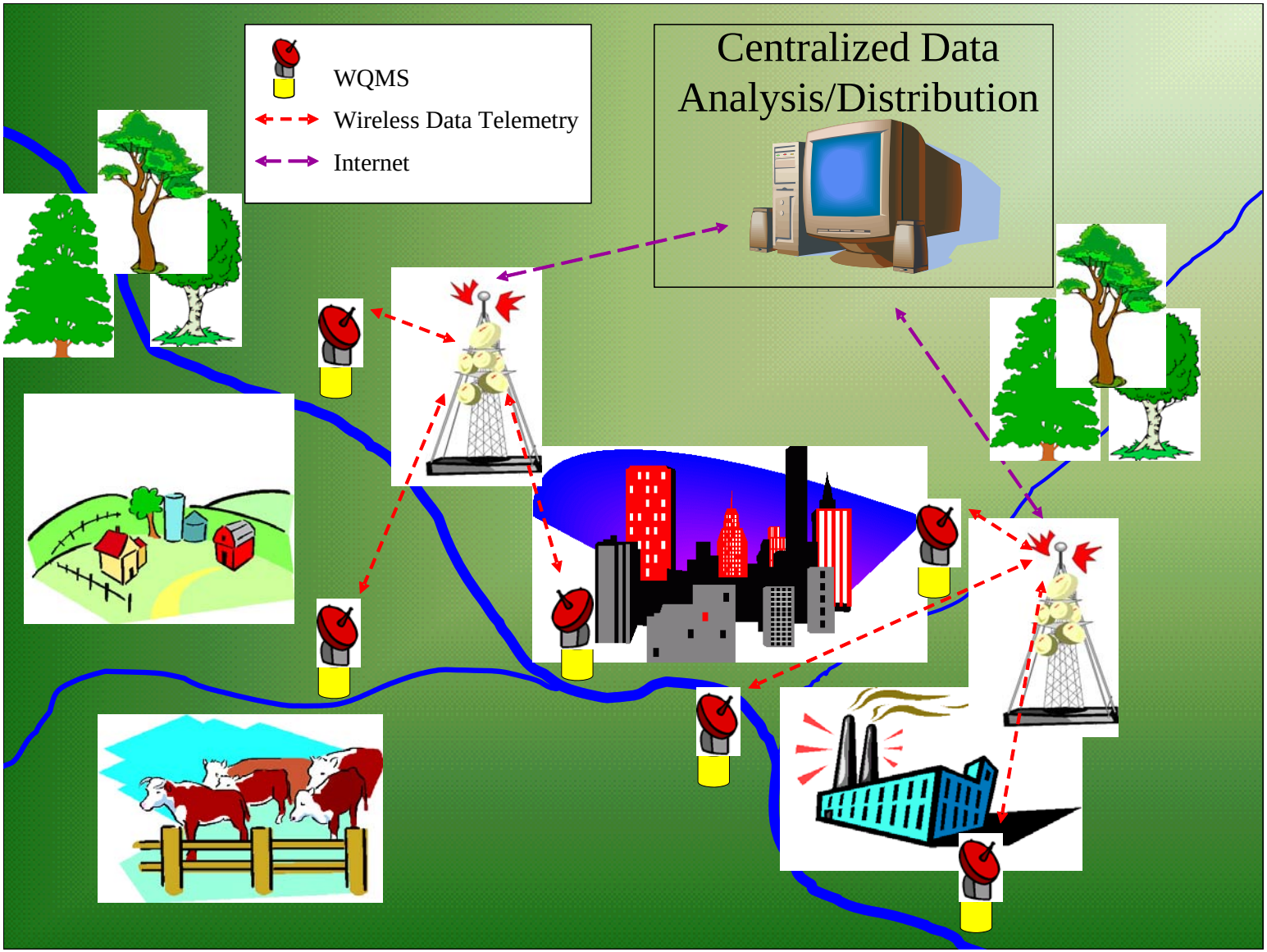
Brown's Island, Wierton, WV

Why Early Warning Systems?

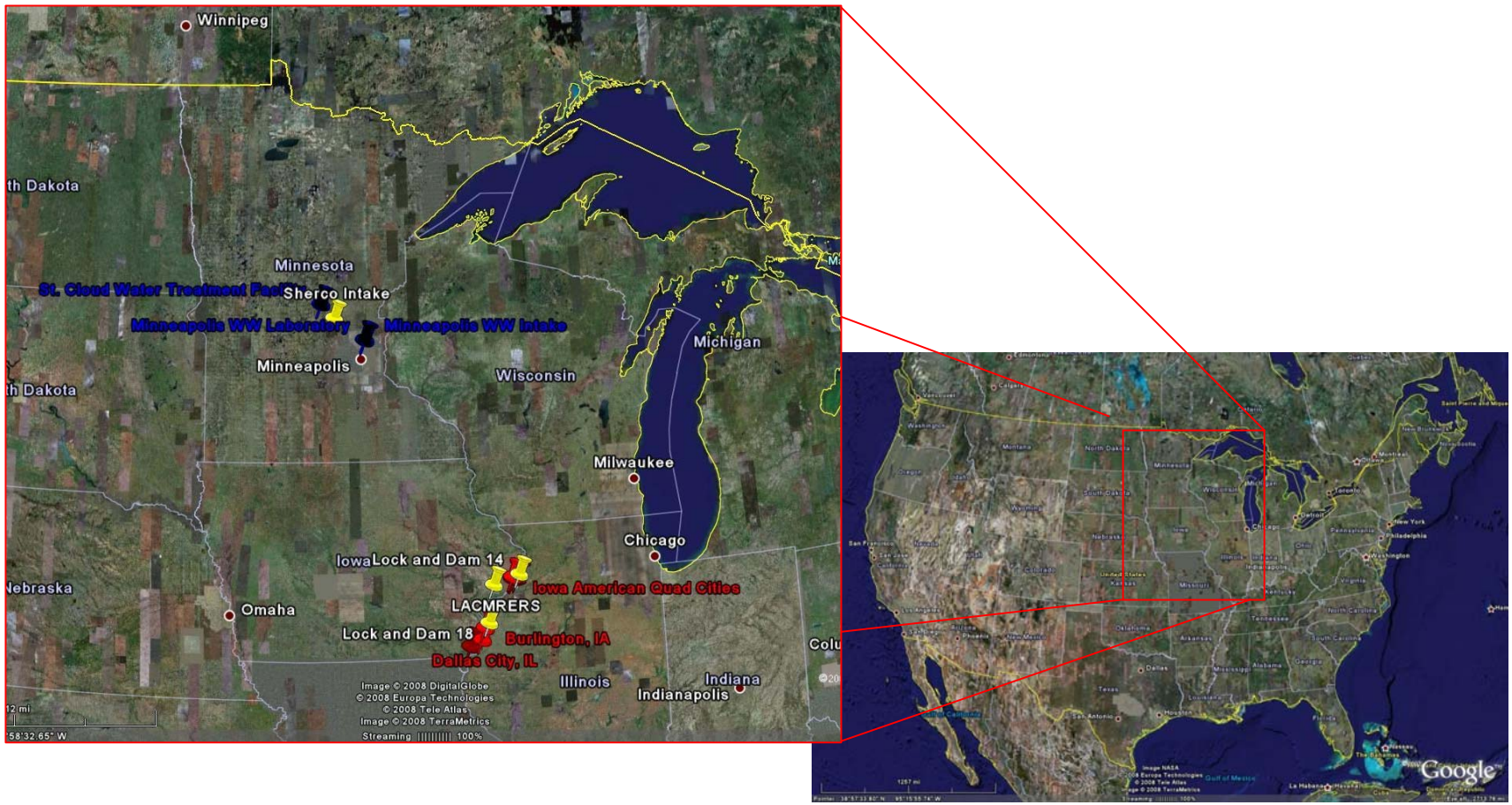
- Source Waters and Distribution Systems are vulnerable to unreported contamination events
  - River Meuse Hydraulic fluid leak 2004 (de Hoogh et al., 2006. Environ. Sci. Technol., 40 (8), 2678 -2685)
    - Utility closed intake
  - Lake Constance, Germany - intentional Atrazine contamination, 2005
    - Utility added a biomonitoring system
  - Ohio River Methylene Chloride contamination, July 2007
    - Utility added activated carbon filtration
- Early detection of episodic contamination
  - early responses by water utilities and regulatory/response agencies
  - minimize potential impacts and associated costs to the water supply, citizens, and industry that utilize the river

