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Environmental Protection
Agency

EPA Tools & Resources Training Webinar:
The Web-based Interspecies Correlation Estimation (Web-ICE) tool for Ecological Risk Assessment

Sandy Raimondo
US EPA Office of Research and Development

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Presentation Outline

- Challenges of evaluating environmental impacts of chemicals
  - Ecological Risk Assessments (ERA) in the US
- How Web-ICE can help
  - Overview of ICE models
  - Examples and case studies
- Tool demonstration
- 2023 Web-ICE updates

Chemicals in the Environment

- More than 80,000 chemicals are or have been used in the US*
  - Pesticides increase food yield
  - Personal care products
  - Industrial chemicals used to make plastics, homewares, etc
  - Fire resistant coatings, suppressants ("forever chemicals")
  - Additives for aesthetics

- Chemicals are released into all environmental compartments
  - E.g., air, water, sediment, biota
  - Intentional release (e.g., pesticides, wastewater)
  - Accidental release (oil spills, industrial leakage)
  - Byproducts (mining, fossil fuel drilling)

* US EPA TSCA inventory

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Ecological Risk Assessment

EPA is responsible for protecting human health and the environment, ensuring clean air, land, and water.

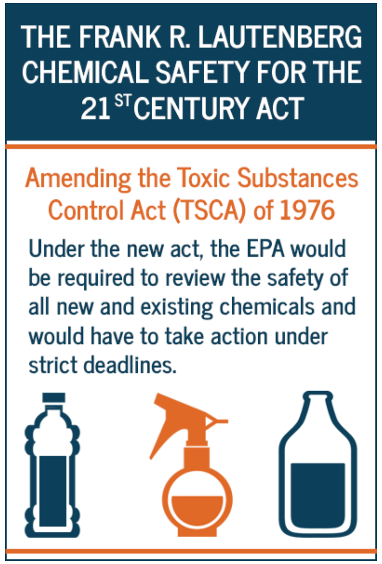
Ecological Risk Assessment (ERA) is the process for evaluating how likely it is that the environment might be impacted as a result of exposure to one or more environmental stressors, including chemicals.

- Where is a chemical found in the environment?
- How much of the chemical is there?
- What does the chemical do to animals and plants where it is located?
- What chemical concentrations causes adverse effects to animals and plants?
- What chemical concentrations are likely to be environmentally “benign” for diverse species?

“The dose makes the poison”

ERA in US Environmental Protection

- Federal Insecticide, Fungicide, Rodenticide Act (FIFRA)
- Clean Water Act (CWA)
- Toxic Substance Control Act (TSCA)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA/Superfund)
- Endangered Species Act (ESA)



Biodiversity Challenges in ERA

- Biodiversity is critical for a healthy environment*
  - > 140,000 invertebrates
  - ~ 3000 species of vertebrates
  - > 18,000 species of plants
  - > 1300 threatened or endangered
- Sensitivity of a chemical is often tested only on a few surrogate species
- International move to reduce animal testing in favor of New Approach Methodologies (NAMs)

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from the gallery of szymek drobniak

*Estimates for United States

How Web-ICE Can Help

Interspecies Correlation Estimation (ICE) models estimate acute toxicity* to untested taxa (species, genus, family) from the known toxicity of a surrogate species

ICE in ERA

- Model estimates increase biodiversity in toxicity database
- Direct toxicity estimation for endangered species
- Allows for species sensitivity comparisons

