Uncertainty in Sediment Risk Assessment: Examples and Applications

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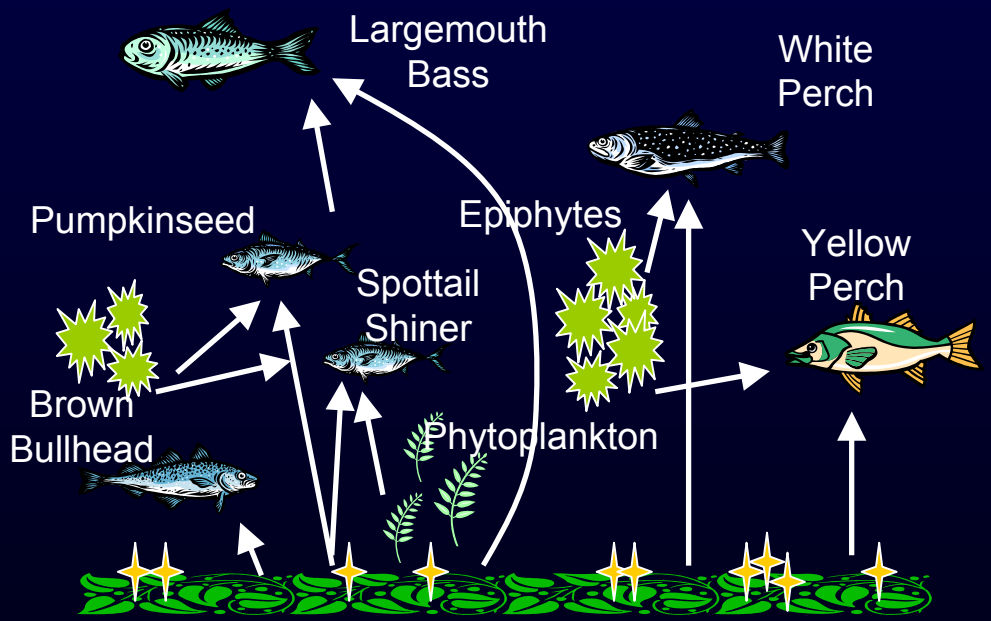
Uncertainty Analysis: Methods

- Qualitative assessments
- Sensitivity analysis
- Data availability and goals of analysis will guide method selection
- Interval analysis ("fuzzy" math)
- Probabilistic tools
  - Single dimension sampling from distributions
  - Two dimensional sampling from distributions