Early Warning System Paradigm

- This EWS paradigm serves as a model for the site specific implementation of EWSs in source waters and distribution systems
  - Water quality monitoring tools
  - Data telemetry
  - Data analysis
  - Information distribution to decision makers
  - Response framework
- Multiple Benefits
  - Source Water
    - Quality
    - Ecological Status
    - TMDL
    - Drinking Water Process Control
  - Distribution System
    - Water Quality Monitoring
    - Water Security


WQMS
Wireless Data Telemetry
Internet
Centralized Data Analysis/Distribution

Upper Mississippi River Early Warning Network

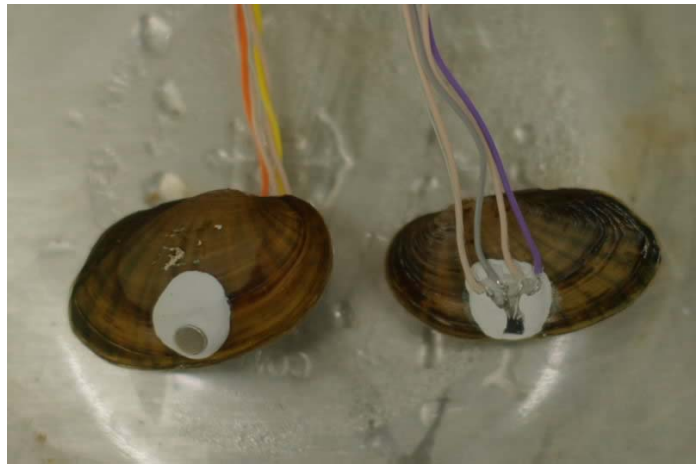


Implementation *Collaboration!!!*

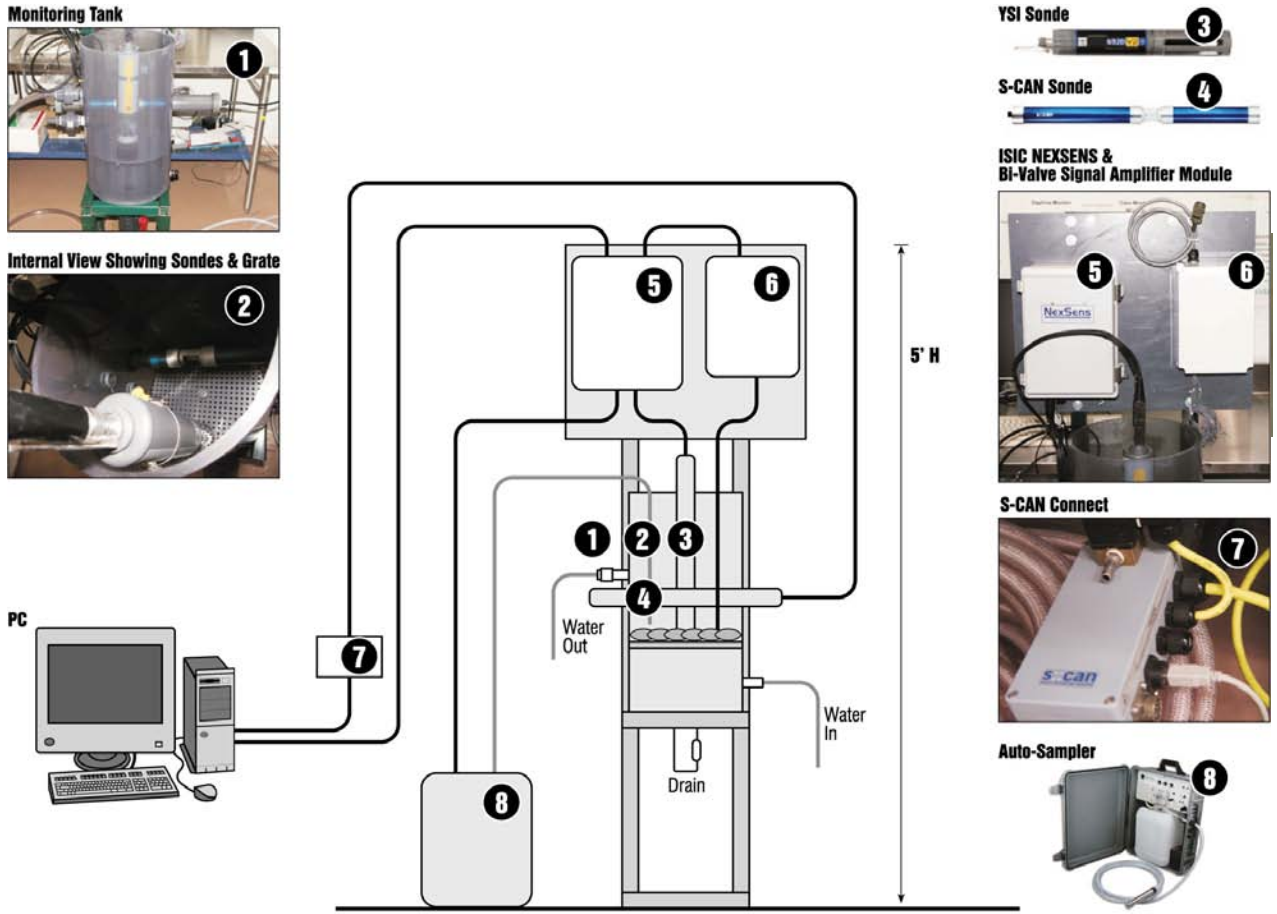
- Upper Mississippi River Early Warning Network
  - Federal
    - U.S. EPA ORD & Region 5
  - State
    - MN Pollution Control Agency
    - MN Dept. of Nat. Res.
    - Iowa Dept. of Nat. Res.
  - Regional
    - Upper Miss. River Basin Assoc
  - Utilities
    - Minneapolis Water Works
    - St. Cloud, MN Water Works
    - Moline, Il Water Works
    - American Water
    - Xcel Energy
  - Universities
    - St. Cloud State University
    - University of MN
    - University of Iowa
- East Fork of the Little Miami River
  - Federal
    - U.S. EPA ORD
  - Local
    - Clermont County
  - Utilities
    - Morehead, KY Water Utility
  - Universities
    - Thomas More College
    - Morehead University

