Addressing Uncertainty and Managing Risk at Contaminated Sediment Sites

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- Sue Vasich, HMSC LLP
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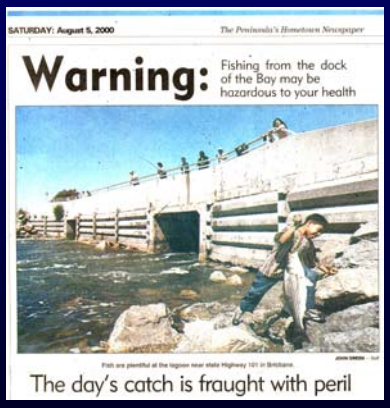
Our History

- Sediment Stability Workshop
  - 22-24 January, 2002
  - New Orleans, LA
- Environmental Stability of Chemicals in Sediments
  - 8-10 April, 2003
  - San Diego, CA
- Addressing Uncertainty and Managing Risk at Contaminated Sediment Sites
  - 26-28 October, 2004
  - St. Louis, MO

Scope of the Sediment "Problem"

- EPA 1997 sediment survey report concludes 1.2 billion yd^3 surficial sediment "pose potential risks"
- Cleanup programs
  - ~350 sediment sites in Superfund
    - ~ 30 megasites (> $50M)
- TMDL program includes numerous sediment issues
- Navigation dredging



Superfund Sediment "Megasites"

- Hudson River, NY - $460 M
- New Bedford Harbor, MA - $361 M
- Bayou Bonfouca, LA - $90 M
- Marathon Battery, NY - $84 M
- Triana/Tennessee River, AL - $80 M
- Fox River, WI - $361 M
- Silver Bow Creek, MT - $97 M
- Commencement Bay, WA – $197 M
- Bunker Hill (Coeur d'Alene Basin)
- Housatonic, MA
- Others expected

Sediment Management Costs

Management Alternative	$/yd^3
Aquatic Disposal	5
Contained Aquatic Disposal	< 20
Confined Disposal Facility	15-50
Geotextile containers	+ 50
Landfill Disposal	
Non-Hazardous	20-24
Hazardous	120
Thermal Destruction	500-1,350

Source: National Research Council, 1997
Committee on Contaminated Marine Sediments

Stakeholder Interests are Diverse

- The stakeholder community for a sediment site can be very large and diverse
  - Federal, state, tribes and local government
  - Local residents
  - Responsible parties
  - Environmental groups
  - Meddlers
  - Etc.
- How do we structure stakeholder interactions in order to make more informed, credible, and defensible decisions?

Sediment Sites are Challenging

- **Sediments are part of a complex, dynamic system**
  - **Water and sediment move**
  - **Gradients are steep**
  - **Species are highly mobile**
  - **Food webs can be complex**

Assessment → **Management**

Risk → **Risk**

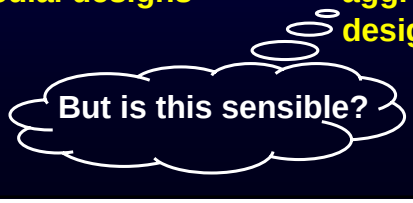
Uncertainty → **Uncertainty**

Risk

- Prediction about an adverse outcome
- Can be reduced, but not eliminated
- Larger risks motivate more aggressive remedial designs

Uncertainty

- Lack of confidence in a prediction
- Can be reduced, but not eliminated
- Larger uncertainties motivate more aggressive remedial designs



Uncertainty Defined

- Uncertainty due to incertitude
  - Can collect more data/information
- Uncertainty due to variability
  - Known population heterogeneity
  - Cannot be reduced only better understood
- The distinction is important

> "Teach yourself to work in uncertainty"
> Bernard Malamud

Sources of Uncertainty

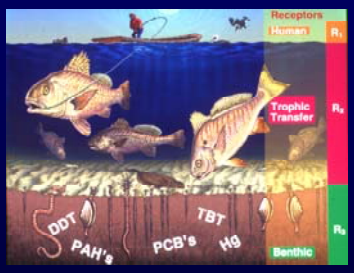
- **Scenario**
  - Missing components in the CSM
  - e.g., failure to consider dredging residuals as a source of exposure
- **Model**
  - Structure and assumptions differ among models
  - e.g., using a BSAF model to capture influence of small site on highly mobile and migratory fish
- **Parameter**
  - Specification of model parameters
  - e.g., TRV, BSAF, K_{ow} for total PCBs