Examples

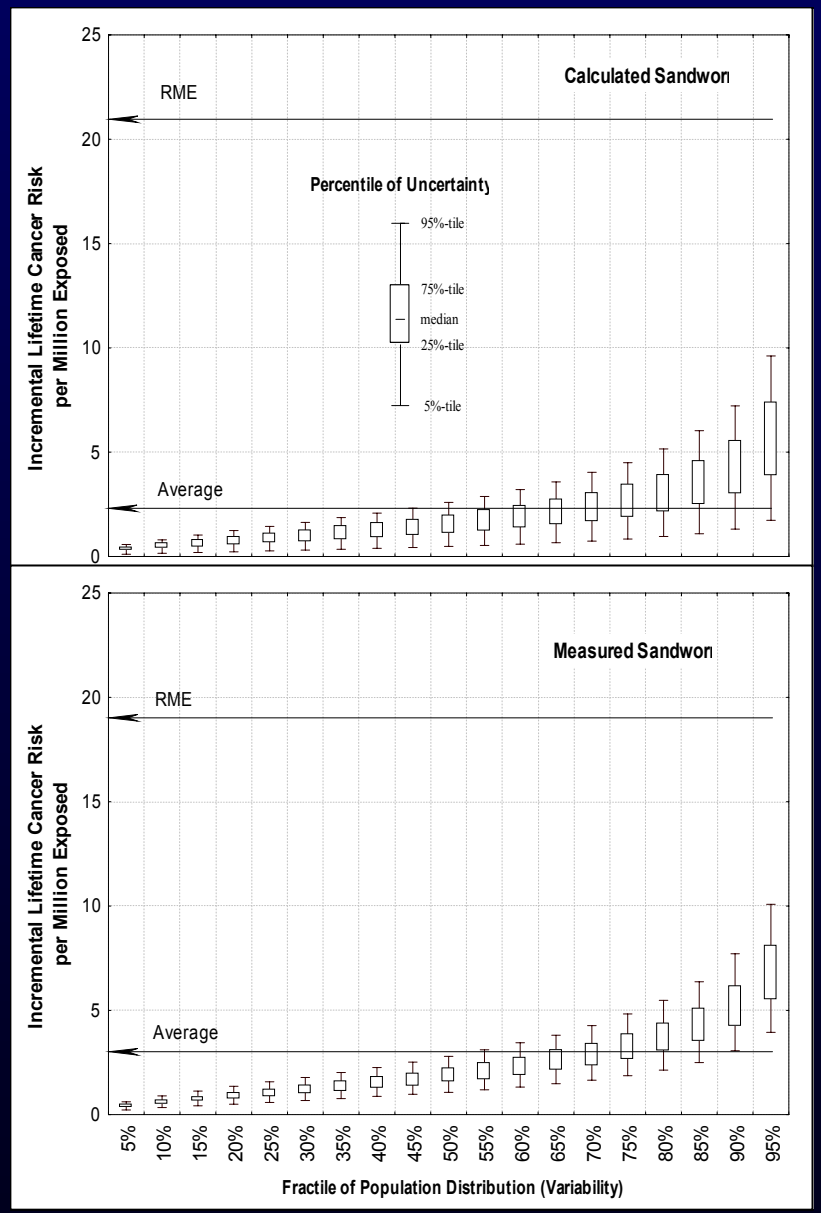
- FISHRAND probabilistic bioaccumulation model
  - First developed for Hudson River RI/FS
  - Bayesian Updating for calibration
  - Revised to include spatial characteristics
  - Used for ecological (and human) risk assessment

- *TrophicTrace* tiered risk assessment tool
  - Interval analysis for uncertainty



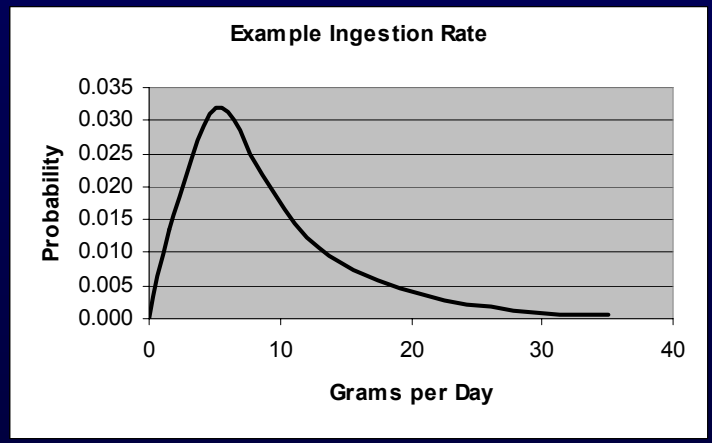
Application of Trophic Transfer Modeling to Evaluate DM

- Human health effects evaluated by using mean, RME and probabilistic input parameters
  - RME always over-estimated risk
- Defaulting to conservative point estimates will create programmatic "burdens"



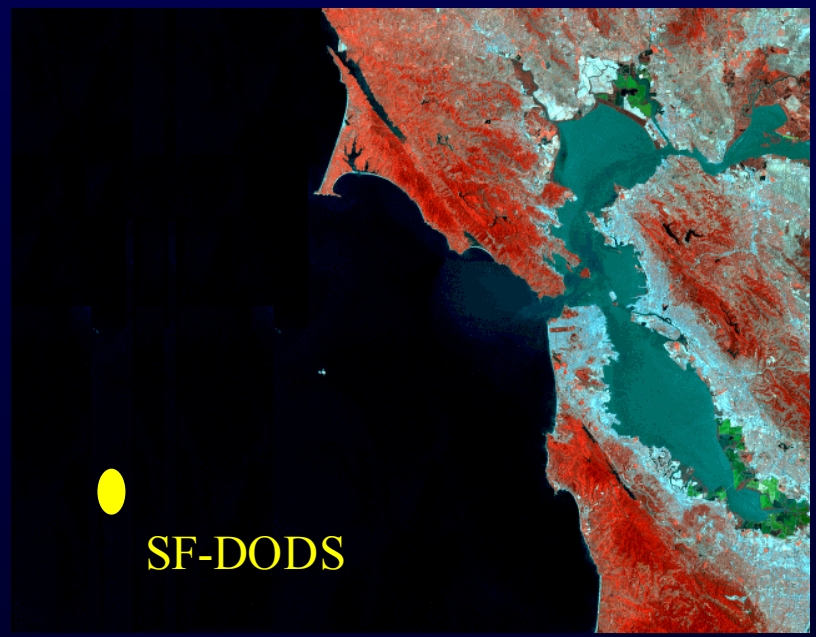
Addressing Uncertainty and the Spatial Elements of Exposure

