# A Unified Aquatic Life Framework for Addressing the Affected Percentages of Individuals, Species, and Time

Charles Delos
Great Lakes Environmental Center
cdelos@glec.com

# Two Approaches for Addressing Time Variability

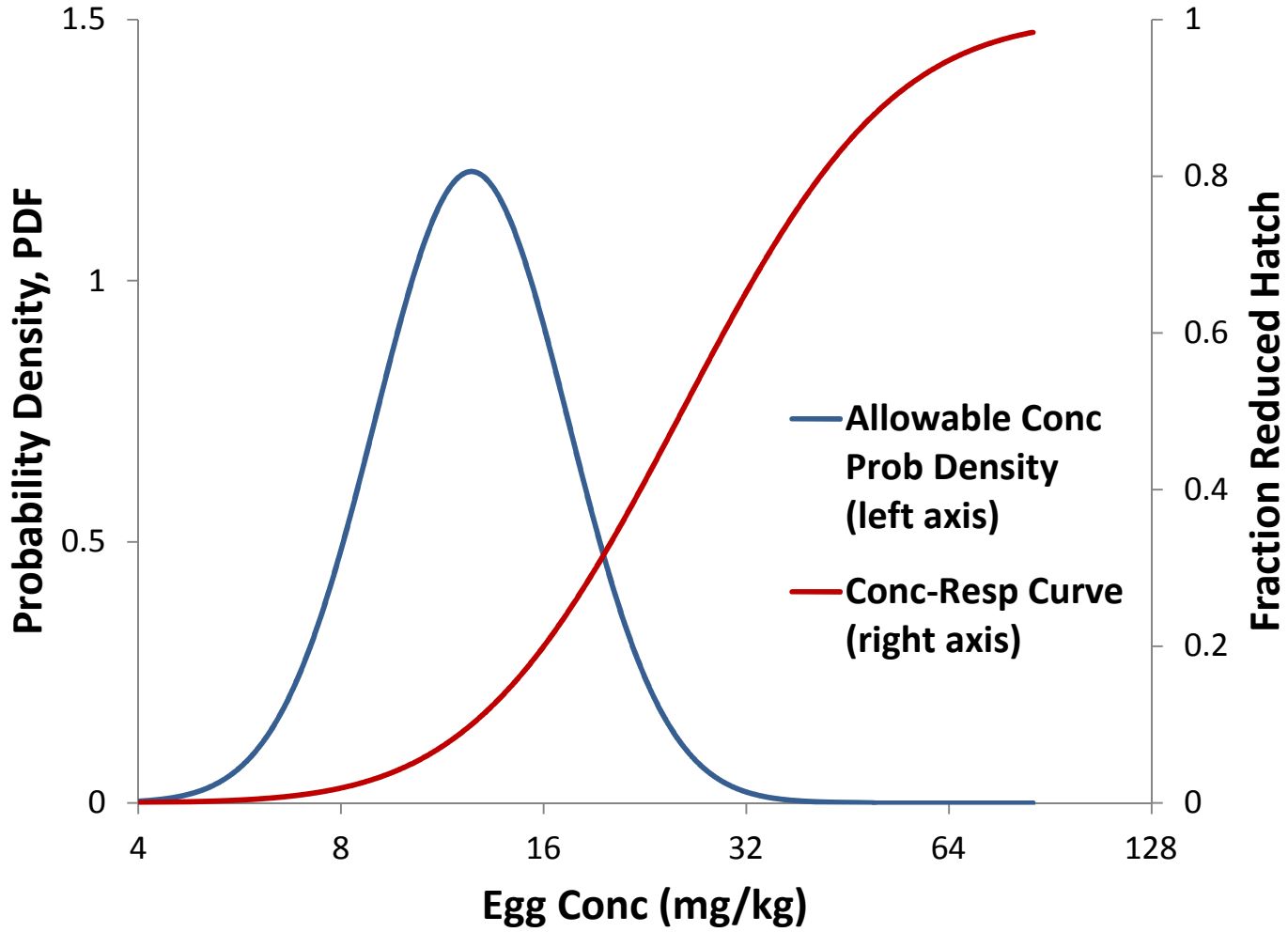
- Simple approach uses distribution of exposure concentrations.
- Complex approach uses a long time series of concentrations.

# An Actual Application Applying the Simple Distribution of Concentrations

- State of Utah adopted a selenium criterion for the Great Salt Lake, Gilbert Bay.
  - Applies to the Se concentration in bird eggs.
  - Set at 12.5 mg/kg, the State's estimate of the EC10 for mallard duck, the most sensitive known species.
  - Applies as the geometric mean concentration.
- Question: What is the aggregate level of effect if the water body geometric mean rises to the EC10 and the variability of concentrations (expressed as a CV or log standard deviation) remains as present?

# Combining Ambient Concentration Distribution with a Species Concentration-Response Curve:

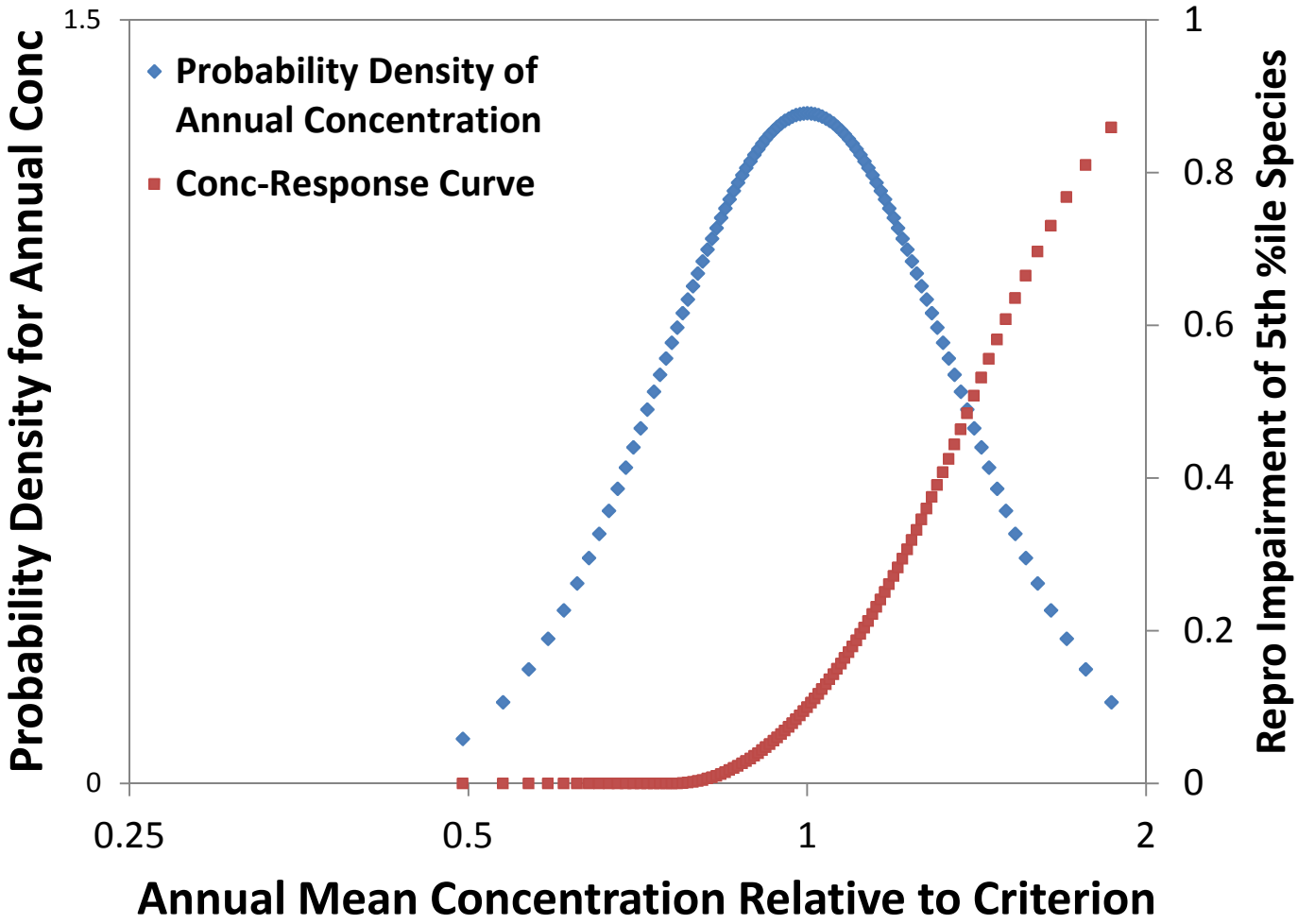
Aggregate Effect = $\sum$ probability$_i$ x Effect$_i$



