Uncertainty Analysis as an Aid rather than a Hindrance to Decisionmaking

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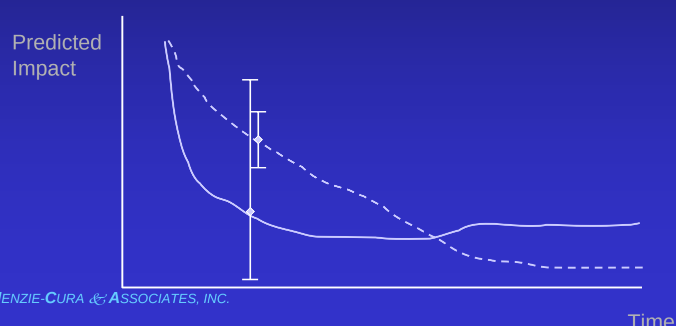
Why is it Important to Quantify Uncertainty?

- There is no such thing as "the number"
- Provides false sense of confidence



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Some Thoughts on Models

- Models need only be sufficiently accurate to facilitate correct decisions
- Effective use of models requires:
  - Knowledge of potential inaccuracies
  - Characterization of uncertainties
  - Specification of criteria to evaluate model performance

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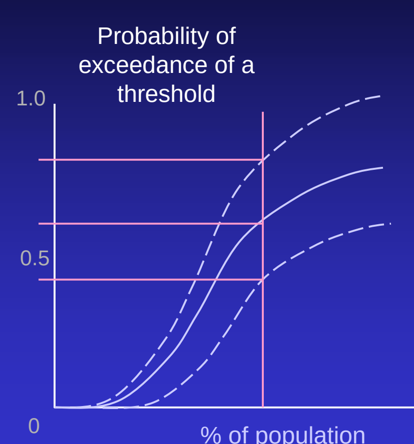
Communicating Uncertainty

- Quantifies contributors to output variance
- Identifies data collection opportunities
- Provides perspective on point estimates
- Can disaggregate variability and uncertainty



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Different Audiences Require Different Approaches

- General public
  - May not understand technical details
  - May have preconceived ideas
- Decisionmakers
  - May understand statistics but are not statisticians
  - Want to know the "bottom line" – so what do I do with this information?

Fallacies of Probabilistic Analysis

- Costs more
- Requires more time
- More difficult to understand (careful presentation can help)
- Provides false sense of how well uncertainties are understood
- Rarely have sufficient data to define distributions
- Don't want to acknowledge the degree of uncertainty

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A Probabilistic Means to an End

- Quantifying uncertainty
  - Other methods available
- Quantifying variability
  - Distribution of PCBs within a population
- Example from the Hudson River
  - Human health risk assessment
  - Ecological risk assessment
    - Population-level effects
  - Most efficient means of organizing the available data given quality, quantity, and considering management goals

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Good Questions for Managers to Ask

- What method(s) were used?
  - Mathematical techniques
  - Sampling and analysis
  - Retrofitting previous analyses
- What data was the analysis based on?
  - Site specific
  - Extrapolated – across species, sites, etc.
- Was there a separation of uncertainty and variability and how was it handled?
- What are the important contributors?

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Strategies for Understanding Uncertainty

- Look to previous analyses
- Break open the models – review results
- Good understanding and evaluation of available data
- Tiered approaches
  - Don't start with 2-D probabilistic
- Reasonable to collapse back to a "bright line" with a context

Example: Evaluation of Open-Water Disposal of Dredged Material

- Moss Landing Harbor, California
- Assemble available data
  - First cut at risks
  - Identify uncertainties, data needs
- Provide a framework for backcalculating threshold levels in sediment or benthos

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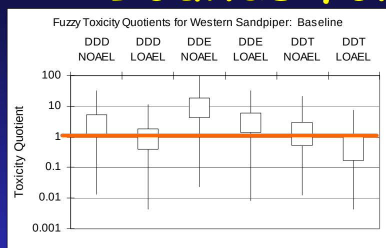
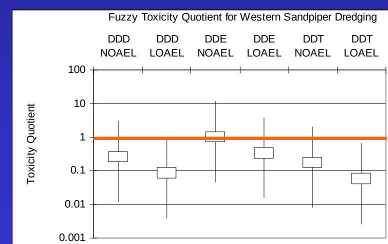
Possible and Probable Bounds for Uncertainty



- Use of fuzzy math to characterize uncertainty
- Exceedances at a glance

- Minimum
- Maximum
- Average
- Average upper-bound



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Interpretative Matrix

- Use possible range to express confidence
- Use probable range to determine potential for risk
- NOAELs and LOAELs evaluated separately