Water Quality Monitoring Tools

- On-line Toxicity Monitors
  - Bivalve Gape
  - Bacteria Luminescence
  - Fish Behavior/Mortality
- Physical/Chemical Sensors
  - Multiparameter Sonde
  - UV/Vis Spectrometer

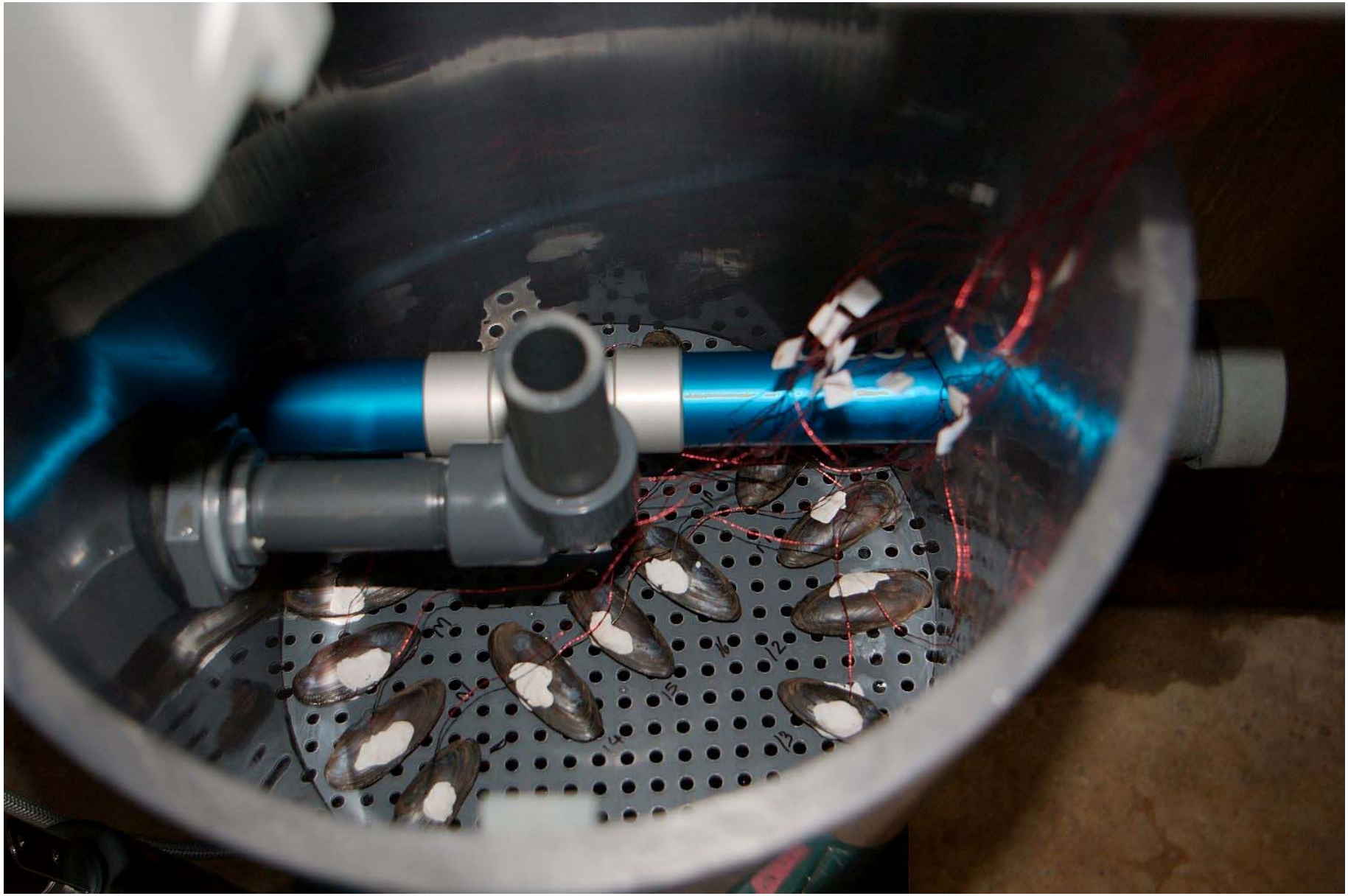


Water Quality Monitoring Tools

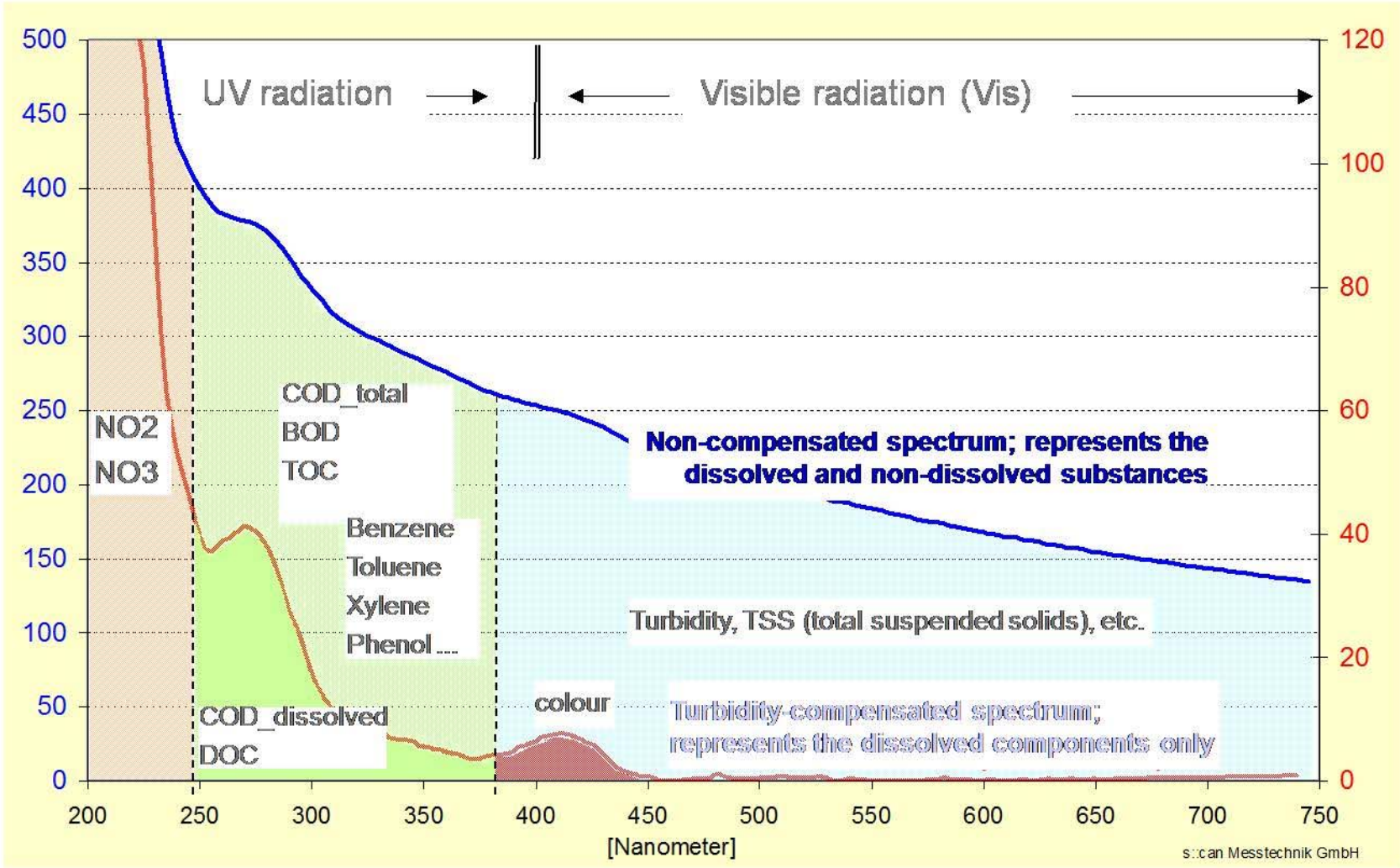


Online Toxicity Monitoring Station Schematic

Field Sites

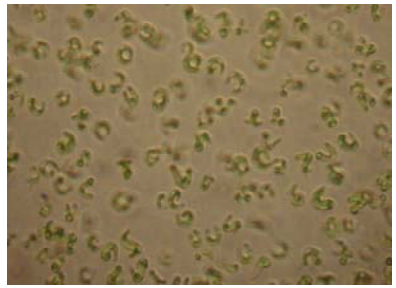


S-CAN Spectrolyzer

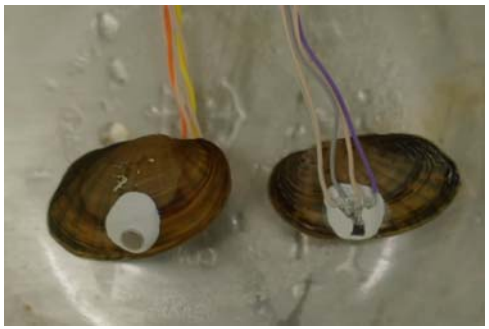


