ECHA Topical Scientific Workshop on Risk Assessment for the Sediment Compartment
7-8 May 2013, ECHA, Helsinki, Finland

Sediment Ecological Risk Assessment

U.S. Environmental Protection Agency Status

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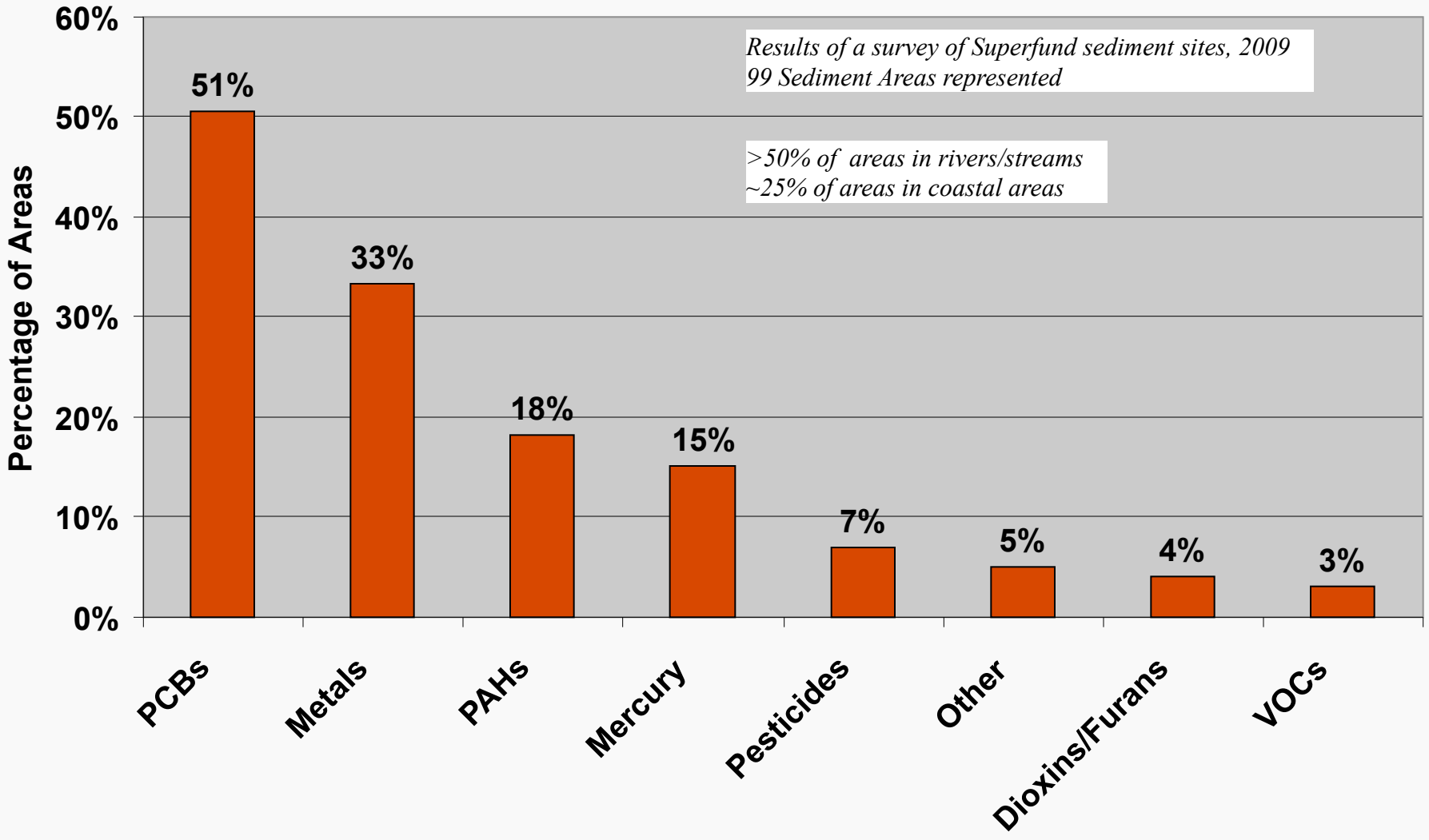
What is Superfund?

- **Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).**
- **Statute charges EPA to protect human health, welfare, and the environment by reducing risks to acceptable levels**
- **Remedial Process (RI/FS):**
  - Remedial Investigation: **Risk Assessments,** Nature & Extent
  - Feasibility Study: Screening of Alternatives
  - Record of Decision

Contaminated Sediment Sites—
Risk Drivers



11 Sediment Management Principles
OSWER Directive 9285.6-08, Feb 2002

Technical

- Control sources early
- Conceptual site model that considers sediment stability.
- Iterative approach in a risk-based framework.
- Evaluate assumptions and uncertainties of data and models
- Select remedy approaches that will achieve risk-based goals.
- Tie sediment cleanup levels to risk management goals
- Design remedies to minimize short-term risks.
- Monitor to assess and document remedy Effectiveness

Process Oriented

- Involve the community early and often.
- Coordinate with states, local governments, tribes, and Trustees.
- Maximize the effectiveness of Institutional Controls; recognize limitations.