Rainbow trout

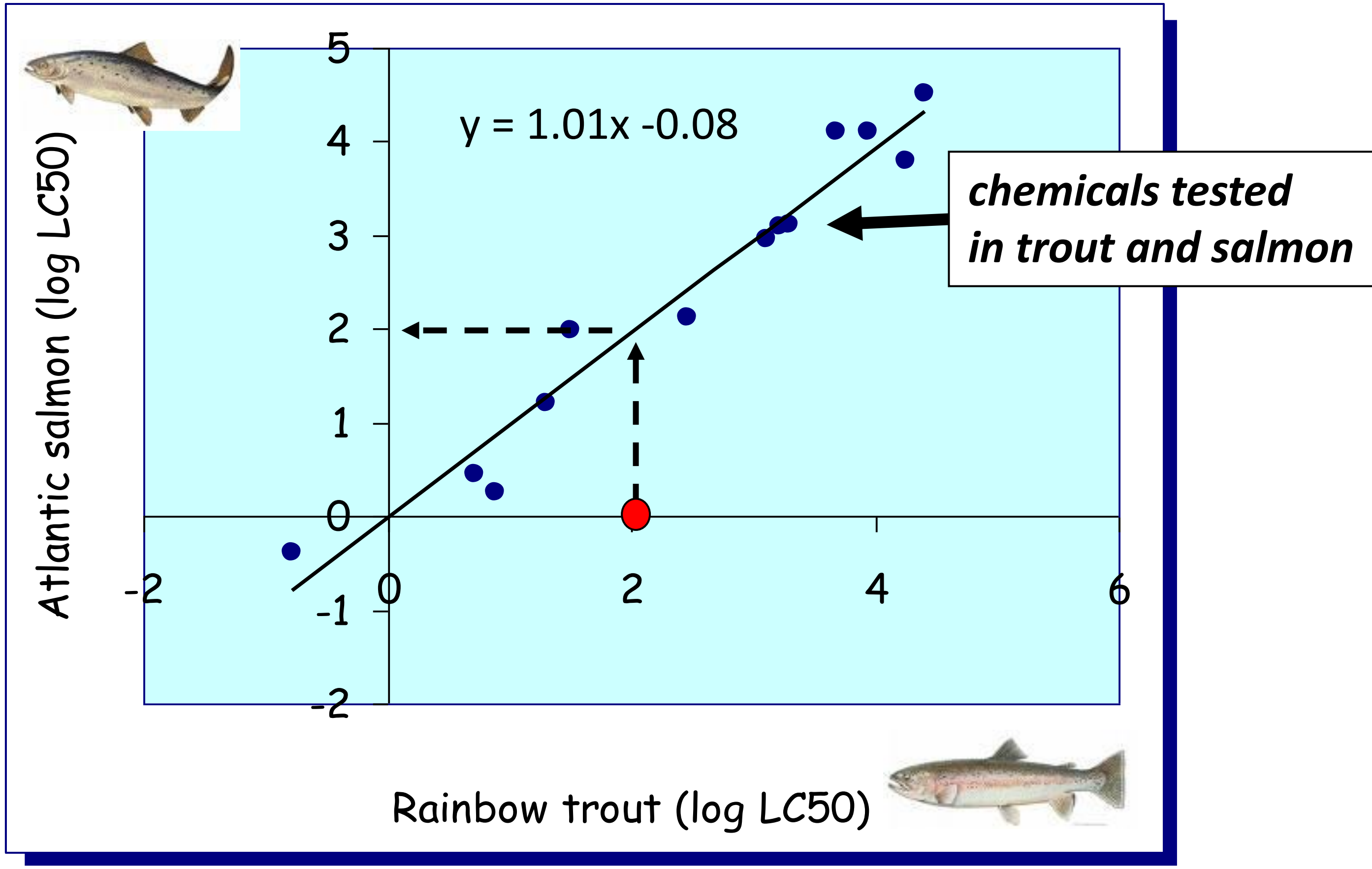
Atlantic salmon

*48-96 hr EC/LC/LD50

What Are ICE Models?

Log-linear models of the relationship between the acute toxicity of chemicals tested in two species.

1. Each ICE models is a relationship of inherent sensitivity between two species
2. Based on standardized database of existing test data
3. Extensive model validation and uncertainty analyses show high prediction accuracy when following user guidance



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How Well Do ICE Models Work?