Average Case (lower bound of the probable range)	Upper Bound Average Case (upper bound of the probable range)	Maximum Case (upper bound of the possible range)	Risk Conclusion	Confidence Level
N ≤ 1 and L ≤ 1	N ≤1 and L ≤ 1	N ≤1 and L ≤1	NSR	High
N ≤ 1 and L ≤ 1	N ≤1 and L ≤ 1	N> 1 and L ≤1	NSR	High
N ≤ 1 and L ≤ 1	N ≤1 and L ≤ 1	N> 1 and L> 1	NSR	Moderate
N ≤ 1 and L ≤ 1	N > 1 and L ≤ 1	N> 1 and L ≤ 1	NSR	Moderate
N ≤1 and L ≤ 1	N > 1 and L ≤ 1	N > 1 and L> 1	NSR	Moderate
N ≤1 and L ≤ 1	N > 1 and L > 1	N > 1 and L > 1	NSR	Low
N > 1 and L ≤ 1	N > 1 and L ≤ 1	N > 1 and L ≤ 1	Potential Risk	Low
N > 1 and L ≤ 1	N > 1 and L ≤ 1	N > 1 and L > 1	Potential Risk	Moderate
N > 1 and L ≤ 1	N > 1 and L > 1	N > 1 and L > 1	Potential Risk	High
N > 1 and L > 1	N > 1 and L > 1	N > 1 and L > 1	Potential Risk	High

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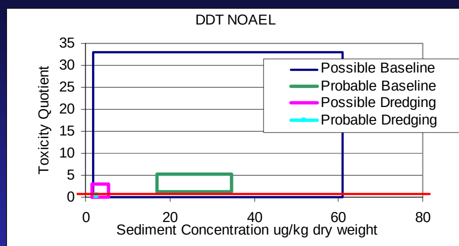
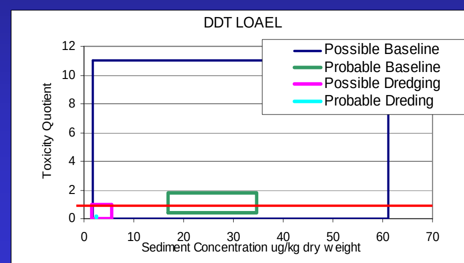
Parameter Sensitivity



- See the impact of input on output
- Scale
- Size of boxes

•Relationship between possible and probable range



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Example: Joint Probability Analysis for Hudson River

- Goal: provide probability of exceedance of increasing magnitude of effect
- Used probabilistic output from FISHRAND-model
- Compare results
  - How do the risk curves shift from year to year
  - How do remedial alternatives compare to no action or monitored natural attenuation
  - How do the uncertainties compare for each alternative

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Focus the Analysis

- Many receptors, years, combinations
  - Focused on otter
  - Annualized risks
- Selected locations in the river
  - Evaluate habitat relative to modeling boxes
- Compared selected years and locations

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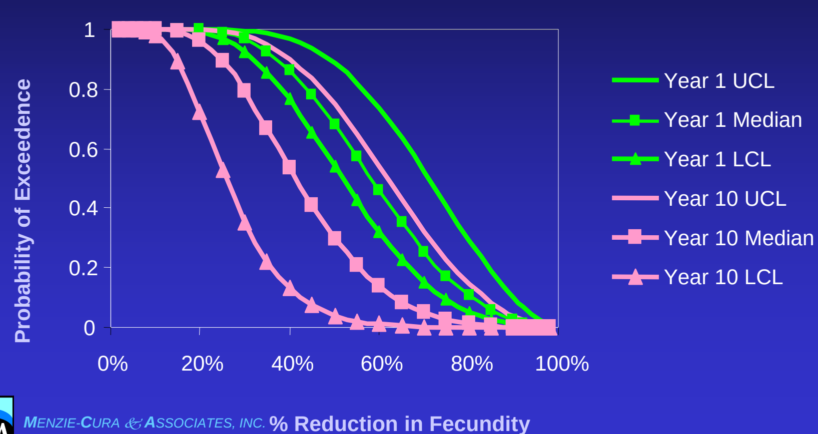
Risk Function for Female Otter Exposed to Total PCBs at RM 189 under No Action



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Knowing What We Don't Know

- Insights from the bioaccumulation modeling literature
- Insights from sensitivity analyses conducted by modelers themselves
- Bioaccumulative compounds
  - Log K_{ow}
  - Percent lipid
  - Total organic carbon or BSAF
  - Partitioning in water column

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Are These Analyses Helping?

- List of case studies
  - Very small!
  - But there are some…
- For example
  - Use first-order Monte Carlo to determine risk category
  - P-bounds for risk range
  - Backcalculate prey concentrations associated with "low" and "moderate" risk
  - Iterative forward calculations to determine sediment concentrations
  - Requires monitoring in future

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Some of the Challenges

- How to best characterize exposures and work with spatial and temporal scales
- Expected value, upper bound, lower bound for receptor-year-location-alternative
  - Many, many results to compare!
  - Visualizing the results can be difficult
- Risk communication
  - Decisionmakers
  - Stakeholders

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