On-line Toxicity Monitor (OTM) Research

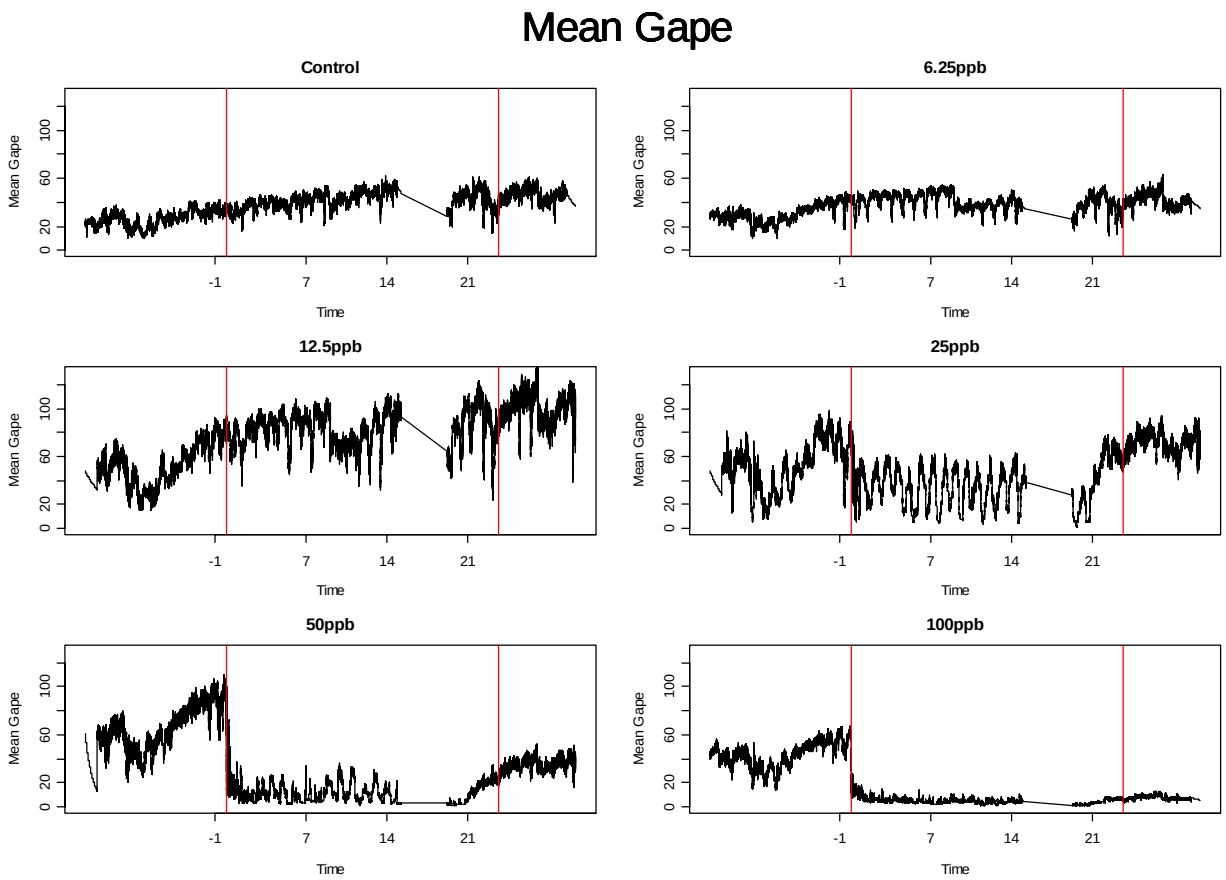
- “Canary in the Coal mine”
- There is no machine or analytical approach to measure toxicity
- Only an organism in its own environment can integrate all factors that contribute to stress
- Continuous, Time-Relevant monitoring



Bivalve On-line Toxicity Monitor



- Based on bivalve gape behavior
- Continuous flow-through design
- Long-Term deployments of up to 1 year or longer
- Minimal maintenance requirements
- Not species specific