EPA 2005 Contaminated Sediment Remediation Guidance

- **Toxicity tests typically provide an integrated measurement of the cumulative effects of all contaminants.**
- **For toxicity tests to be useful, it is important to have demonstrated a concentration-response relationship.**
- **However, no single endpoint can quantify all possible risks**
  - combination of physical, chemical, and biological endpoints usually provides best overall approach for measuring risk reduction and assessing the long-term effectiveness of a remedial action

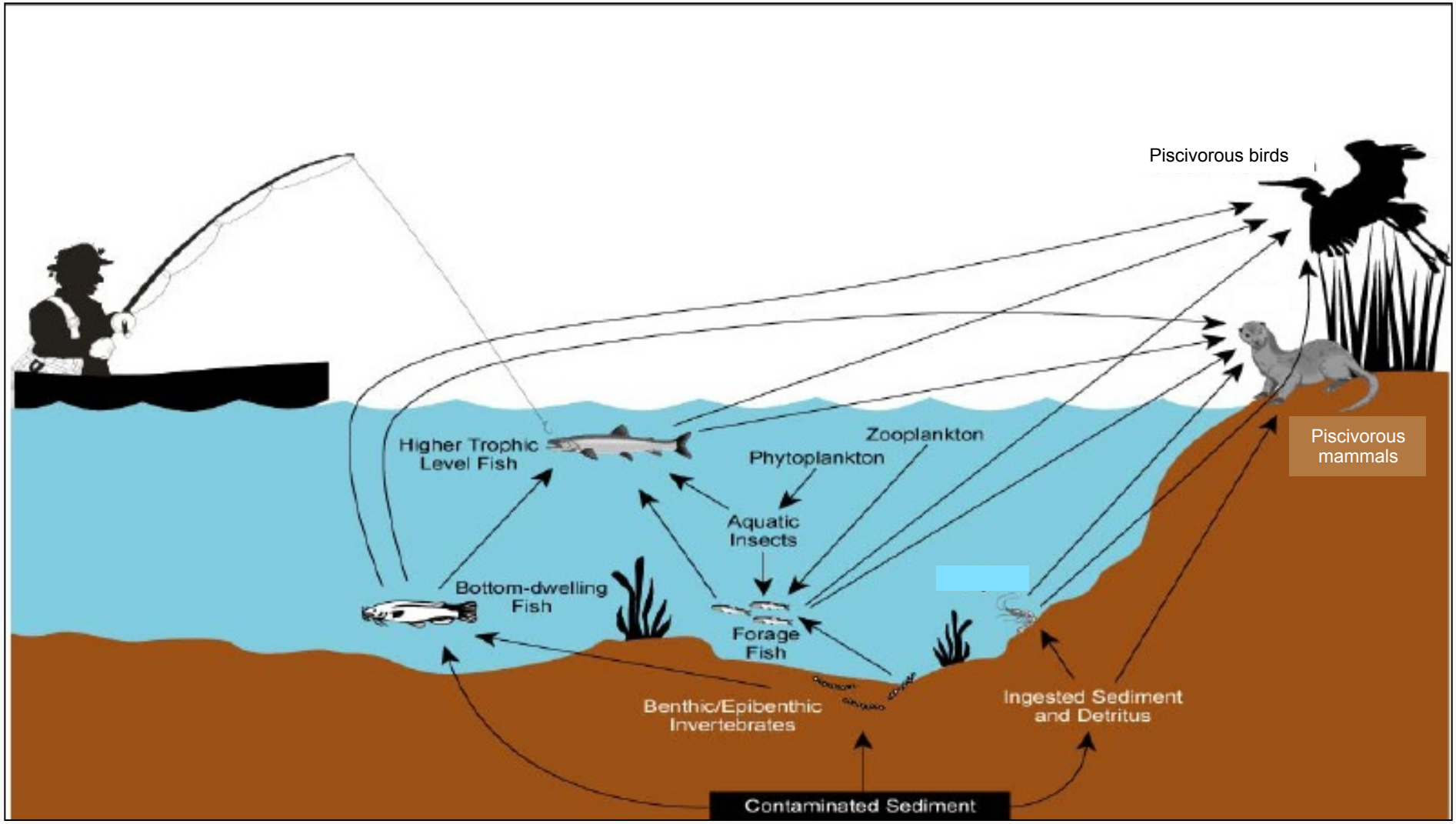
U.S. EPA 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. http://www.epa.gov/superfund/health/conmedia/sediment/guidance.htm