17,416 data points validated through leave-one-out cross-validation (v3.3)

Shared taxonomic level	Significant models (N)	Percentage within predicted range (v3.3)			
		5-fold	10-fold	50-fold	> 50-fold
Genus (1)	444	95	99	100	0
Family (2)	1144	92	98	100	0
Order (3)	430	87	98	100	0
Class (4)	5734	77	87	97	100
Phylum (5)	1658	62	76	93	100
Kingdom (6)	8006	55	70	89	100

Interlaboratory variation of acute toxicity

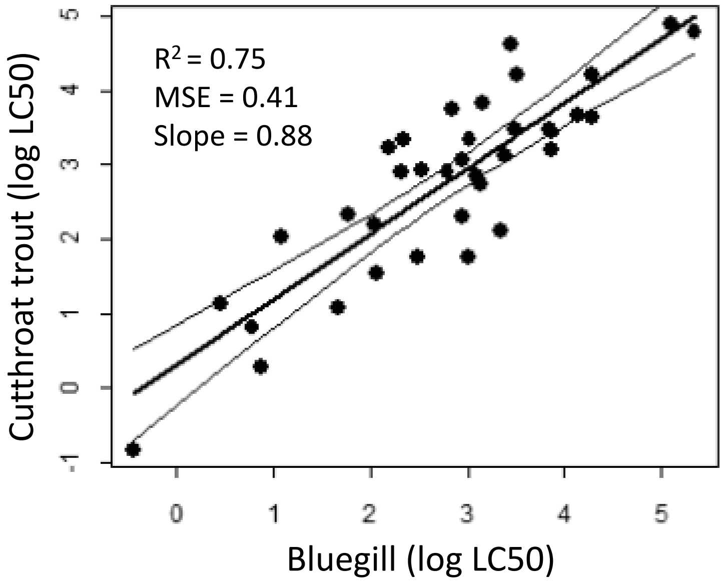
- ~11-fold average (max/min)
- Can range over two orders of magnitude (>100 –fold)

Willming et al. (2016), Raimondo et al. (in review)

User Guidance for Robust Predictions

High confidence, robust predictions associated with models containing:

- High R^2 (>~ 0.6)
- Low Mean Square Error (MSE; <~ 0.95)
- High slope (>~ 0.6)



Consistent & Reproducible

- 4 versions of ICE models for aquatic animals developed since 2007
- All version predict with same accuracy
- Different datasets
- Aquatic & wildlife