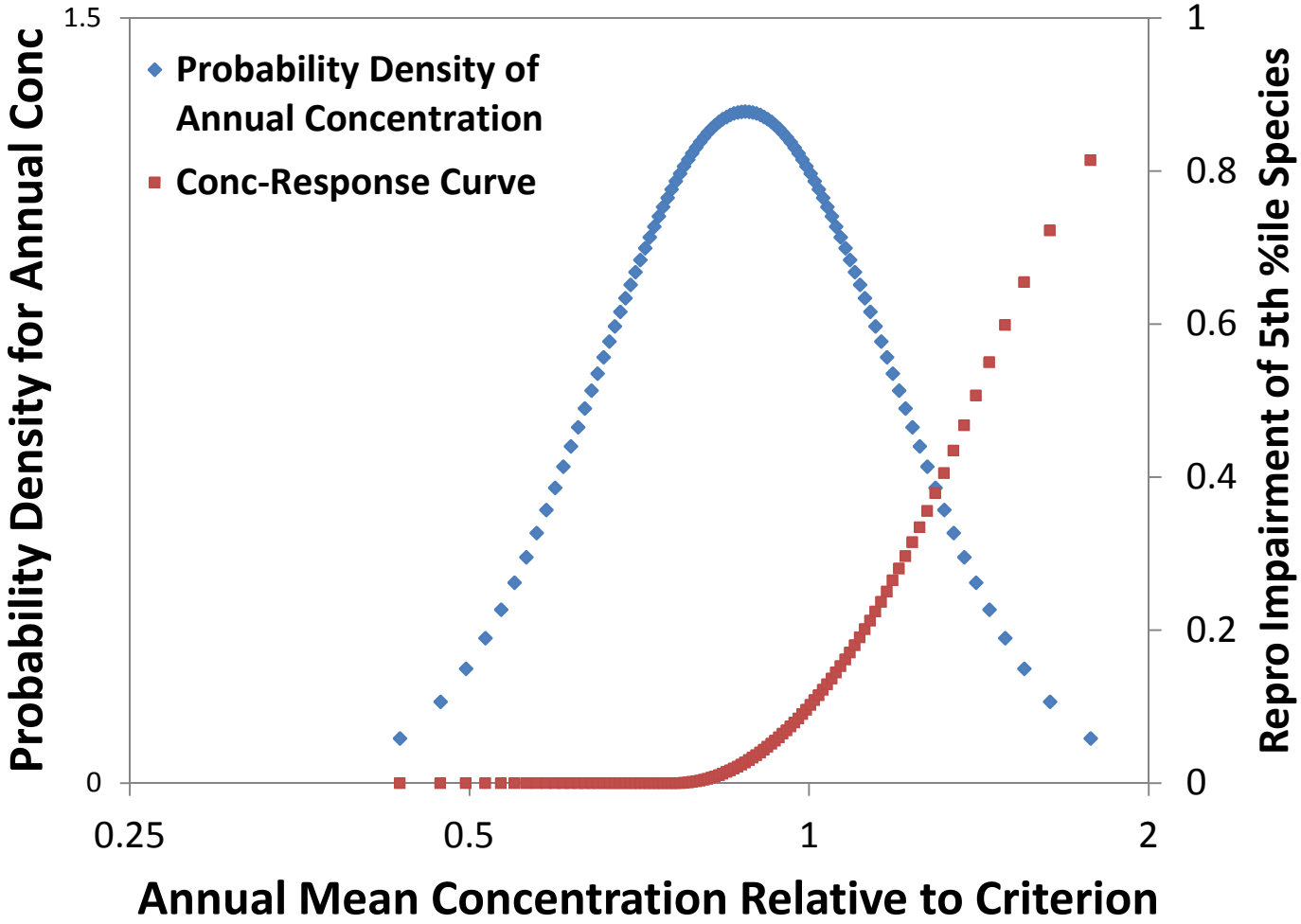
# Hypothetical Illustration: Selecting a Return Interval for Exceeding a Criterion

- Possible application: let's say a state wants to allow the annual reproductive season mean Se fish tissue concentration to exceed the criterion only once in "X" number of years.
- We ask: for various values of the return frequency, X, what is the level of aggregate effect on the hypothetical $5^{th}$ percentile species having EC10=Criterion?