Typical Elements of a Conceptual Site Model for Sediment

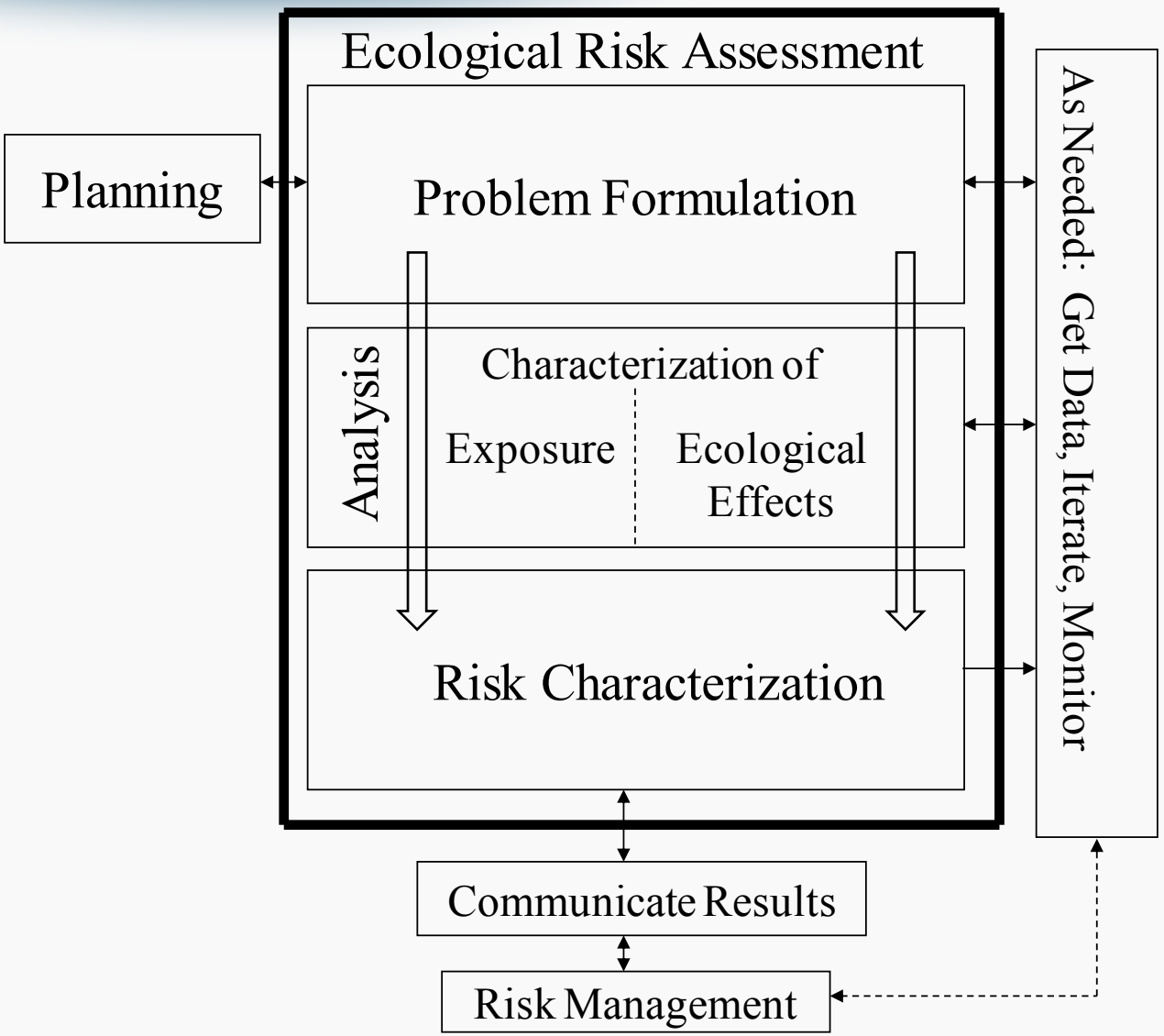
Sources of Contaminants of Concern: • Upland soils • Floodplain soils • Surface water • Ground water • Non-aqueous phase liquids (NAPL) and other source materials • Sediment "hot spots" • Outfalls, including combined sewer outfalls and storm water runoff outfalls • Atmospheric contaminants	Exposure Pathways for Humans: • Fish/shellfish ingestion • Dermal uptake from wading, swimming • Water ingestion • Inhalation of volatiles Exposure Pathways for Biota: • Fish/shellfish/benthic invertebrate ingestion • Incidental ingestion of sediment • Direct uptake from water
Contaminant Transport Pathways: • Sediment resuspension • Surface water transport • Runoff • Bank erosion • Ground water advection • Bioturbation • Food chain	Human Receptors: • Recreational fishers • Subsistence fishers • Waders/swimmers/birdwatchers • Workers and transients Ecological Receptors: • Benthic/epibenthic invertebrates • Bottom-dwelling/pelagic fish • Mammals and birds (e.g., mink, otter, heron, bald eagle)

U.S. EPA 2005. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. http://www.epa.gov/superfund/health/conmedia/sediment/guidance.htm