Scales and Complexity

- Laboratory analysis of chemistry, toxicity, and bioavailability provide reproducible, predictable results
- The challenge is in defining the meaning of those results with respect to the system of concern
- Uncertainty inherent in this process

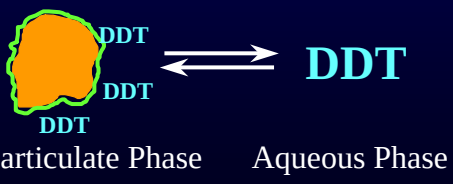
Problem Formulation

- **Conceptual models missing pathways and/or receptors**
- **Missing assessment endpoints**
- **Interaction with non-chemical stressors**
- **Stakeholder involvement**



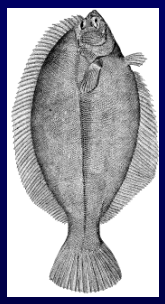
Exposure Assessment

- **Spatial and temporal elements**
  - **Dynamic system**
  - **Consideration of time and space for mobile species**
  - **Spatial heterogeneity**
  - **Bioavailability processes**



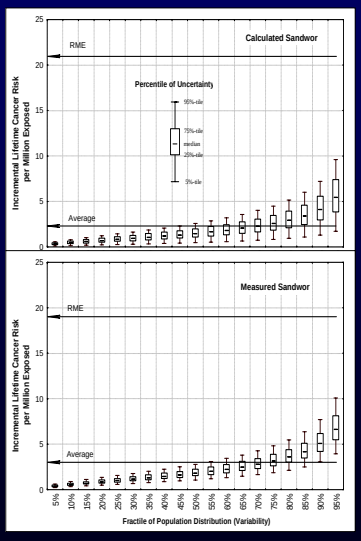
Effects Assessment

- Extrapolation
  - Benthos vs. other receptors
- Use of lab vs. field replicates
  - Conceals variability
- Toxicological mixtures
- Ecological relevance of effect
  - Differing thresholds for abundant, rapidly reproducing species versus less abundant, slowly reproducing species?



Risk Characterization

- Uncertainties emphasize need to describe range of outcomes
  - What fractile of the population are we protecting? (variability)
  - How confident can we be in our decision? (uncertainty around the variability)
  - Is 113 ppb scientifically defensible considering uncertainty?
- Risk aversion vs. uncertainty aversion

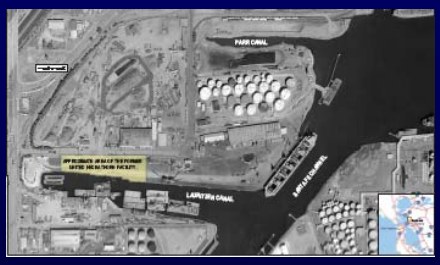


Risk Management

- Navigation vs. Cleanup
  - Do the sediments have to go?
- *In situ* alternatives
  - Monitored Natural Recovery (MNR)
  - Capping
  - Treatment
- *Ex situ* alternatives
  - Dredging/Excavation
    - Containment
    - Treatment
- How do you compare the risks / uncertainties for each and reach defensible decisions?

Key Risk Management Questions

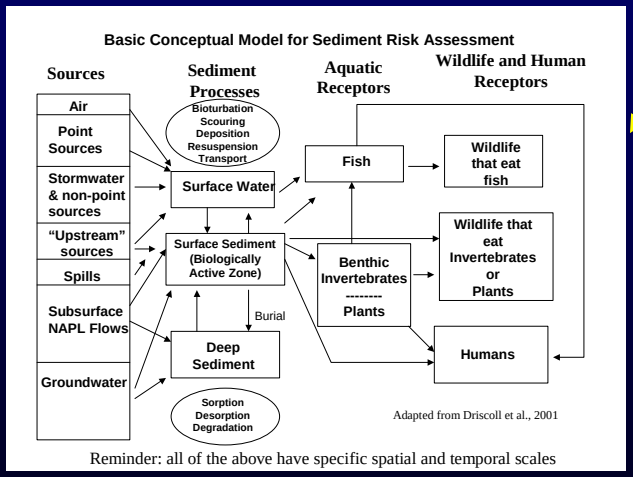
- Can we achieve low cleanup levels with dredging?
- What is the probability of unacceptable, future exposure at a capped site?
- What are the likely rates of "recovery" for a MNR option, i.e., what is the probable trajectory for exposures and risks through time?