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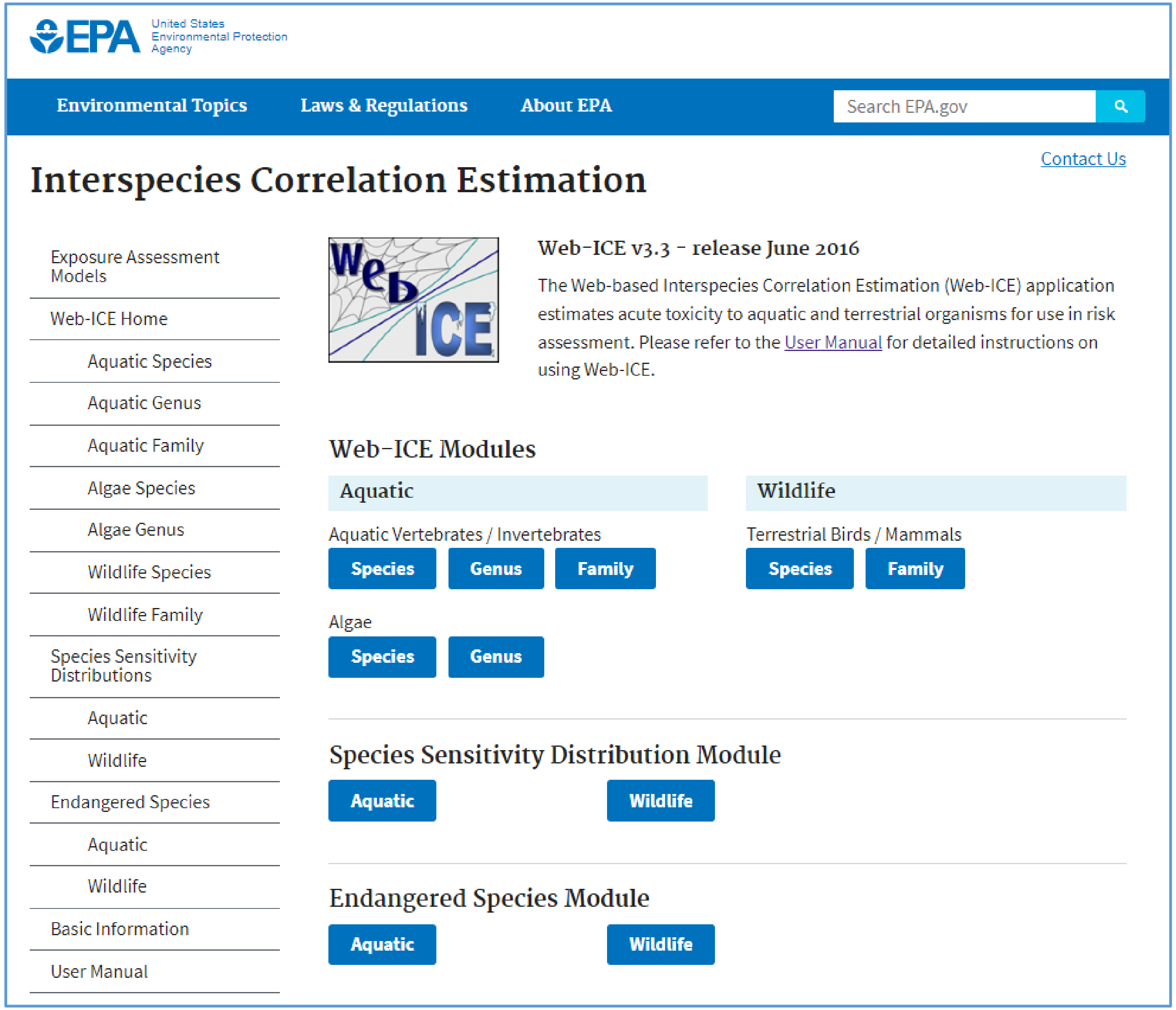
Web-ICE Application

- An internet application developed by the US EPA in 2007
- Publicly available collection of models (v3.3):
  - 3300 aquatic animal species, general, and families
  - 850 mammal and bird species and families
  - 100 algae species and genera
- Contains modules to:
  - Estimate toxicity to a single taxa
  - Derive acute hazard levels from diverse taxa
  - Estimate endangered species sensitivity
- Applicable to ERAs conducted under all regulatory statutes



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Case Study Demonstrations

1. National Water Quality Criteria (WQC)
   - EPA Office of Water (OW) under Clean Water Act (CWA)
   - Water quality benchmarks for the "Forever Chemical" PFOA (2022, draft)

2. Endangered Species Assessment for Aluminum in Oregon
   - Region 10 under CWA and the Endangered Species Act (ESA)
   - Aluminum WQC in Oregon (2020)

3. Chemical Evaluation under Toxic Substance Control Act (TSCA)
   - Office of Pollution Prevention and Toxics (OPPT) under TSCA
   - Data "poor" and data "rich" scenarios

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National Water Quality Criteria (WQC)

- EPA develops criteria for determining levels protective of humans and aquatic life using the latest scientific knowledge.
- These criteria are recommendations; state and tribal governments adopt these criteria or use them as guidance in developing their own.
- Criteria are a scientific assessment of ecological effects.
- EPA bases aquatic life criteria on how much of a chemical can be present in surface water before it is likely to harm aquatic animals, plants, and aquatic-dependent wildlife.
- EPA aquatic life criteria protect both freshwater and saltwater organisms from short-term and long-term exposure.
- For more information: https://www.epa.gov/wqc