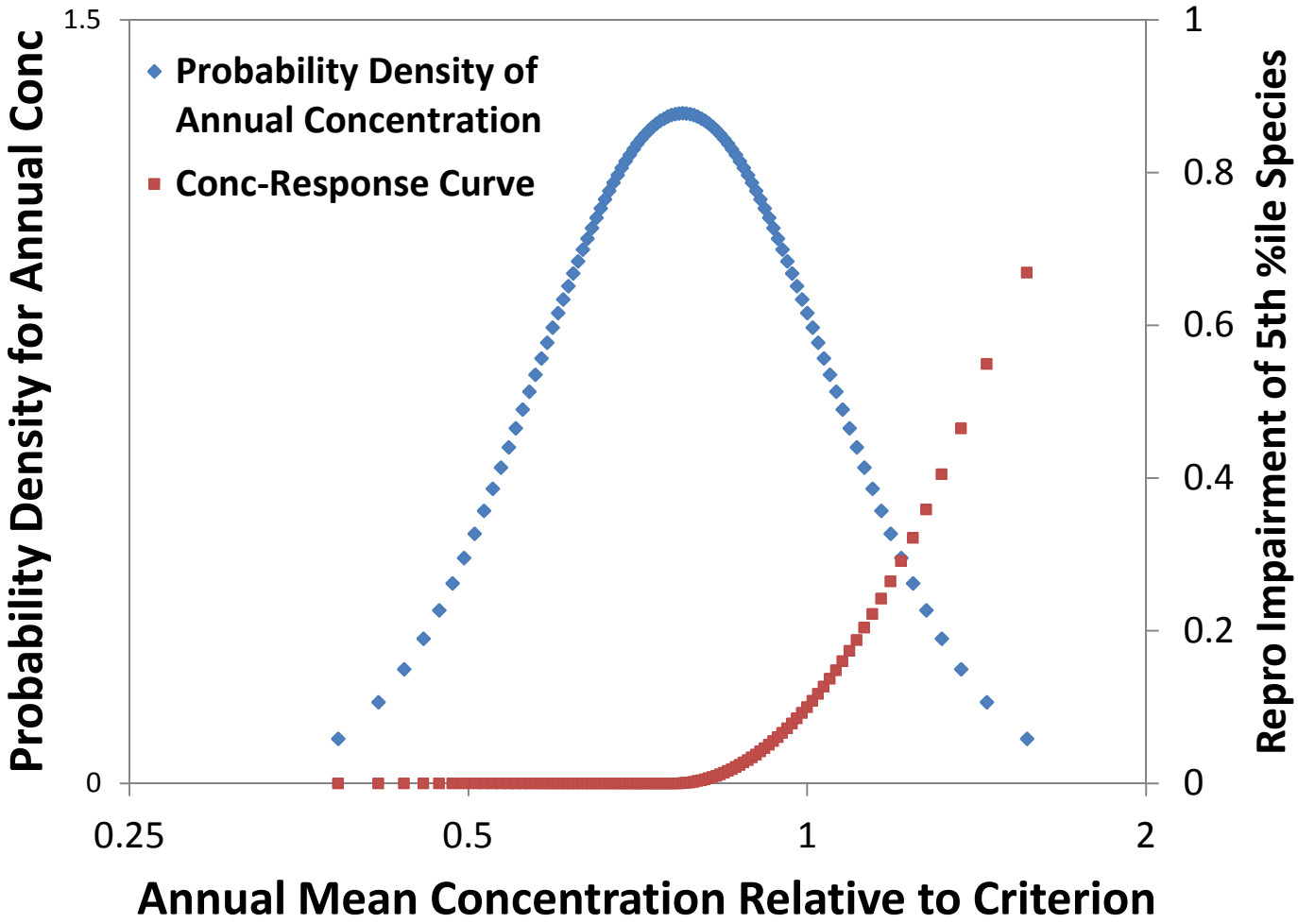
# Trial 1: Once in 2 Years



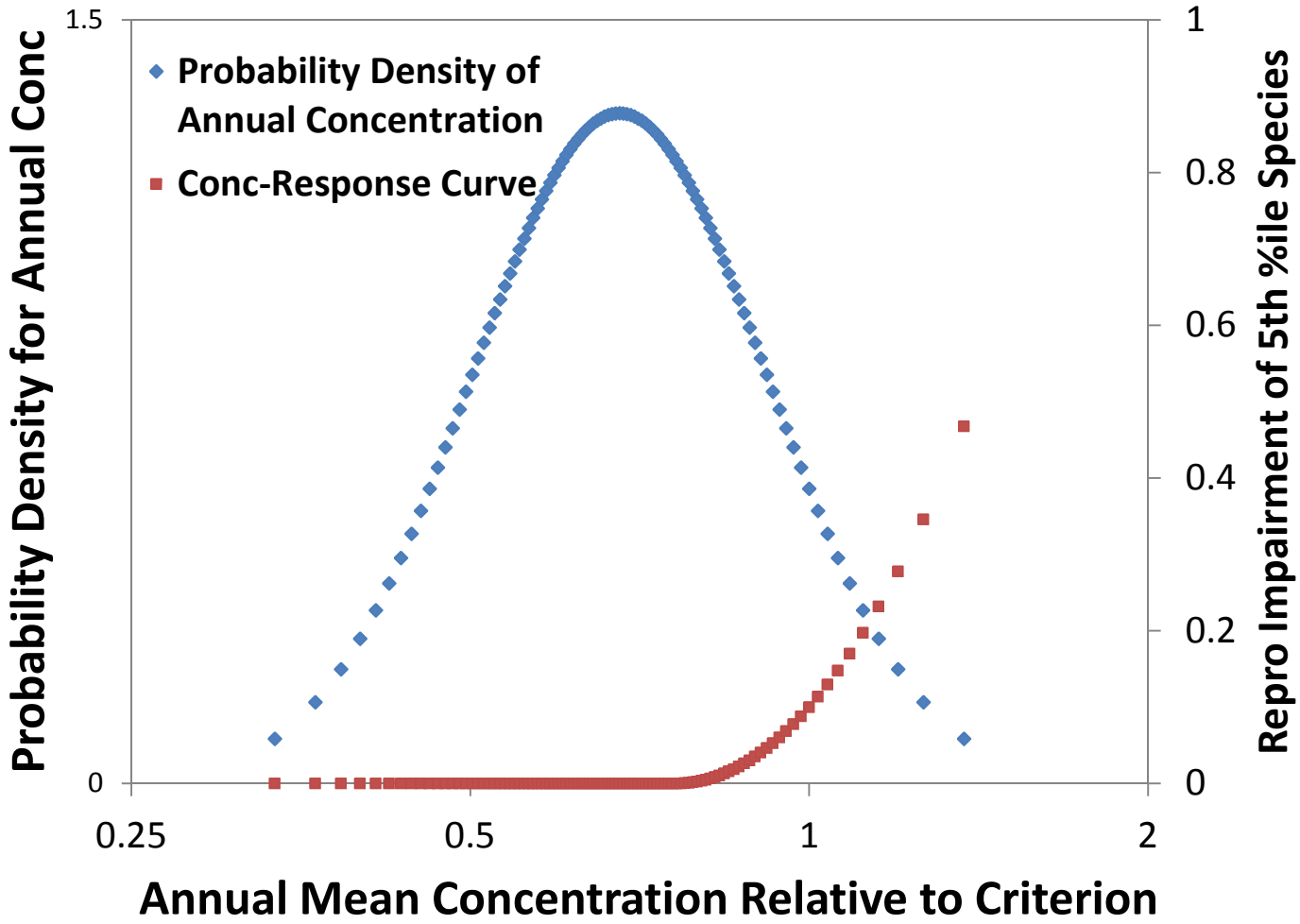
# Trial 2: Once in 3 Years



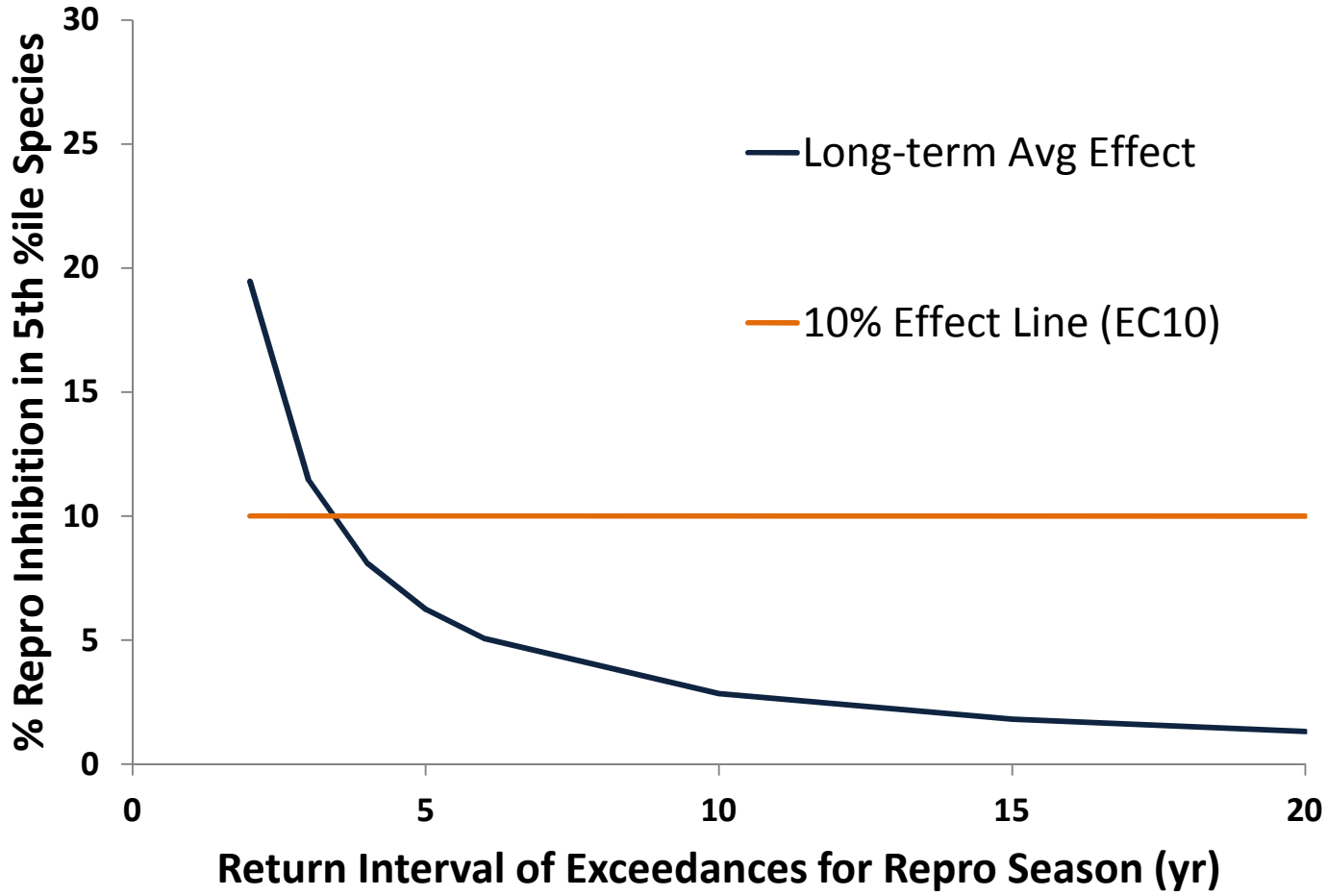
# Trial 3: Once in 5 Years



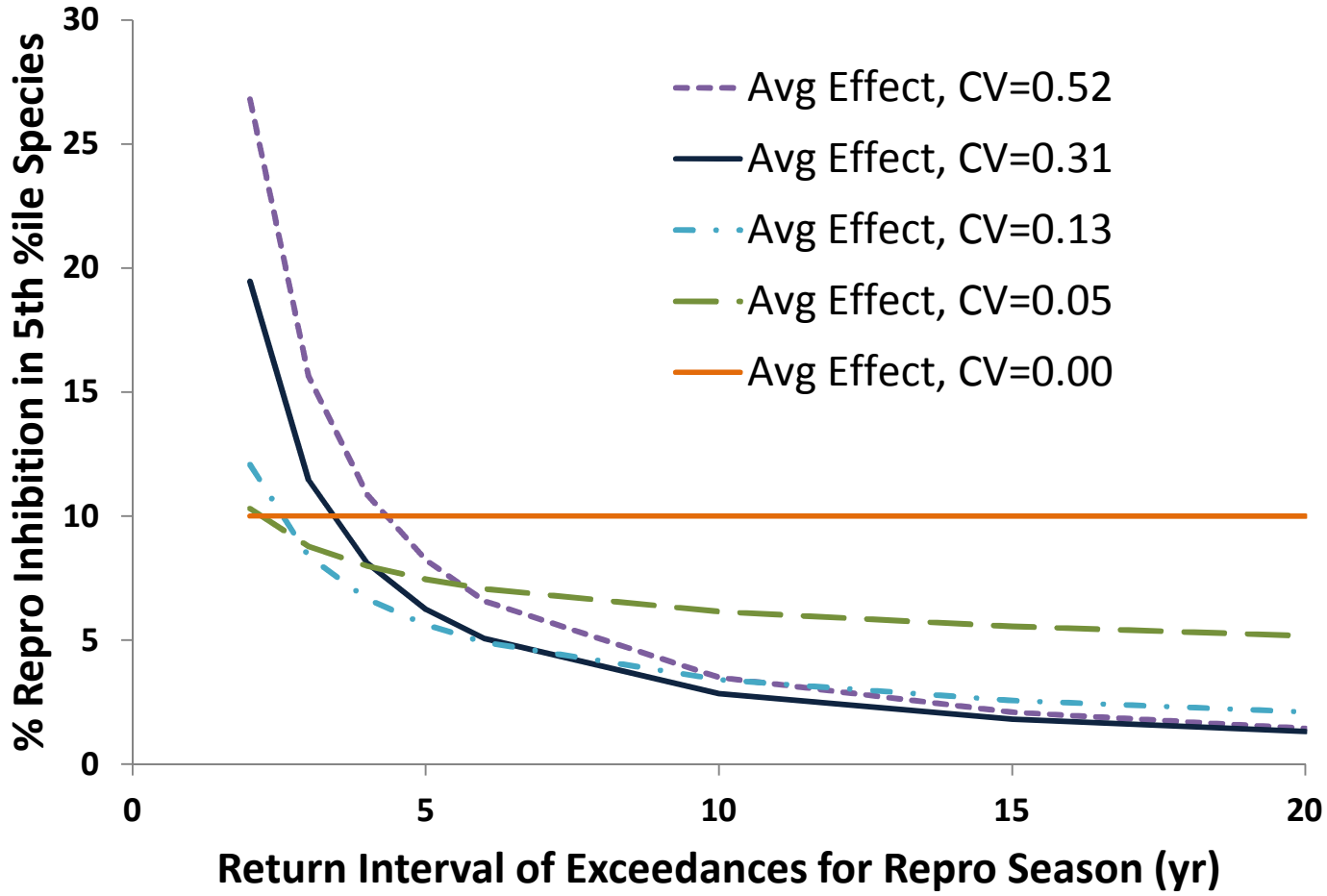
# Trial 4: Once in 10 Years



# Results for Various Exceedance Frequencies



# Influence of Annual Concentration Variability



# Complex Approach

- The next set of slides addresses the complex approach, which uses a time series of exposures rather than the statistical distribution of exposures.

# Higher Tier Assessment: Combined Application of Kinetic Toxicity Model and Population Model

*- For Each Species, Apply Two Models -*

- Kinetic toxicity model to translate from lab test exposures to continuously variable concentrations.
- Life-stage structured population model.