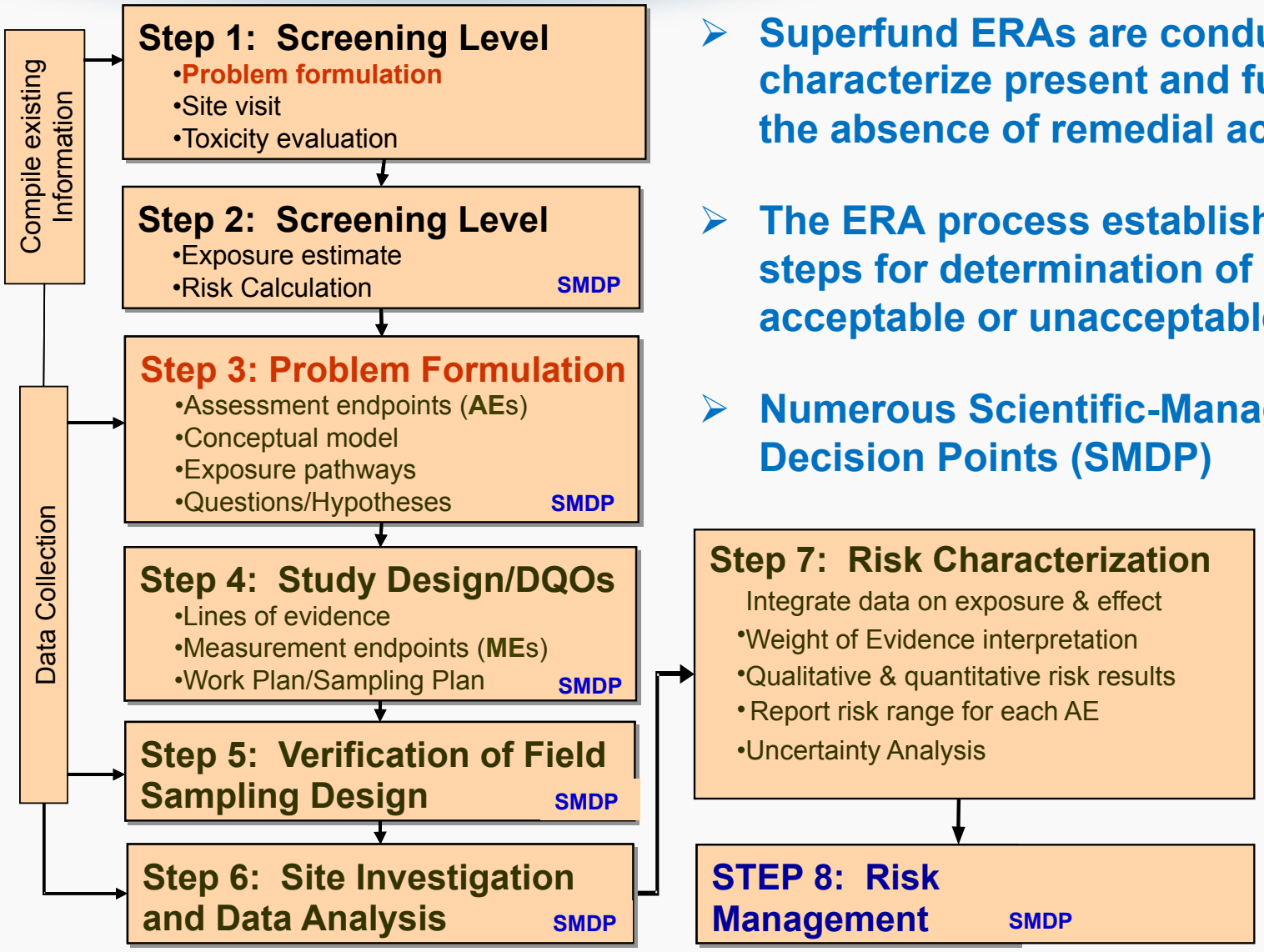
What we are protecting



Ecological Risk Assessment Framework U.S. EPA (1998)



Eight Step ERA Process for Superfund



- **Superfund ERAs are conducted to characterize present and future risks in the absence of remedial action**
- **The ERA process established technical steps for determination of risk as acceptable or unacceptable**
- **Numerous Scientific-Management Decision Points (SMDP)**

U.S. EPA. 1997. Ecological Risk Assessment Guidance for Superfund, Process for Designing and Conducting Ecological Risk Assessments, OSWER 9285.7-25, EPA 540-R-97-006.

General Superfund practice

- **Collect site-specific data through laboratory and/or field studies**
- **Toxicity testing of benthic invertebrates and food-chain modeling for assessing risks to birds and mammals are often conducted at sediment sites.**
- **Toxicity testing on groups of individual organisms is inferred to the site area population for the ERA**
- **Synoptic or observational analyses (i.e., abundance/ diversity of bottom-dwelling species, fishes, and emergent/ submergent vegetation) often treated as a supplemental LOE**

General Superfund practice

- **We do not extensively use probabilistic risk analysis at Superfund sediment sites, but it is a tool used in some cases.**
- **We still rely on the hazard quotient (HQ) method**
  - Site environmental concentrations compared to benchmarks (screening-level assessment only)
  - Site tissue concentrations compared to CBRs
  - Food-chain model estimates of dietary exposure concentration (e.g., daily dose) compared to a TRV
- **Background**
  - OSWER has **policy** (OSWER 9285.6-07P, *2002*) and **guidance** (OSWER 9285.7-41; EPA 540-R-01-003, *2002*)
  - Risks associated with background are to be considered in both risk assessment and risk management
  - Generally, Superfund does not set cleanup levels below background

There is an increased focus on bioavailability

- **Reduce uncertainties in sediment exposure and risk assessments by including bioavailability data**
- **Recent technical guidance supports use of bioavailability information**
- **Desire for decision-oriented bioavailability methods and tools.**
- **Driving work in developing sediment amendments for use in remediation**
- **EPA has included reductions in bioavailability as a remedial action objective in site decision documents**

Why are we conducting Ecological Risk Assessments at Superfund Sites?