- Must be able to describe, quantify and where possible reduce uncertainty in our risk estimates
  - Be accountable for how that uncertainty is factored into decision making
- Develop more realistic approaches for describing how receptors use the sites and how this affects their exposure to contaminants



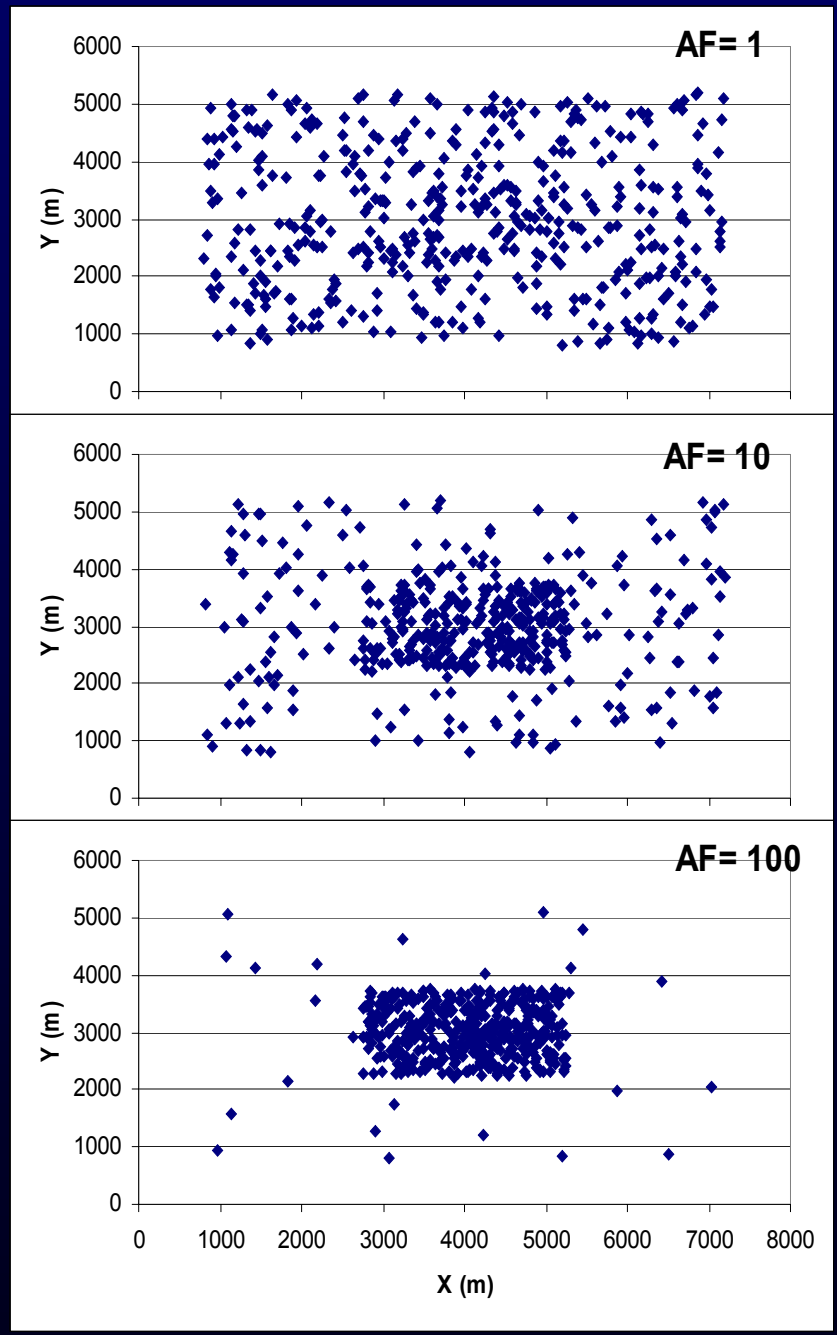
Spatial/temporal Scales of Predicting Far-field Impacts