50 Clean Water Act 1972-2022 The Next 50 Years

WQC Minimum Data Requirements (MDRs)

Freshwater		Saltwater	
A	The family Salmonidae	A	Family in the phylum Chordata
B	A second family of Osteichthyes[1] preferably a commercially or recreationally important warmwater species	B	Family in the phylum Chordata
C	A third family in the phylum Chordata[2]	C	Either the Mysidae or Penaeidae family
D	A planktonic crustacean	D	Family in a phylum other than Arthropoda or Chordata
E	A benthic crustacean	E	Family in a phylum other than Chordata
F	An insect	F	Family in a phylum other than Chordata
G	A family in a phylum other than Arthropoda[3] or Chordata	G	Family in a phylum other than Chordata
H	A family in any order of insect or any phylum not already represented	H	Any other family

[1] Bony fish; [2] Vertebrates and relatives; [3] Invertebrates with exoskeleton

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Fulfilling the MDRs for PFAS Chemicals

2022 Draft Aquatic Life Criteria for Perfluorooctanoic Acid (PFOA)

https://www.epa.gov/wqc/aquatic-life-criteria-perfluorooctanoic-acid-pfoa#2022

Freshwater

A	The family Salmonidae
B	A second family in the Osteichthyes, preferably a commercially or recreationally important warmwater species
C	A third family in the phylum Chordata
D	A planktonic crustacean
E	A benthic crustacean
F	An insect
G	A family in a phylum other than Arthropoda or Chordata
H	A family in any order of insect or any phylum not already represented