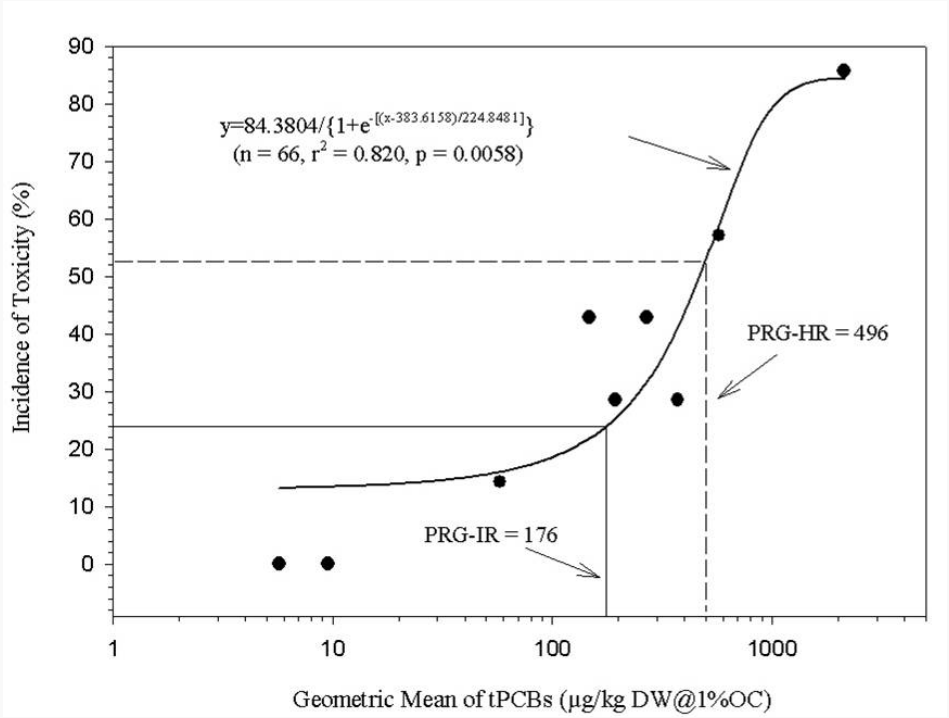
- **We need risk-based clean-up levels to address unacceptable risk**
  - EPA OSWER policy directive (OSWER 9285.7-17, *1994*)
  - *Related to the "level of protection" question in the workshop thought-starter #1*

- **Data related to survival, growth and reproduction are the primary LOE that we prefer for determining ecologically-protective sediment concentrations.**

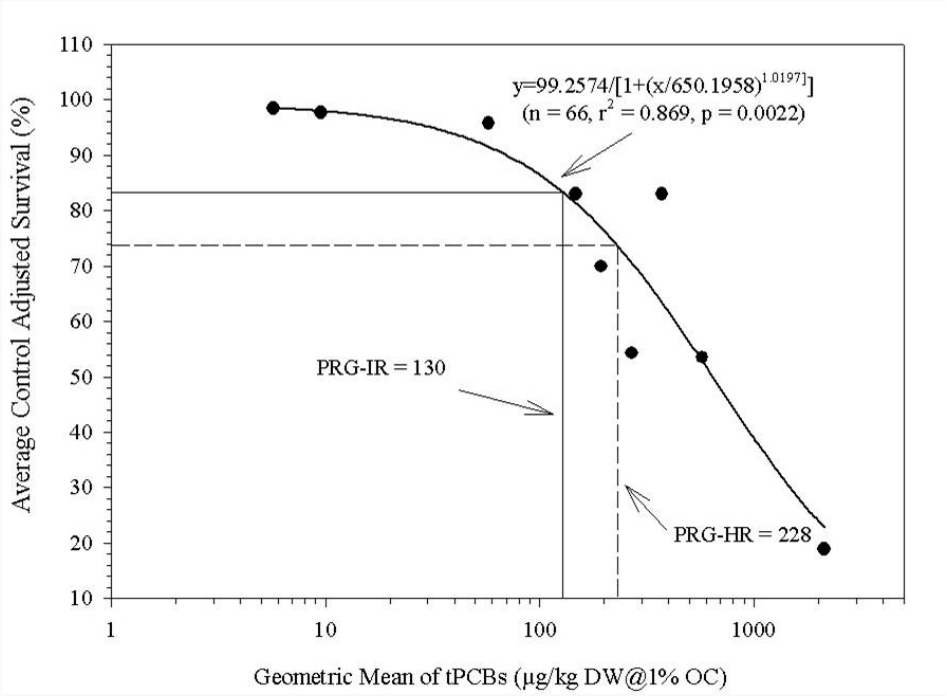
- **Risk range reported in the Risk Characterization**
  - Risk managers in communication with assessors able to select appropriate protective level from the range