- Contaminant concentration varies over space/time at disposal sites
- Animals spend variable amounts of time in or around disposal sites
- Exposure estimates must include spatial/temporal variables



Spatial Issues in Exposure Assessment

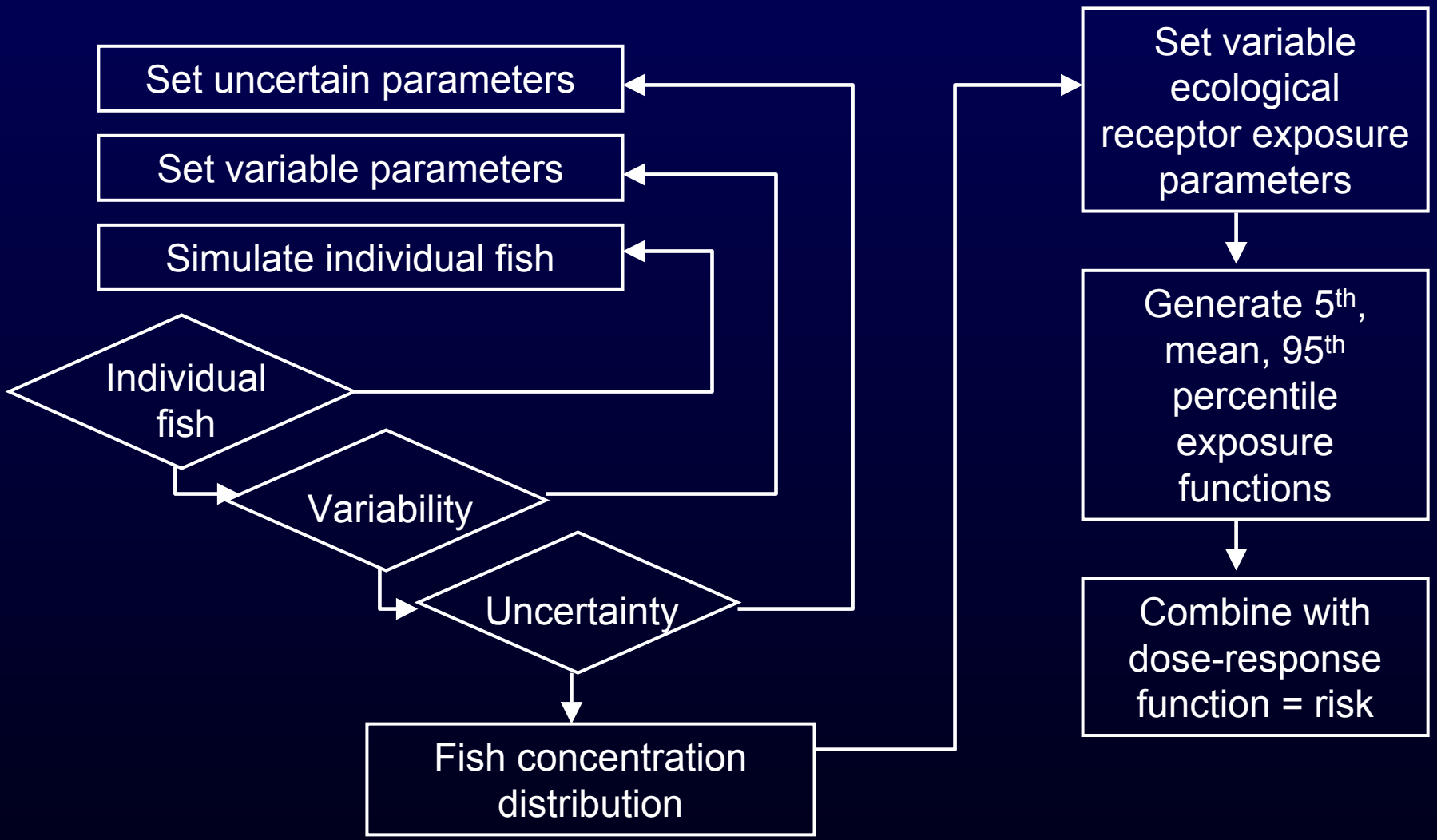
- Disposal sites are relatively small (3.75 km^2)
- Fish mobility varies among species
  - Many recreational and commercial species range over large areas
- Do disposal sites attract fish?
  - How will this affect exposure?