Experimental *Corbicula fluminea* Copper Exposures

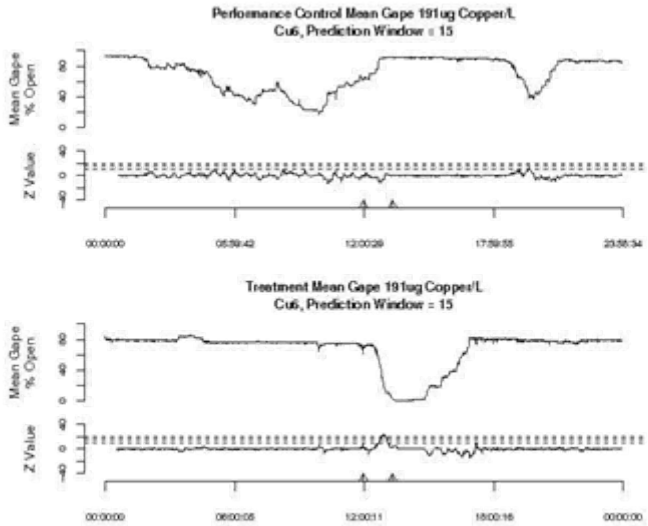
Data Telemetry

- Data communication must be time-relevant
- Bidirectional
  - Data from remote system to server
  - Trigger from server to remote system
- Internet, SCADA, or satellite

Minneapolis Water Works Installation

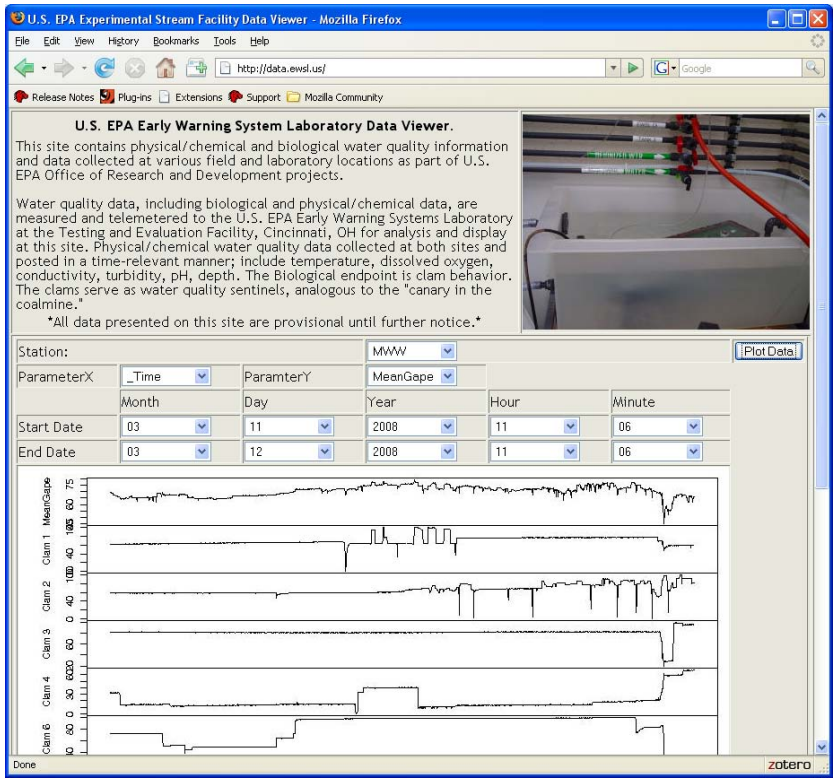
Data Analysis

- Analysis of trends must be appropriate to the nature of the data.
  - Time Series Analysis accounts for temporal dependence
  - Each site should act as its own control using a time-series approach to examine changes in the observed data
- The spatial component of data collected throughout a network is critical
- Seasonal trends can present difficulties in data interpretation
- Alarm criteria should include changes in individual water quality parameters as well as more complex correlated changes in multiple parameters



Information Distribution

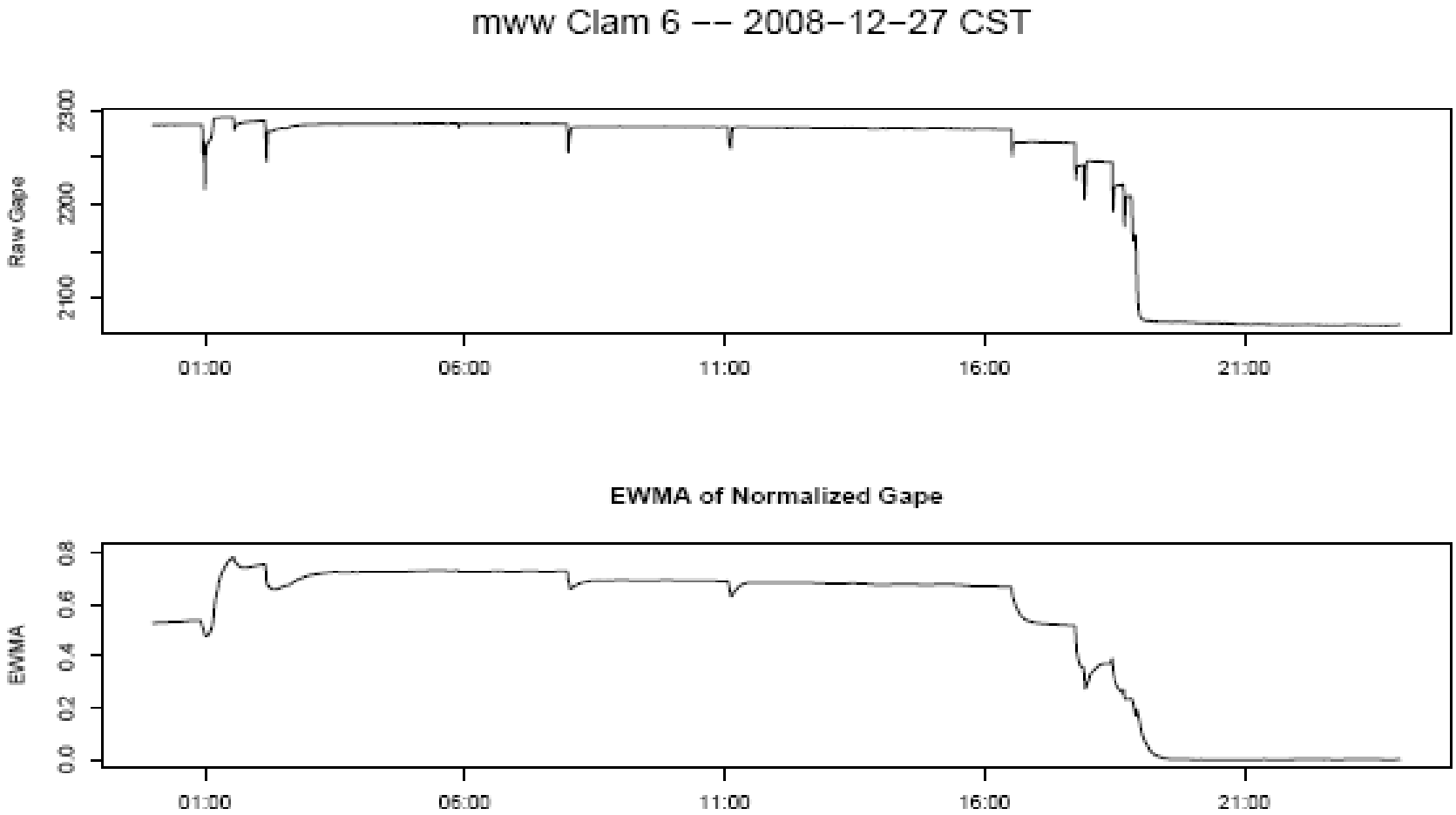
- System managers and decision makers need quality information as it is collected to make informed decisions
- Information must be packaged in a manner to concisely convey observed conditions requiring minimal interpretation
  - Web based data exploration tools
  - Email alerts