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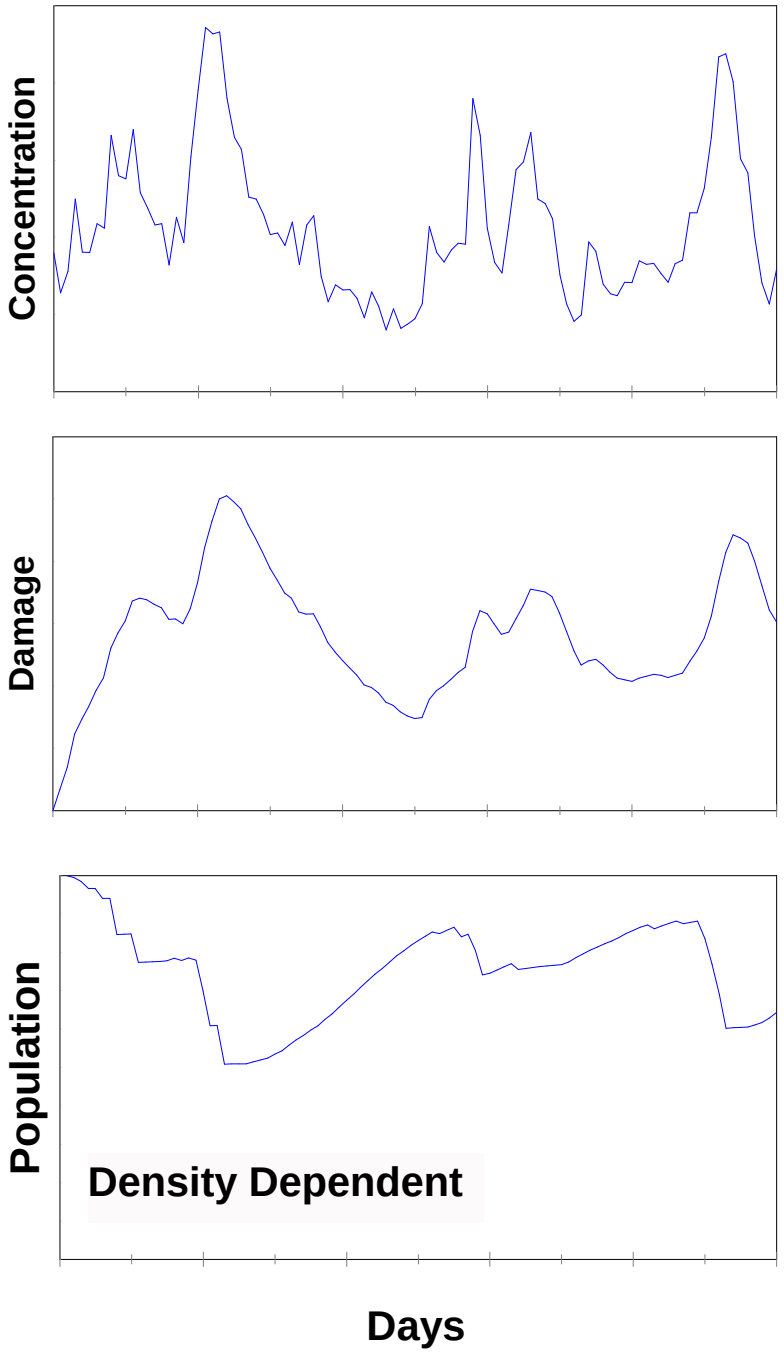
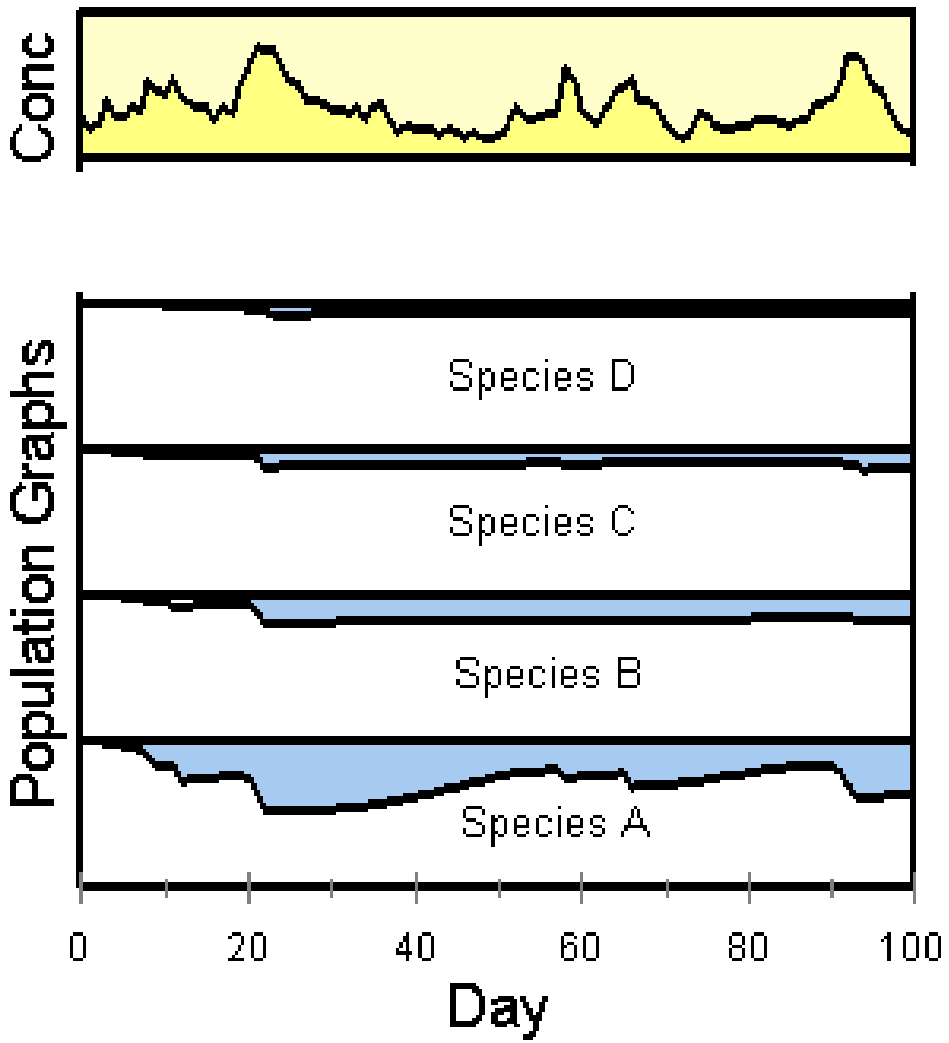
*- For Each Species, Apply Two Models -*

- Kinetic toxicity model to translate from lab test exposures to continuously variable concentrations.
- Life-stage structured population model.
- The combination allows discerning:
  - How sensitivity differs among individuals and between life stages.
  - How reductions in survival and reproduction differ in their effect on populations.
  - How population effects differ between species that recover rapidly and species that recover slowly.

- Toxicant concentration, short example
- Accumulation of stress in individuals of one species
- Population response in one species



# Generating an Assemblage Toxicity Index for Tested Representative Species



# Kinetic Toxicity Model

- Needed to predict toxicity of continuously variable concentrations
- Provides input (such as death rates) to population model.

# Minimum Data Needed to Calibrate Toxicity Model for Each Animal Species

- Required

- Acute LC50
- Chronic survival EC50 or EC20
- Chronic EC50/EC20 ratio (conc-response slope)