Sediment toxicity testing—using concentration-response relationships

Incidence of Toxicity



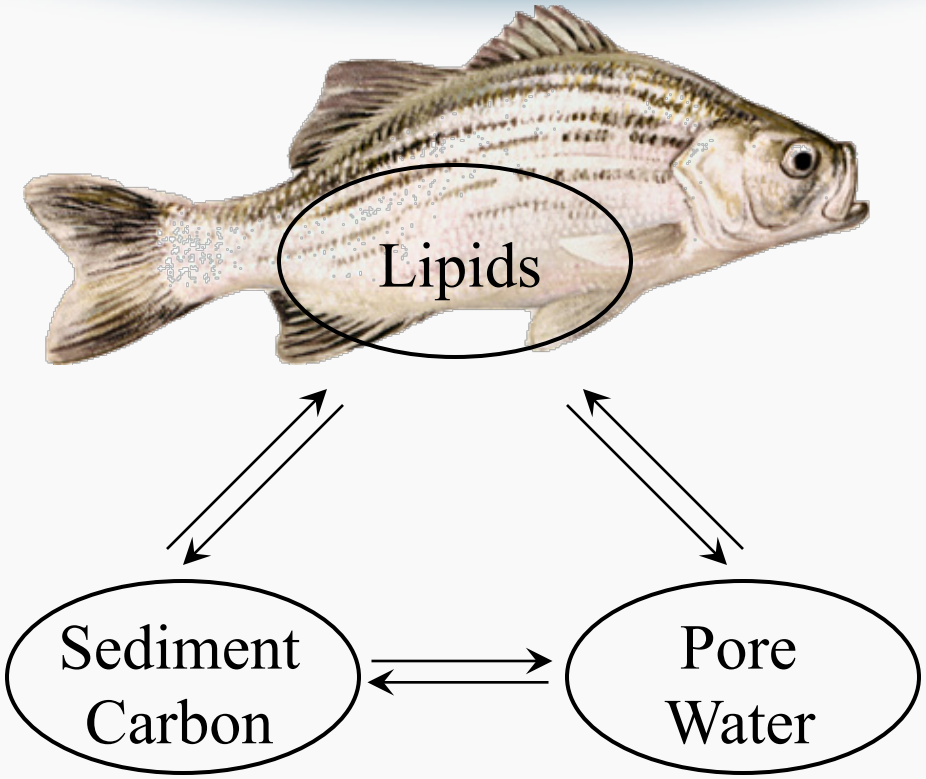
Magnitude of Toxicity



(MacDonald et al., 2007)

- **Develop site-specific relationships between sediment chemistry and toxicity**
- **Risk assessors should be encouraged to assist risk managers in defining level of effect for decisions**