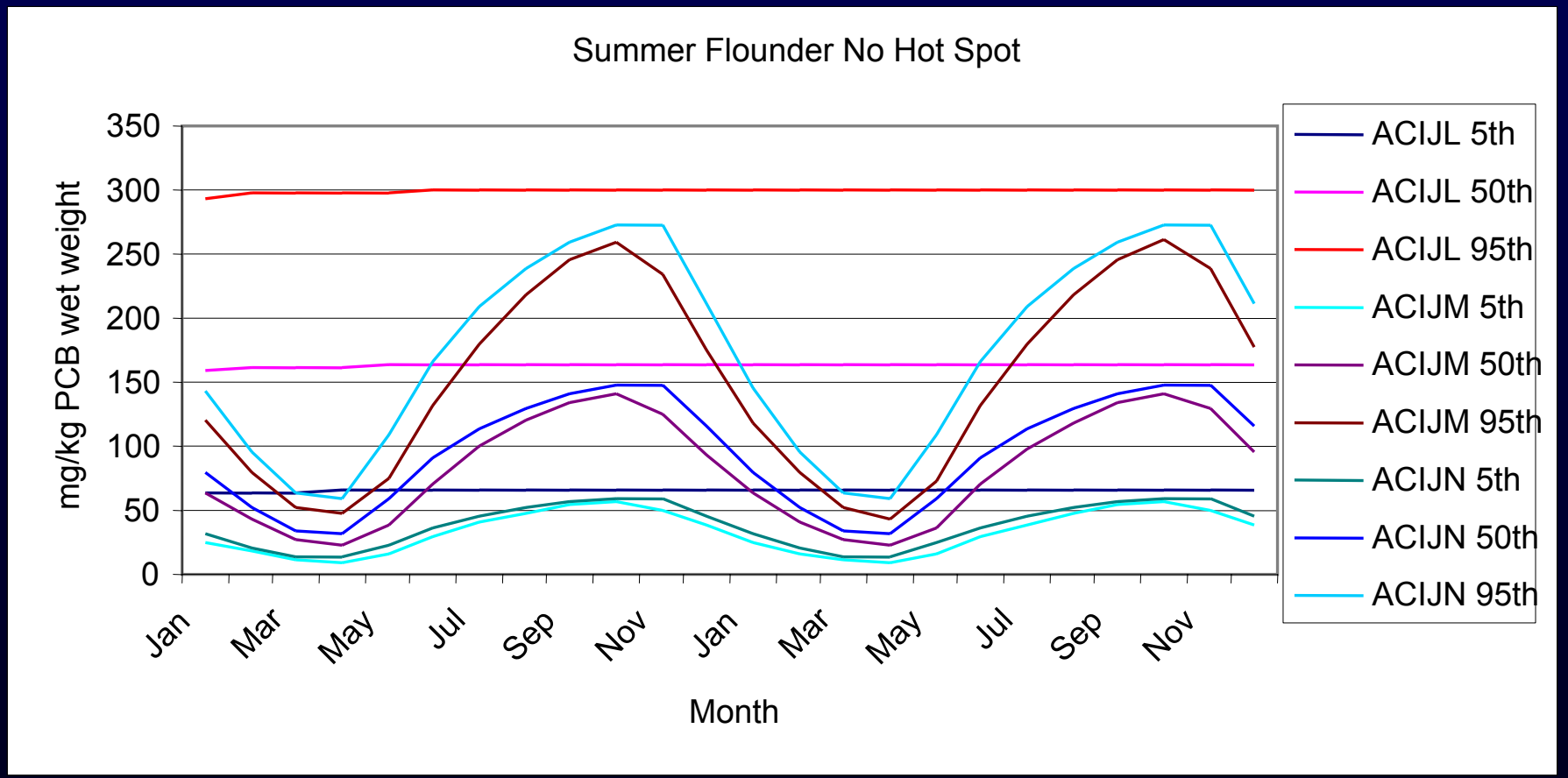
Disaggregation of State Variables

- Knowledge of uncertainty/variability
  - Low uncertainty in body weight, lipid
  - Uncertainty in exposure estimates
- Availability of data to operationally separate uncertainty from variability
  - Log K_{ow}
- Management goals
  - Decision to dispose of dredged sediments