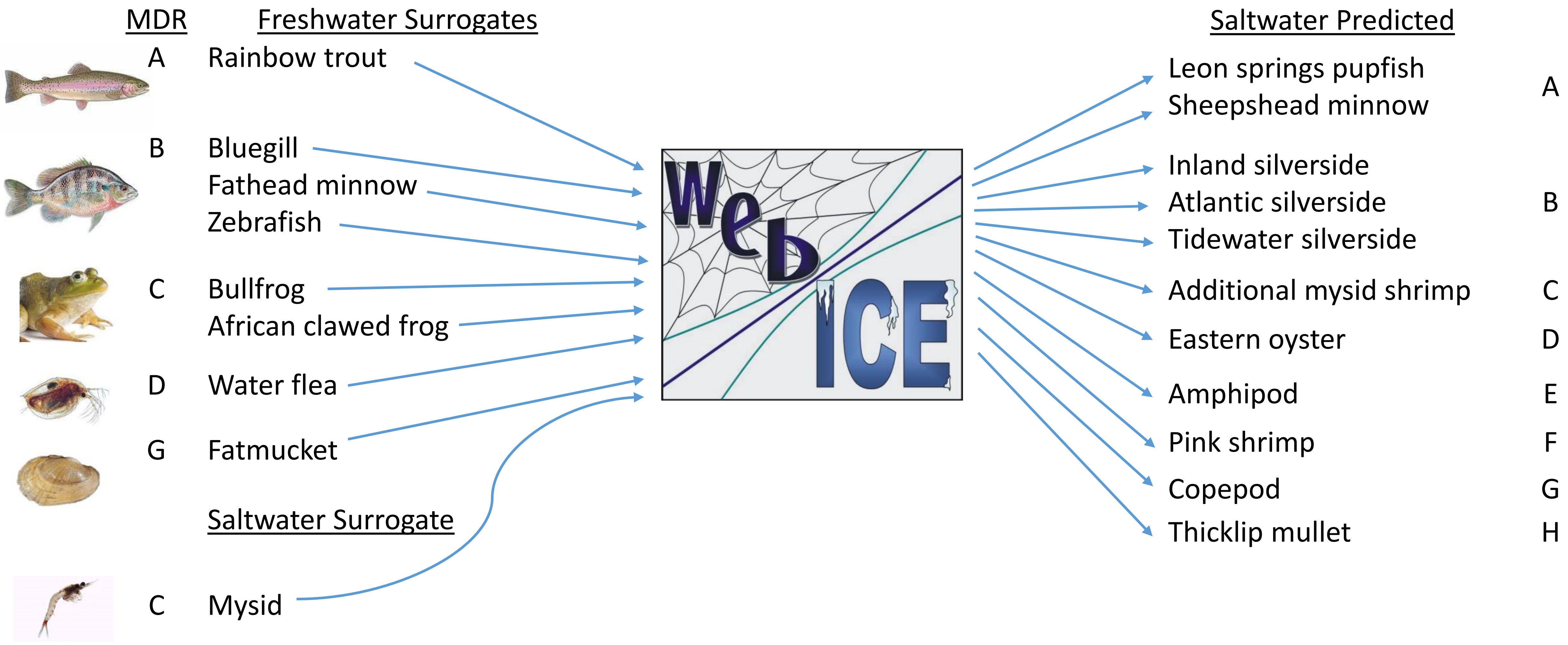
Saltwater

A	Family in the phylum Chordata
B	Family in the phylum Chordata
C	Either the Mysidae or Penaeidae family
D	Family in a phylum other than Arthropoda or Chordata
E	Family in a phylum other than Chordata
F	Family in a phylum other than Chordata
G	Family in a phylum other than Chordata
H	Any other family

Test data available (green): C, D, F

Test data not available (red): A, B, E, G, H

Fulfilling the MDRs for PFAS Chemicals



* Used as weight of evidence

Endangered Species Assessments

- Under ESA, federal actions cannot jeopardize listed species
  - Pesticide and chemical registration
  - Water quality criteria
- ERAs must focus on endangered species when and where they may co-occur with federal action
- Aluminum Water Quality Criteria (WQC) in Oregon (2020)
  - Federal action: to establish aluminum water quality criteria to protect aquatic life in freshwaters under the jurisdiction of the State of Oregon.
  - Consultation: 18 listed species
  - Link: https://gaftp.epa.gov/region10/ORAI/Revised_BE/Main_010220_clean.pdf

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The Green Sturgeon and Aluminum

Green Sturgeon (*Acipenser medirostris*)

- Anadromous: live in both fresh and saltwater of the Pacific Northwest
- Spawning and juvenile rearing in rivers
- Migration to saltwater to feed, grow, and mature, returning to freshwater to spawn
- Long-lived, slow-growing fish
- Listed as threatened under ESA in 2006

www.worldlifeexpectancy.com

Aluminum (Al)

- One of the most common, naturally occuring elements
- Sources of Al in Oregon:
  - Mining and other activities that release it from soils
  - Urban stormwater, industrial discharge, wastewater effluent, agriculture/forestry, atmospheric deposition
- Non-essential to wildlife
- Can affect ability to regulate ions, like salts, and inhibit respiratory functions, like breathing.
- Can accumulate on the surface of fish gills, leading to respiratory dysfunction, and possibly death.