Equilibrium Partitioning Bioaccumulation Model

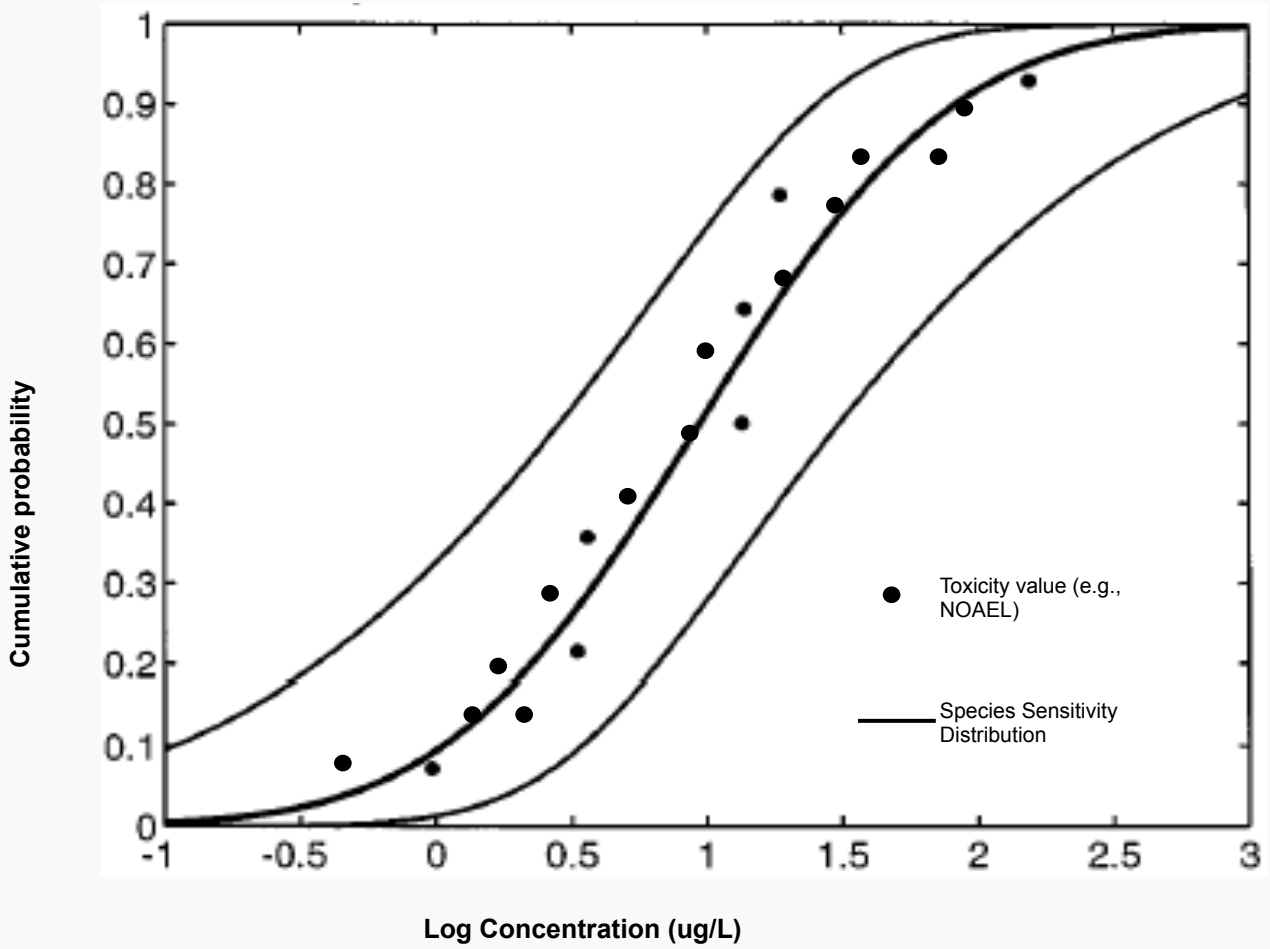


$$BSAF = \frac{C_b / f_{lipid}}{C_s / f_{OC}} = \frac{C_\ell}{C_{SOC}}$$

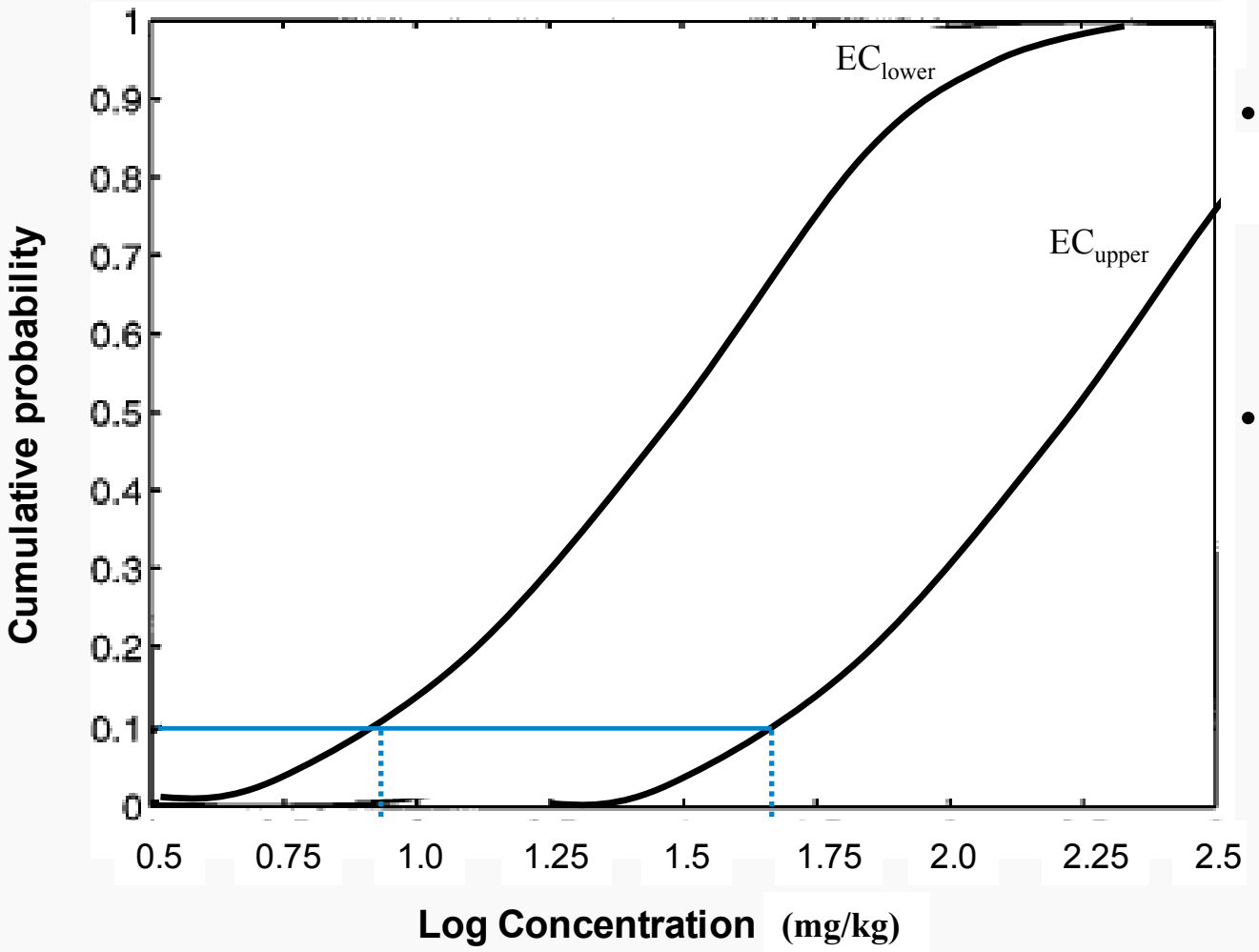
$$SRG = \frac{C_f \cdot f_{OC}}{BSAF \cdot f_{Lipid}}$$

BSAF	=	Biota/Sediment Accumulation Factor (unitless; g carbon/g lipid)
C_b	=	Organism concentration at steady state (µmol/g wet wt)
f_{lipid}	=	Fractional lipid contents of the tissues (g/g wet wt)
C_s	=	Contaminant concentration in the sediments (µmol/g dry wt)
f_{OC}	=	Fractional organic carbon contents of the sediments (g/g dry wt)