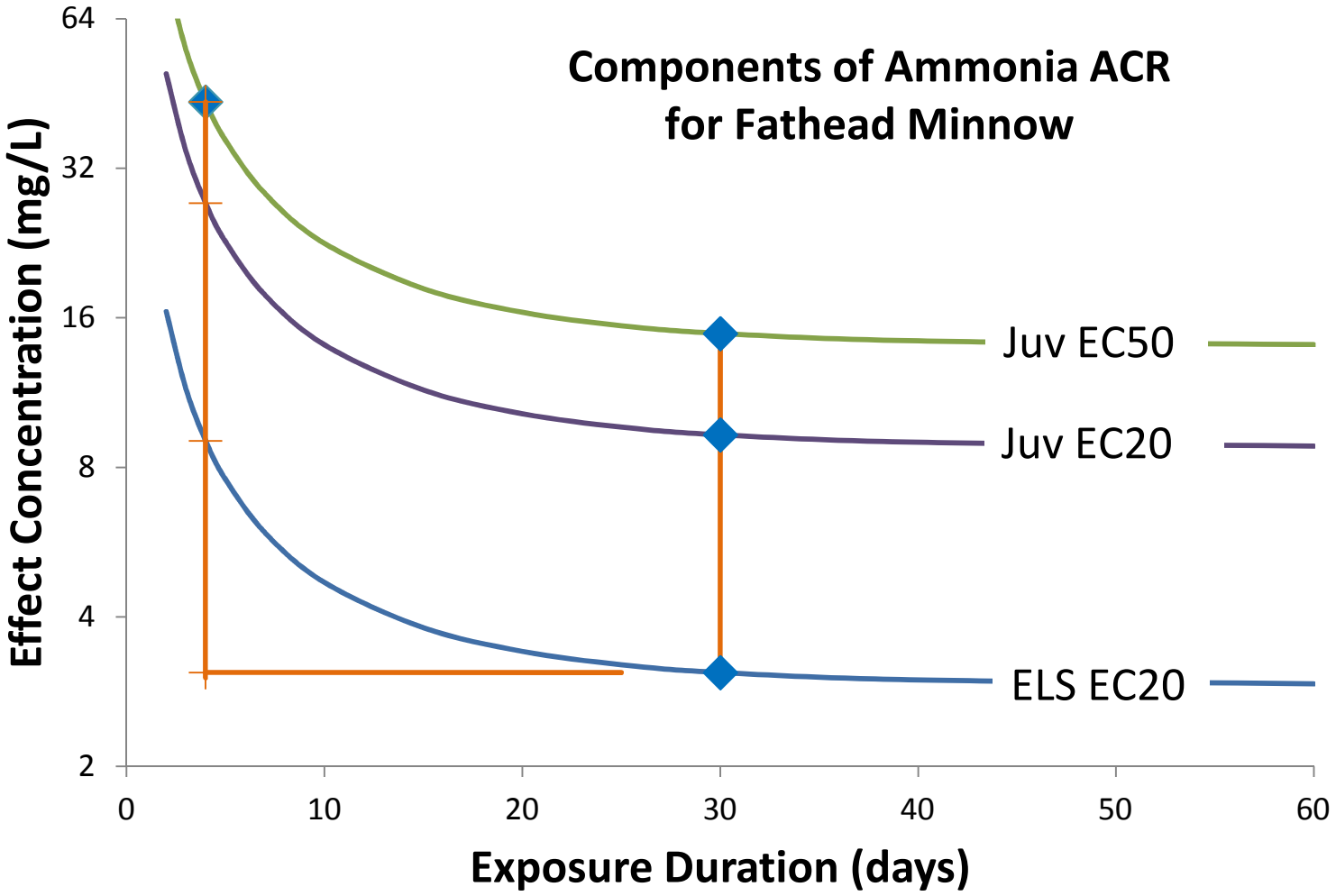
- Desirable

- Chronic ECx differences between early life stages and juvenile-adult stages

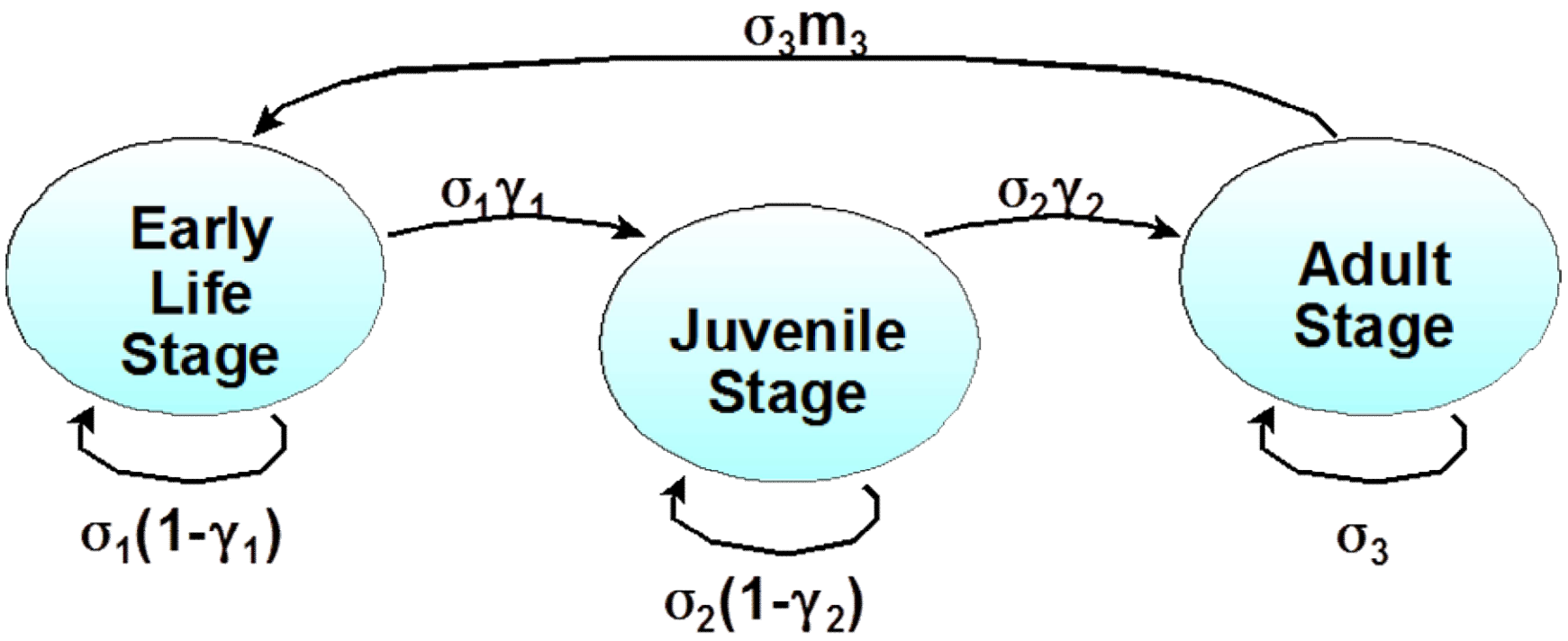
- Optional

- Chronic ECx differences between lethal and sublethal effects (growth-reproduction)