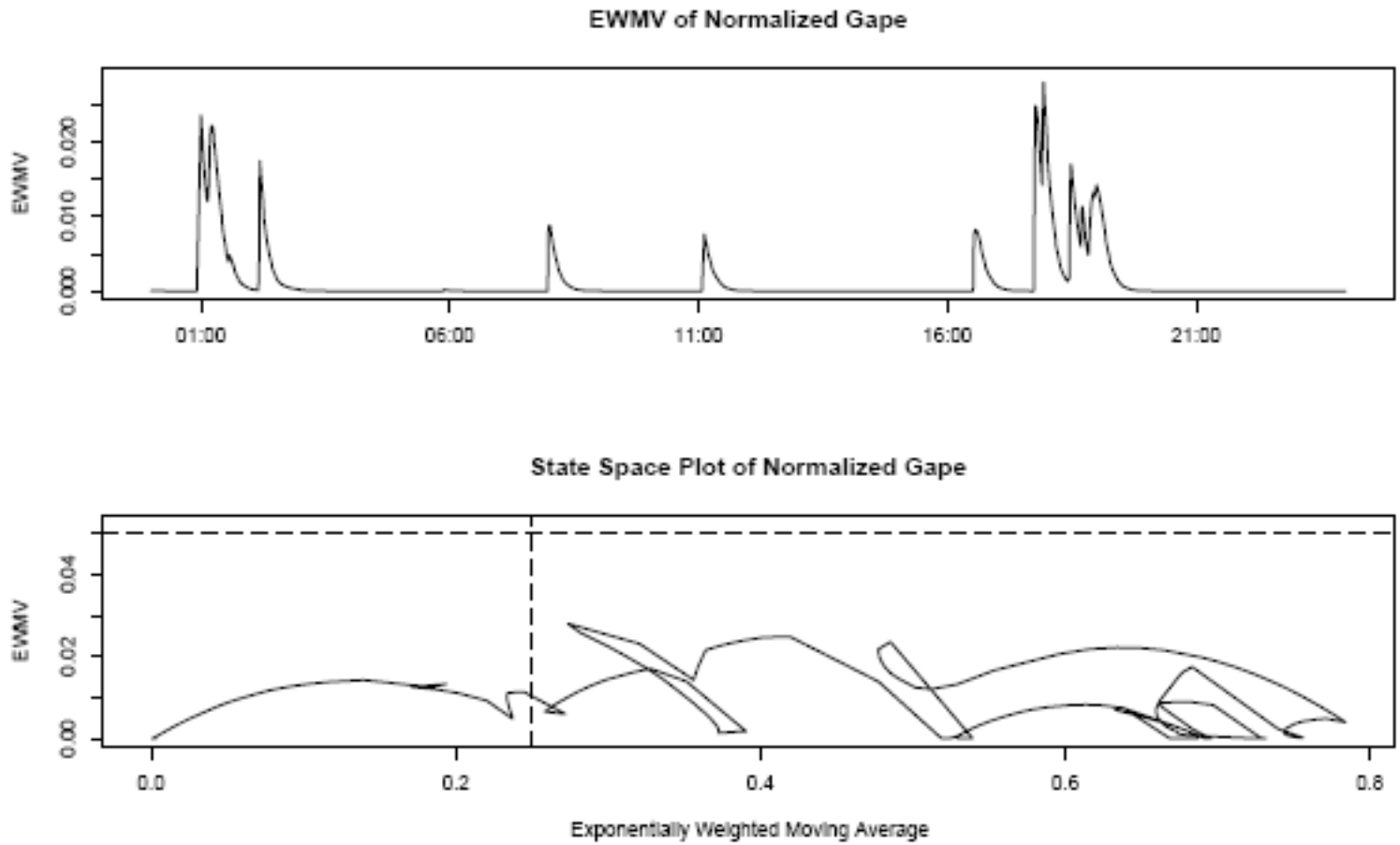
Example Data Overview

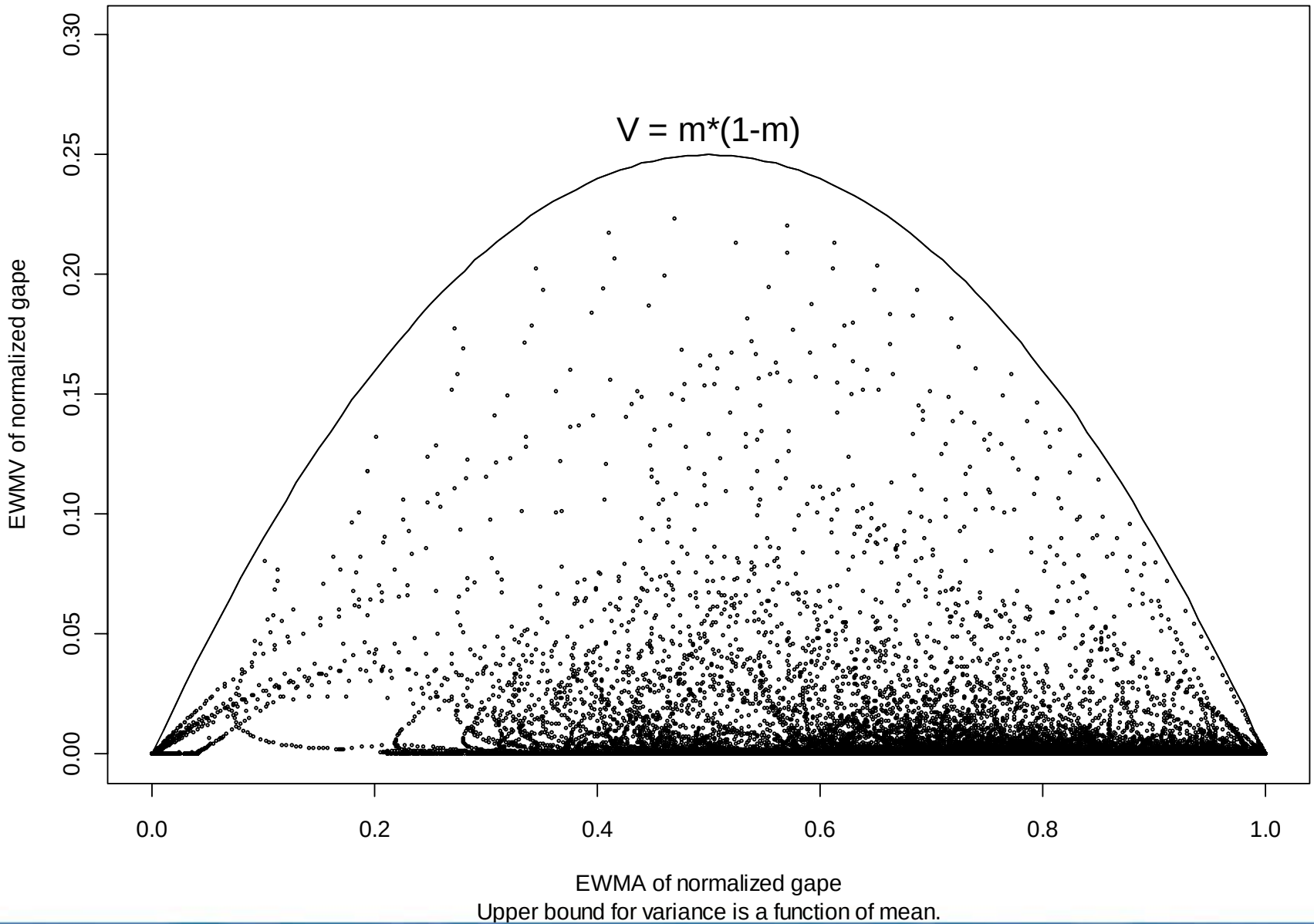
- Raw clam gape data is read and stored
- Seven day rolling min and max are used to normalize raw data to the interval [0,1]
- EWMA/EWMV are calculated to detect gape closing events (GCE)
- Large fraction of clams simultaneously in GCE state and length of time in state indicate possible ongoing toxic exposure