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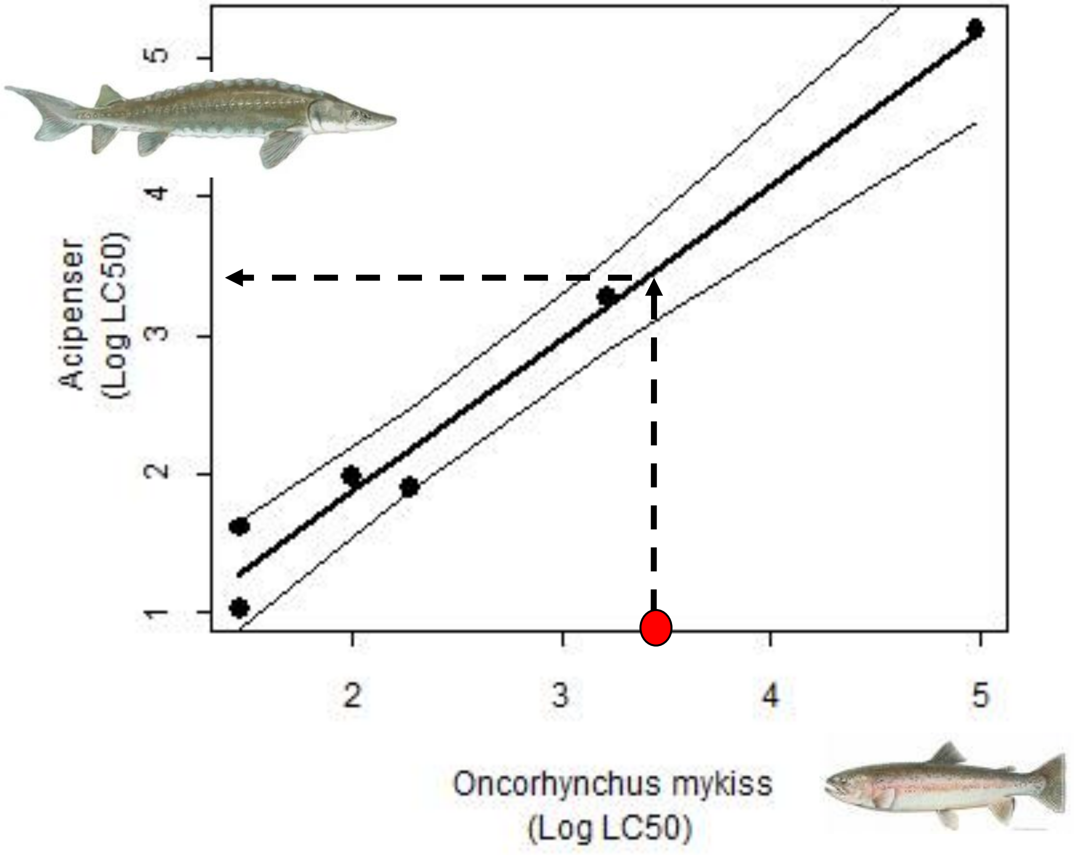
Effects of Al on Green Sturgeon

- Al toxicity data were not available for any species within the Order Acipenseriformes
- 15 surrogate species were available to predict to the genus *Acipenser* in Web-ICE v3.3
- The Rainbow trout-to-*Acipenser* ICE model was selected based on model guidance
  - Rainbow trout acute value = 3,312 µg/L
  - *Acipenser* Genus Mean Acute Value (GMAV) of 3,593 µg/L

GMAV/adjustment factor = LC05

- Conclusions based on this value*:
  - The Criterion Continuous Concentration was protective of the Green sturgeon
  - The action would result in a slight increase in mortality if exposed to the criterion *maximum* concentration