# Simple Use of the Kinetic Model to Help Understand Acute-Chronic Ratios



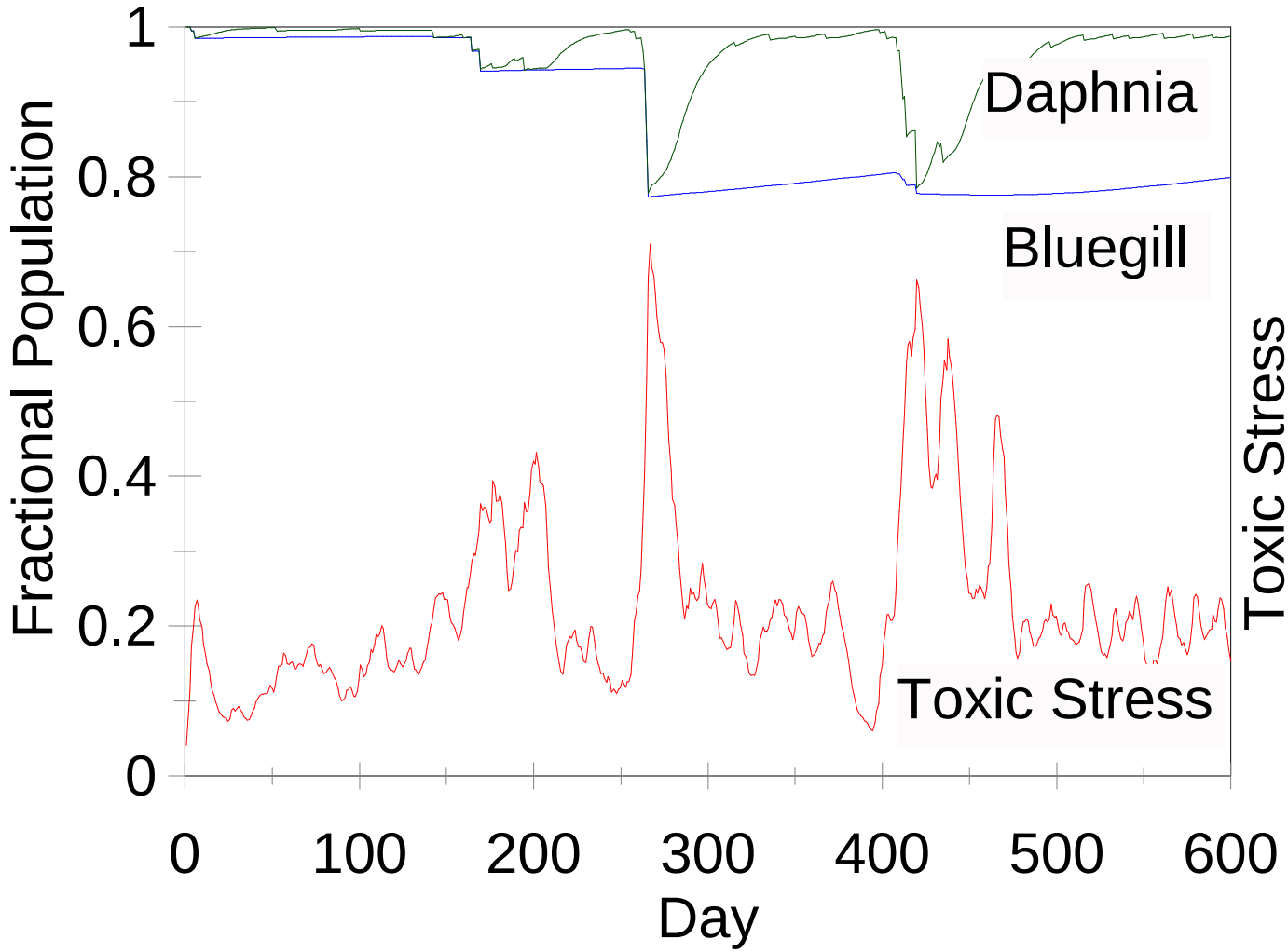
# Stage-Structured Population Model



# Population Model Input Parameters

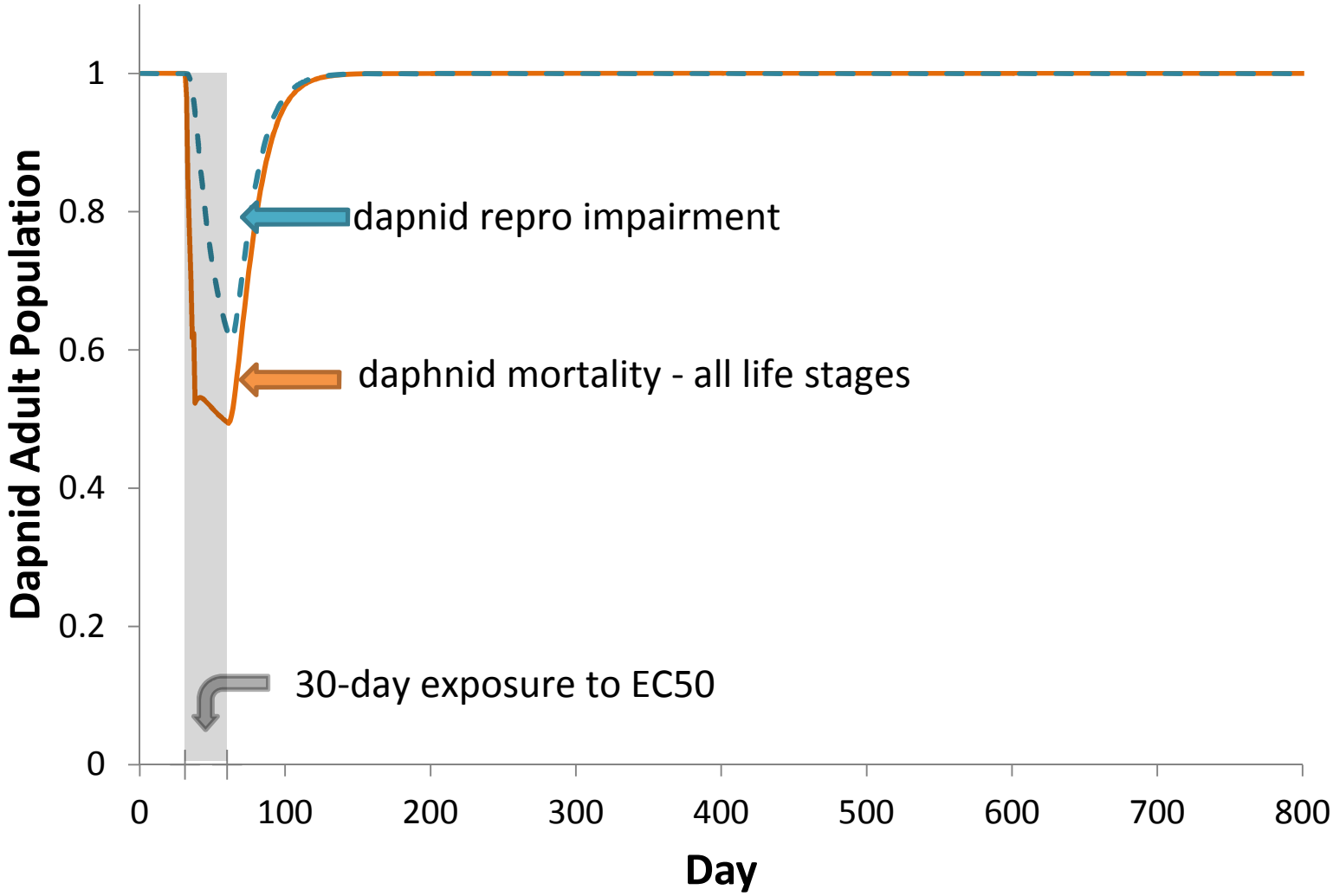
- Decide how many life stages you want to divide the species lifespan into.
- For each life stage, specify its:
  - Duration
  - Background survival rate
  - Reproductive rate – for adult stage(s) only.