Species Sensitivity Distributions



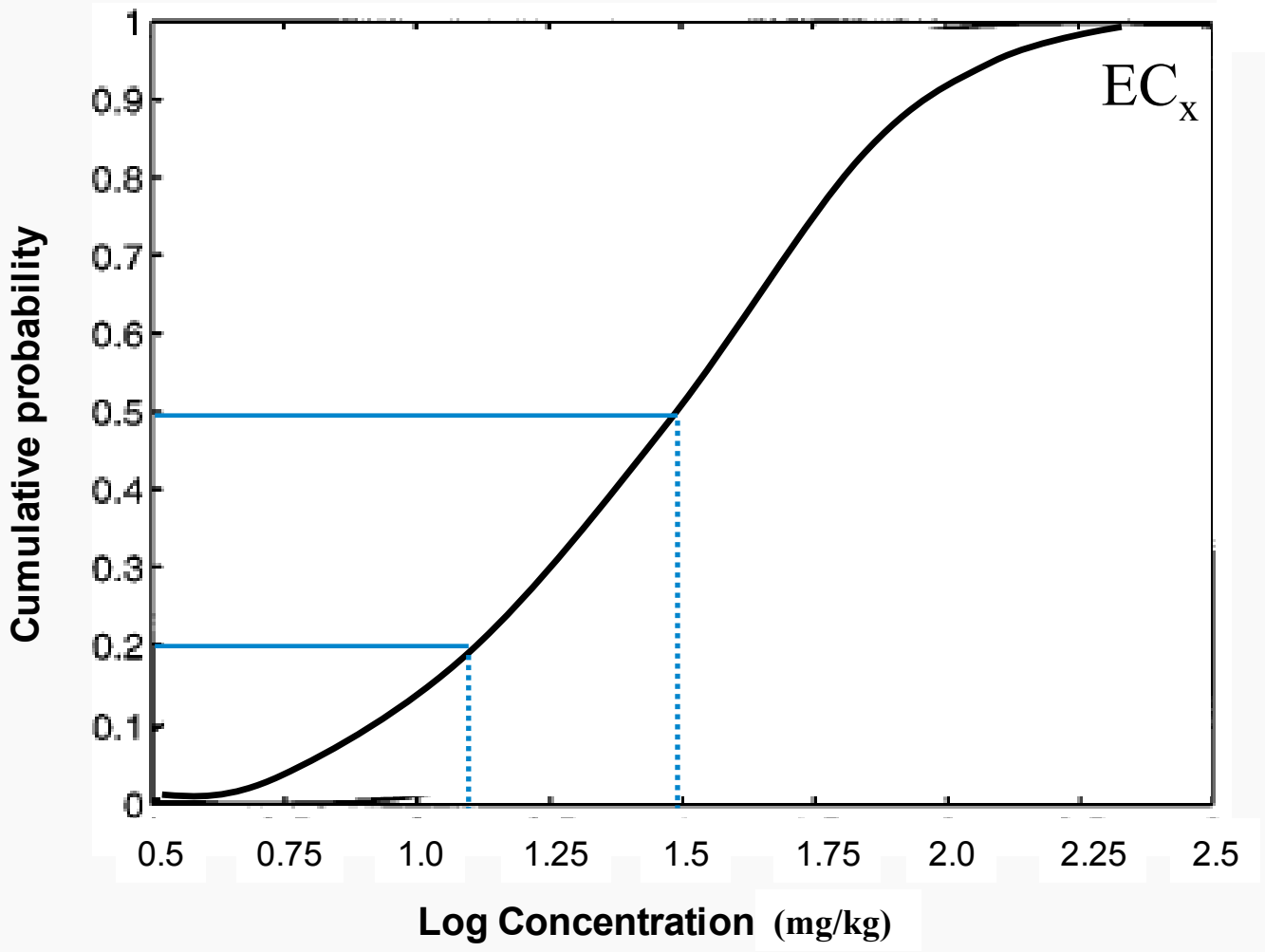
Option 1: Develop SSDs for two point estimate effects concentrations (ECx) of interest



- Select an upper and lower EC_x value, for bounding decisions.
- Then, a probability level (percentile) for protection of species is chosen
- The corresponding concentrations from the SSDs define the lower and upper bounds of the risk range

Note: Blue lines here are examples. They do not imply any technical preference or policy

Option 2: Use a single SSD developed from the data for a selected ECx



- Then two percentile levels are selected for defining the risk range off of the SSD curve.

Note: Blue lines here are examples. They do not imply any technical preference or policy

Summary

- **The purpose of the ERA is to support development of risk-based cleanup levels where risks are determined to be unacceptable and risk management is needed**
- **EPA Sediment Management Principles require risk assessment as a basis for remedial decisions**
- **The 8-step ERA Guidance for Superfund provides a flexible framework to characterize ecological risks**
- **Survival, growth, and reproduction endpoints are used**
  - Overall ERA includes physical, chemical, and biological endpoint measurements
- **New scientific approaches can be incorporated into Superfund ERA practice**

Thank You

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