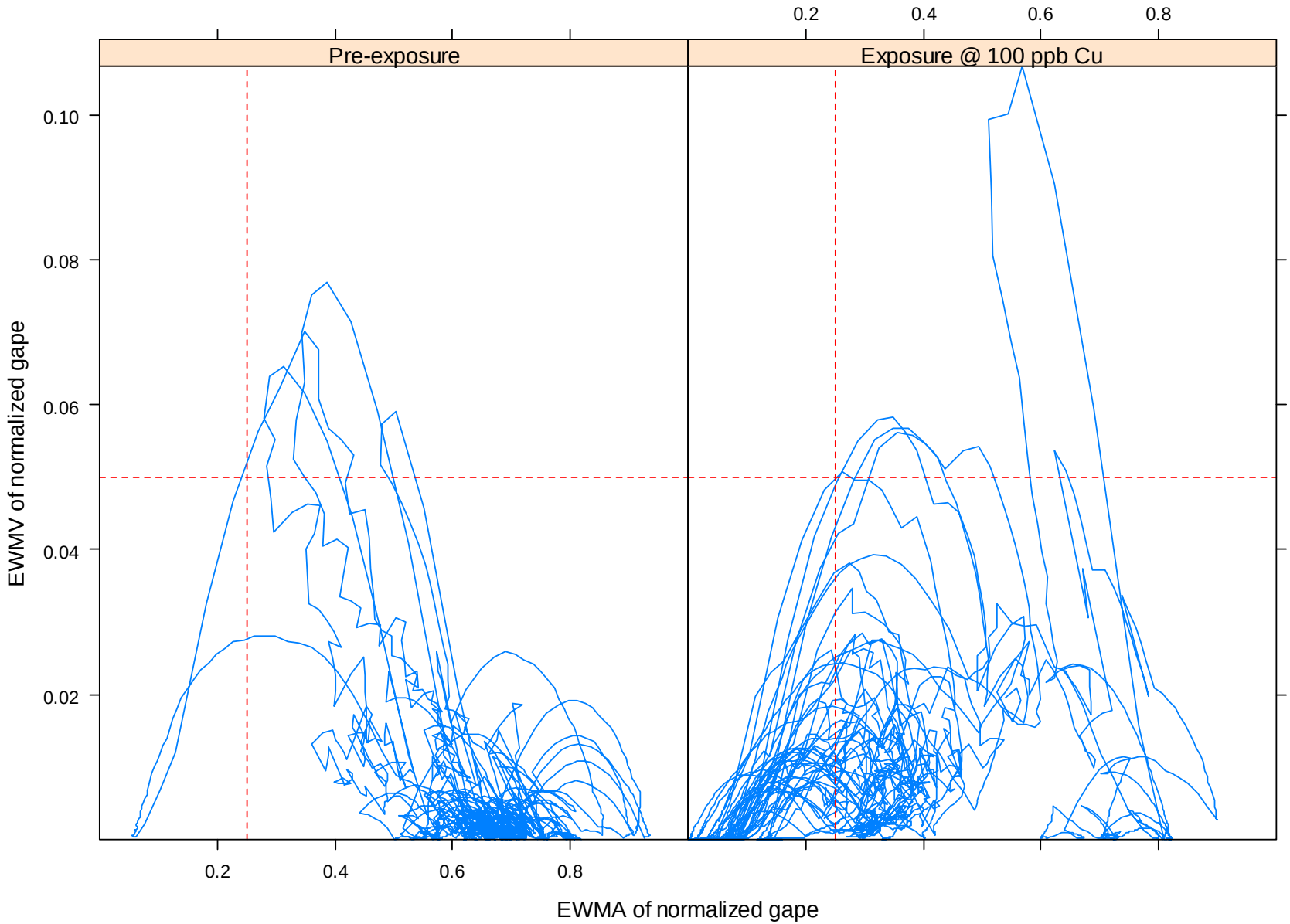
Example: MWW Clam 6

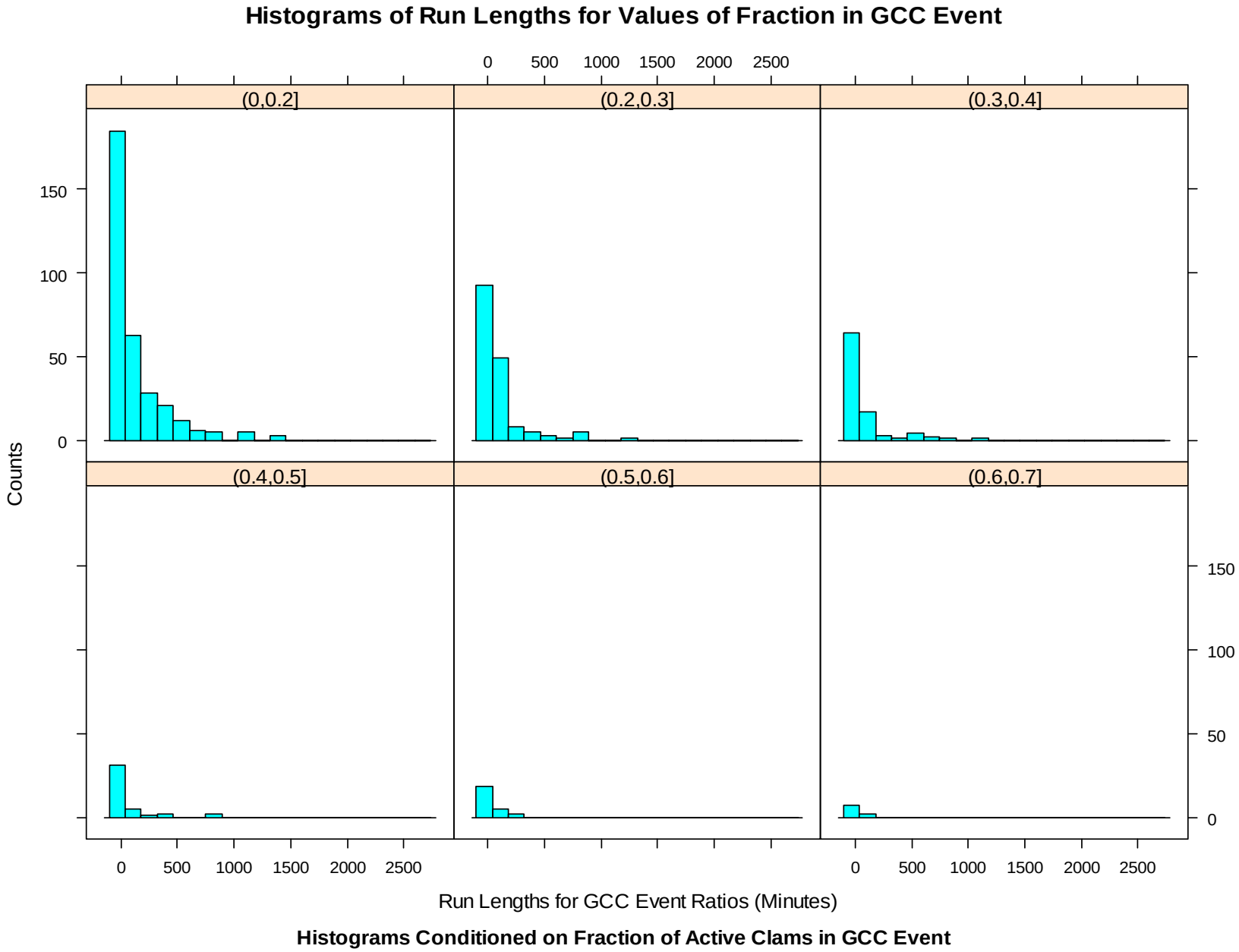


Example: MWW Clam 6

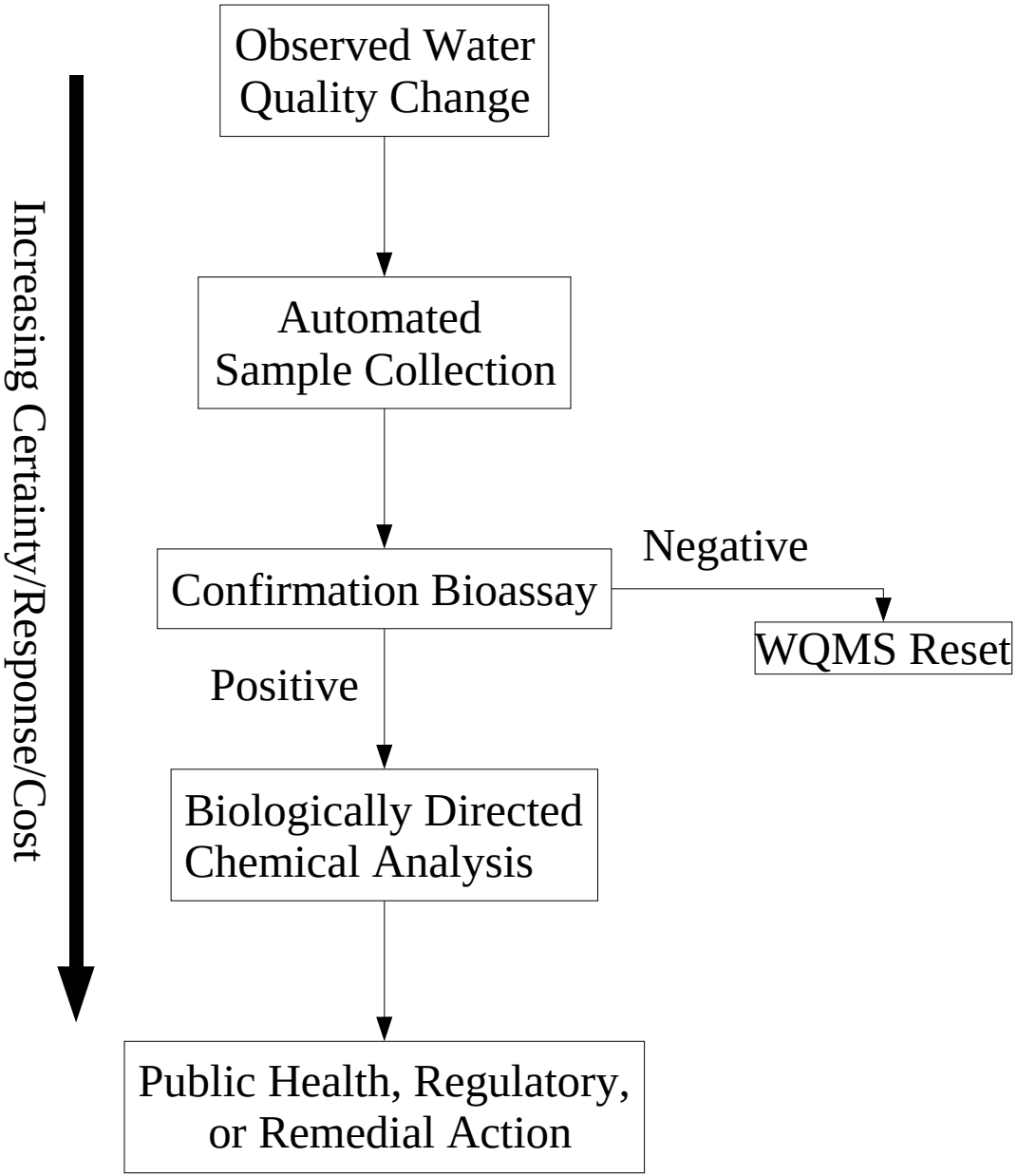



EWMV vs. EWMA for MWW Data
V = m*(1-m)
EWMV of normalized gape
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.0
0.2
0.4
0.6
0.8
1.0
EWMA of normalized gape
Upper bound for variance is a function of mean.


ESF-6 Clam1 EWMA/EWMV Plot by Exposure Status
Pre-exposure
Exposure @ 100 ppb Cu
EWMV of normalized gape
EWMA of normalized gape
0.02
0.04
0.06
0.08
0.10
0.2
0.4
0.6
0.8


Histograms of Run Lengths for Values of Fraction in GCC Event
(0,0.2]
(0.2,0.3]
(0.3,0.4]
(0.4,0.5]
(0.5,0.6]
(0.6,0.7]
Counts
0
50
100
150
0
500
1000
1500
2000
2500
Run Lengths for GCC Event Ratios (Minutes)
Histograms Conditioned on Fraction of Active Clams in GCC Event

Tiered Response Model



Future Work

- Deployment of Algorithm
- Data sharing agreement
- Database replication
- Site upstream of Quad Cities at Mid American Energy Plant
- Site at National Great Rivers Research and Education Center, Alton IL
- Rapid TIE Methodology

Contact Information

Joel Allen
USEPA/ORD/NRMRL
26 W. MLK Drive
Cincinnati, OH 45268
allen.joel@epa.gov
513-487-2806