# Modeling Effects on Populations



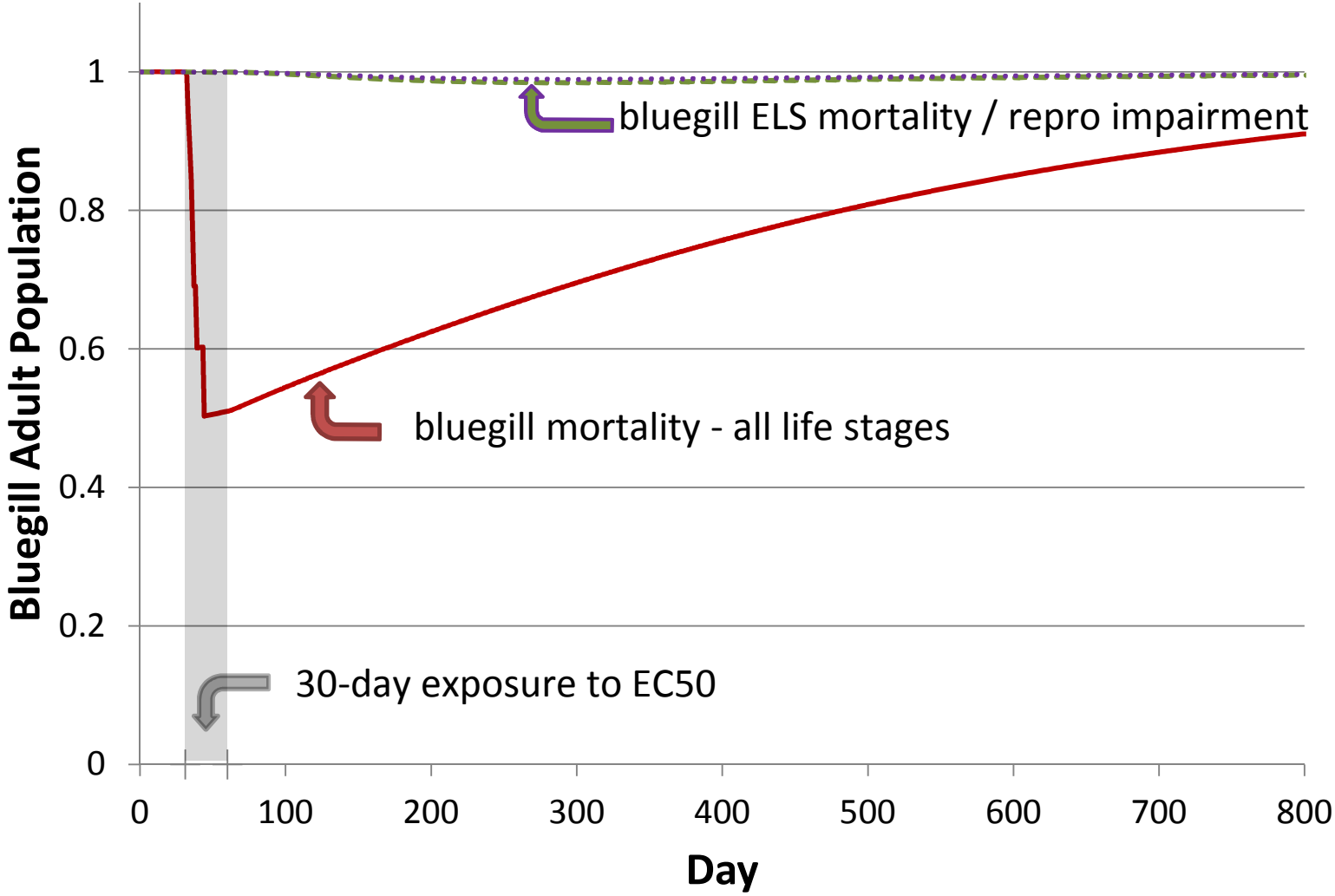
# Mortality v. Repro Effects

*Daphnia response to 30-day Pulse Exposure at EC50*



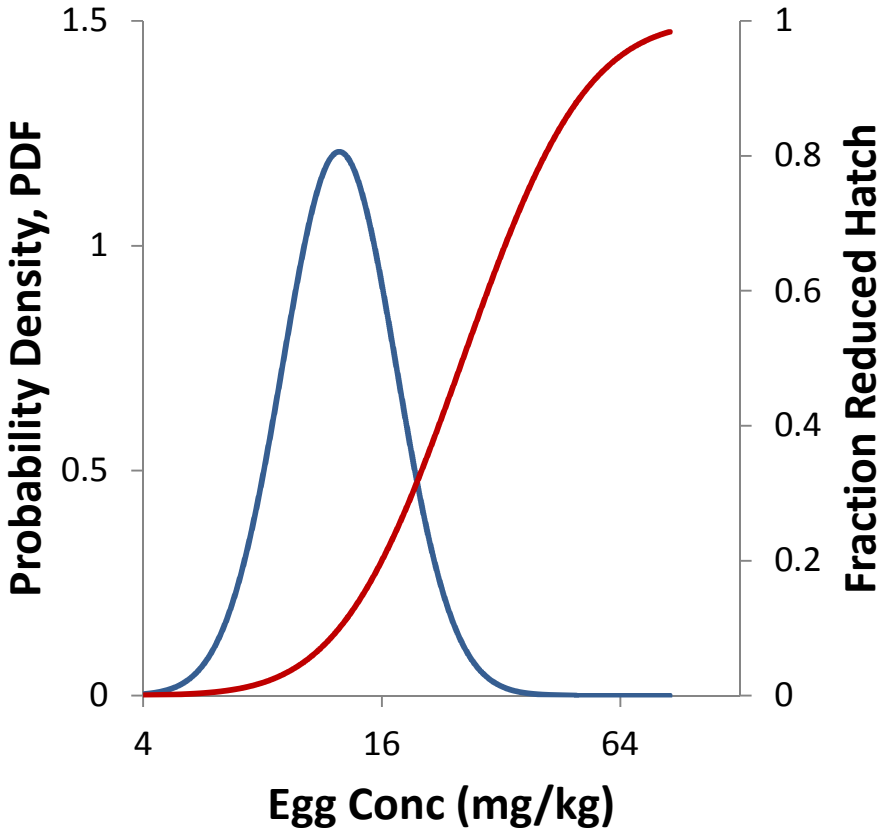
# Mortality v. Repro Effects

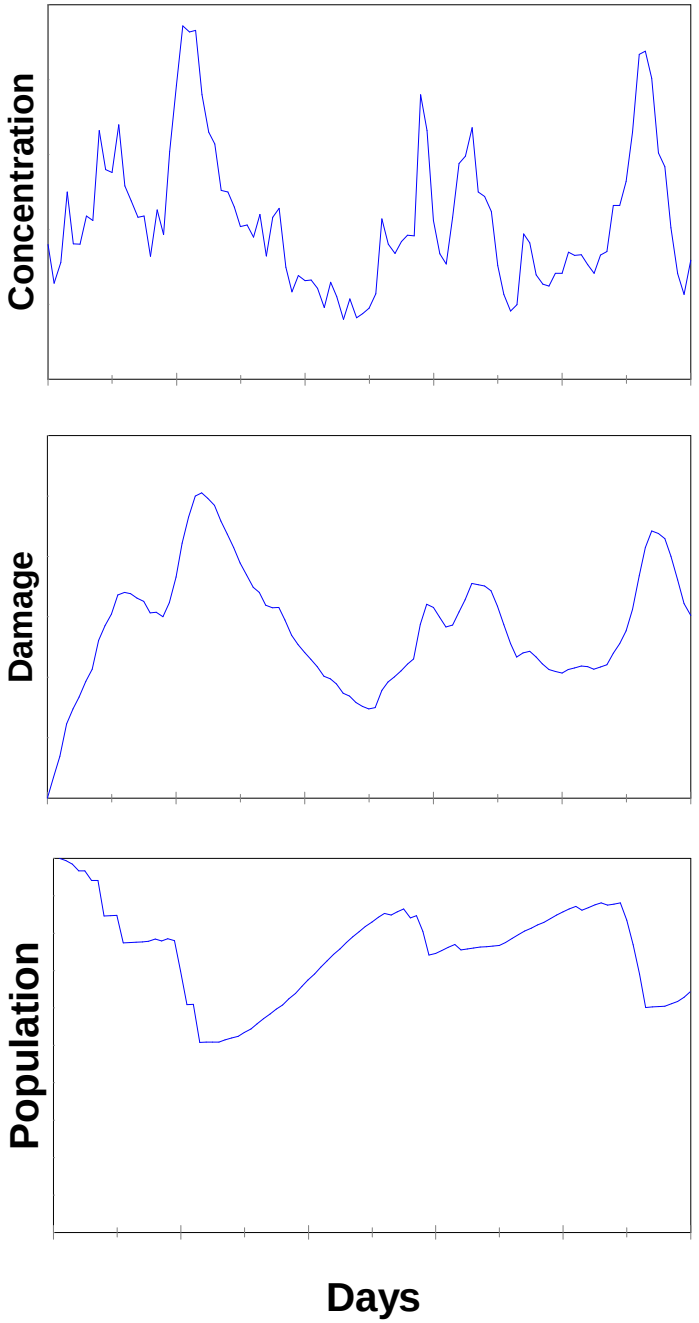
*Bluegill response to 30-day Pulse Exposure at EC50*



# Comparing the Simple and Complex Approaches:

## Coupled Concentration Distribution & Response Curve
## vs.
## Coupled Toxicity Model & Population Model


1.5
1
0.5
0
Probability Density, PDF
1
0.8
0.6
0.4
0.2
0
Fraction Reduced Hatch
4
16
64
Egg Conc (mg/kg)


Concentration
Damage
Population
Days

# Comparing the Simple and Complex Approaches:

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- Simple approach:
  - Bypasses kinetics of toxicity.
  - Bypasses sequencing of events.
  - Cannot discern life-stage sensitivity differences.
  - Cannot discern chronic lethal from sublethal effects.
  - Omits persistence of loss concepts (recovery time): cannot discern short-lived from long-lived species.

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