Rules for Managing Uncertainty

- Uncertainty must be managed throughout assessment and management
- Think ahead
  - What questions will I want answers to when deciding among management options
- Model early
  - Models are a fact of life in sediment assessment
  - Use them early to define data needs
  - Use them often to refine the assessment, e.g., sensitivity analysis

Managing uncertainty starts here...

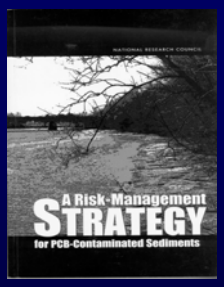


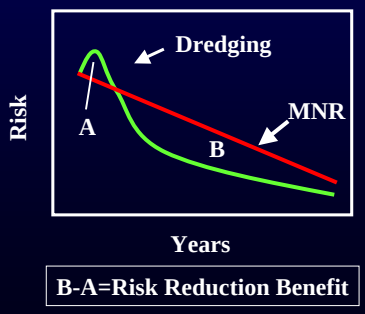
Reminder: all of the above have specific spatial and temporal scales

What questions must be answered to select the best management option(s)?

The Mysteries of Remedial Decision Making

- **Value of comparative approaches, e.g., NAS report**
- **Risks and uncertainties exist for each management alternative**
  - **There is no zero-risk option**
  - **More complex remedial designs = larger pool of uncertainty**
- **We need rigorous methods!**





B-A=Risk Reduction Benefit

Evaluation and Selection of Management Alternatives

Identify feasible/available management alternatives

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Evaluate and compare risks associated with the alternatives

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Evaluate and compare costs of the alternatives

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Develop management strategy

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Develop logic to apportion sediment among selected alternatives

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Develop monitoring plan

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Execute monitoring of management alternative performance

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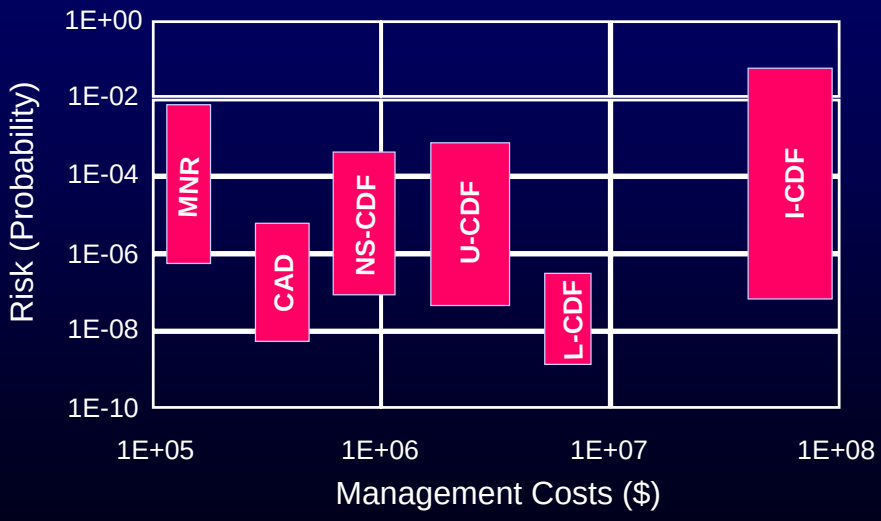
Provide feedback for ensuring performance of management alternatives and the assessment/management process

Following Bridges et al., in press

Risk-Based Decision Making

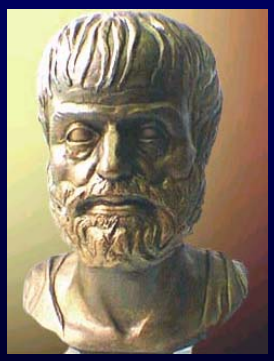


Conference Structure

- **Panels**
  - **Day 1**
    - **An Overview of Remedial Activities**
    - **Setting the Stage for Effective Management Decisions**
  - **Day 2**
    - **Processes of Relevance to Selecting Remedies**
    - **Understanding and Managing Uncertainty in Assessment and Management**
  - **Day 3**
    - **Comparison-Based Decision Making**
    - **Summary and Synthesis**
    - **Wrap Up**

Timeless Truth of Risk Assessment and Management

"It is the mark of an instructed mind to rest satisfied with the degree of precision which the nature of the subject permits and not to seek an exactness where only an approximation of the truth is possible."



Aristotle (384-322 B.C.)