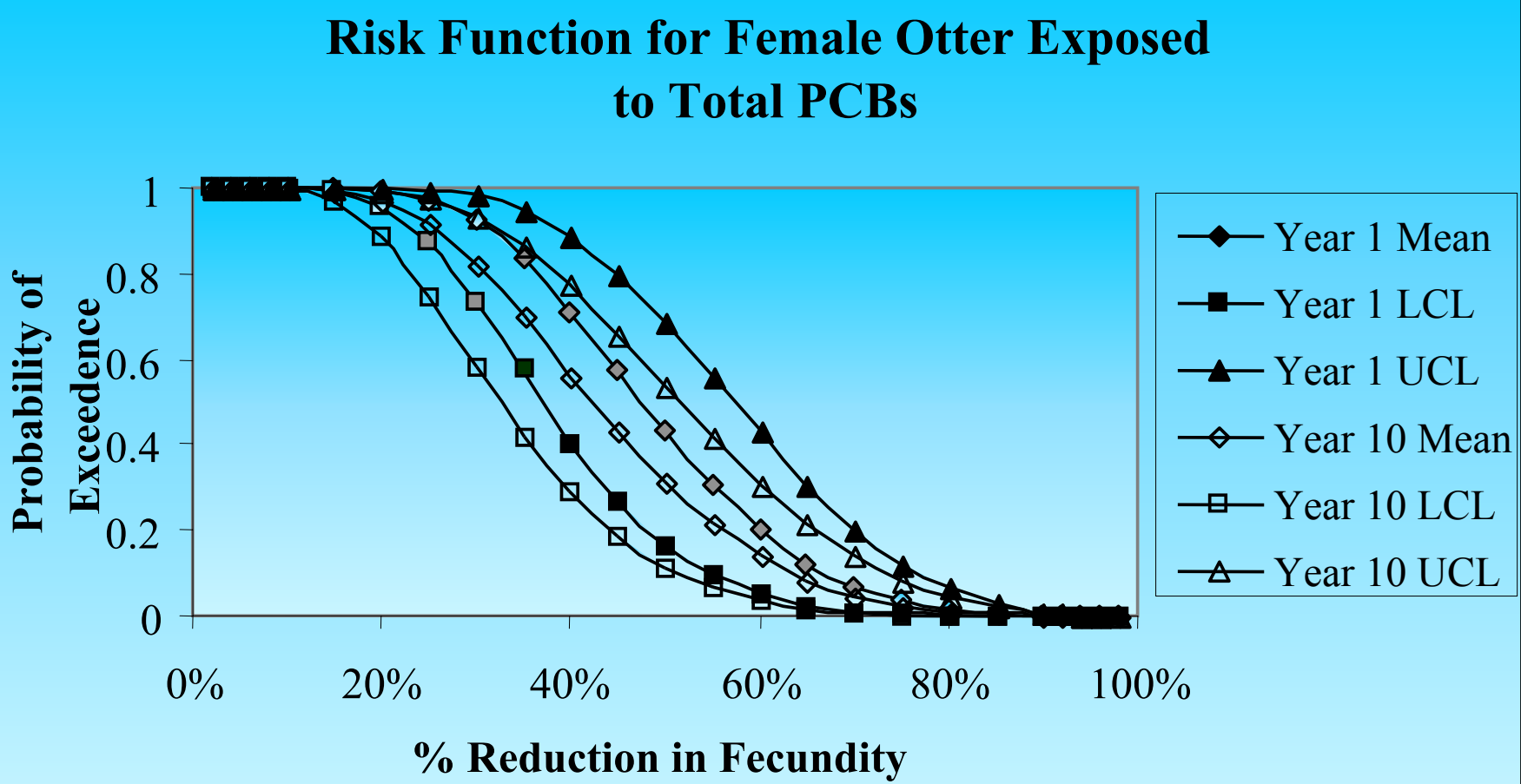
Modeling Framework



Example of FISHRAND-migration Output



Two Dimensional Latin Hypercube



TrophicTrace

- **Microsoft® Excel Add-In**
- **Steady-state bioaccumulation model based on Gobas (1993 and 1995) for organics**

- **Uptake and trophic transfer of inorganics are modeled using empirical BCFs or Trophic Transfer Factors (TTF)**
- **Default sediment-driven food web can be edited**

TrophicTrace

- Calculates cancer risk and hazard indices for humans via fish ingestion
- Can calculate risks to ecological receptors, e.g., fish, osprey, bald eagle, mink, and otter

- Designed as flexible tool that can be customized for region/site-specific use
- Required data libraries within the system, but can be edited/updated by the user

Invertebrate EqP with Sediment

Measured sediment concentration = 28.1 µg/kg dry weight

	TOC = 1.2%	TOC = 2.0%	TOC = 3.8%	TOC = 5%
Benthic Lipid = 0.5%	11.7	7.0	3.7	2.8
Benthic Lipid = 1.0%	23.4	14.1	7.4	5.6
Benthic Lipid = 1.2%	28.1	16.9	8.9	6.7
Benthic Lipid = 2.0%	46.8	28.1	14.8	11.2

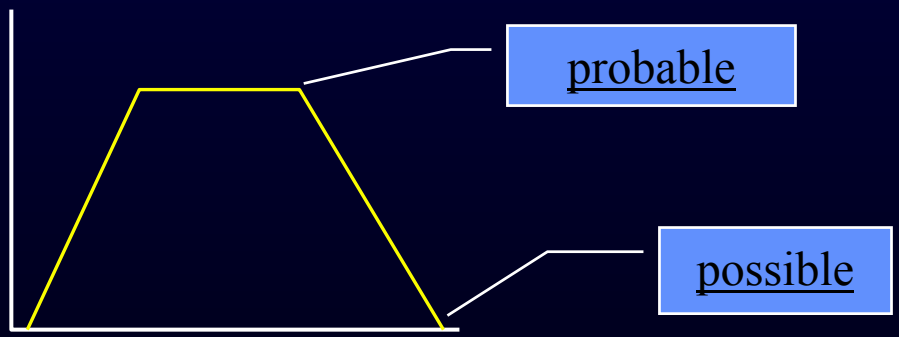
Predicted benthic invertebrate concentration µg/kg wet weight

Order of Magnitude Effects

- K_d and other partitioning assumptions for inorganics
- BCF values from the literature
- Log K_{ow} values for organics/mixtures
- Lipid content
- Ingestion rate
- Uncertainty in sediment concentrations

Use of Interval Analysis

- Just “uncertainty” for a particular predefined fractile
- Provide ranges (possible and probable)
  - Can’t rely on users to specify distributions
  - Conceptually easier to understand
- Mathematical properties



Some Publications

- von Stackelberg, K., D. Burmistrov, I. Linkov, D.J. Vorhees, and T.S. Bridges. 2002. Importance of uncertainty and variability to predicted risks from trophic transfer of contaminants in dredged sediments, in press *Risk Analysis*
- von Stackelberg, K., Burmistrov, D., Linkov, I., Cura, J., and Bridges, T. 2002. The use of spatial modeling in an aquatic food web to estimate exposure and risk. *Science of the Total Environment* 288(1-2):97-110
- Linkov, I., K. von Stackelberg, D. Burmistrov, and T.S. Bridges. 2001. Uncertainty and variability in risk from trophic transfer of contaminants in dredged sediments. *Science of the Total Environment* 274:255-269

Conclusions

- The importance and consequences of management decisions necessitates the use of quantitative methods
- Must develop confidence measures for our assessments that can be communicated to the public and regulated parties
- Effective regulatory implementation of risk-based approaches will require some standardization