*Conclusions only applicable to populations of Green sturgeon in Oregon

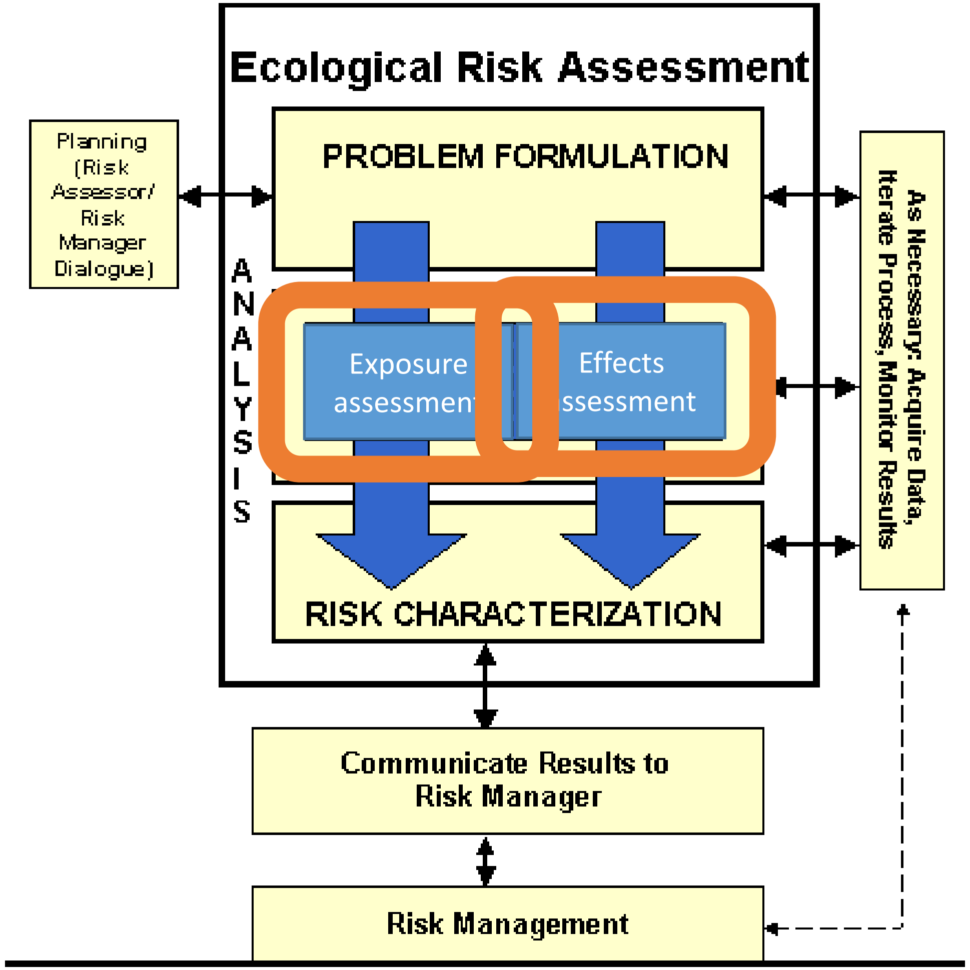
TSCA Chemical Evaluation

As amended by the Frank R. Lautenberg Chemical Safety for the 21st Century Act:

- Requires EPA to evaluate existing chemicals with clear and enforceable deadlines

Prioritization → Risk Evaluation → Risk Management

- Risk evaluations determine whether a chemical presents an unreasonable risk to health or the environment under the conditions of use
- EPA must have at least 20 chemical risk evaluations ongoing at any given time on High-Priority Substances
- No MDRs, ERAs typically based on limited toxicity data
- Follow the EPA ERA paradigm



Link: https://www.epa.gov/assessing-and-managing-chemicals-under-tsca/chemicals-undergoing-risk-evaluation-under-tsca

Hazard Assessments

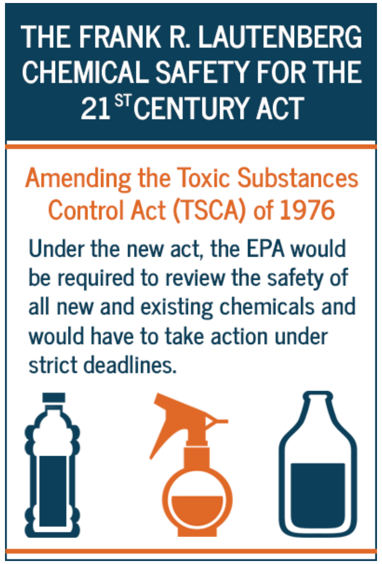
Chemicals

Compound A:

- Flame retardant and plasticizer
- Hazardous Substance List, regulated as a workplace hazard
- Data “rich”

Compound B:

- Gasoline additive, solvent for resins, gums, and waxes
- Data “poor”



Standard Methodologies

Species Sensitivity Distribution

- Cumulative probability distribution of species sensitivity
- Hazardous Substance List, regulated as a workplace hazard
- Data “rich”

Assessment Factor (AF) Approach

- Identify most sensitive species
- Divide by AF (i.e., 5)

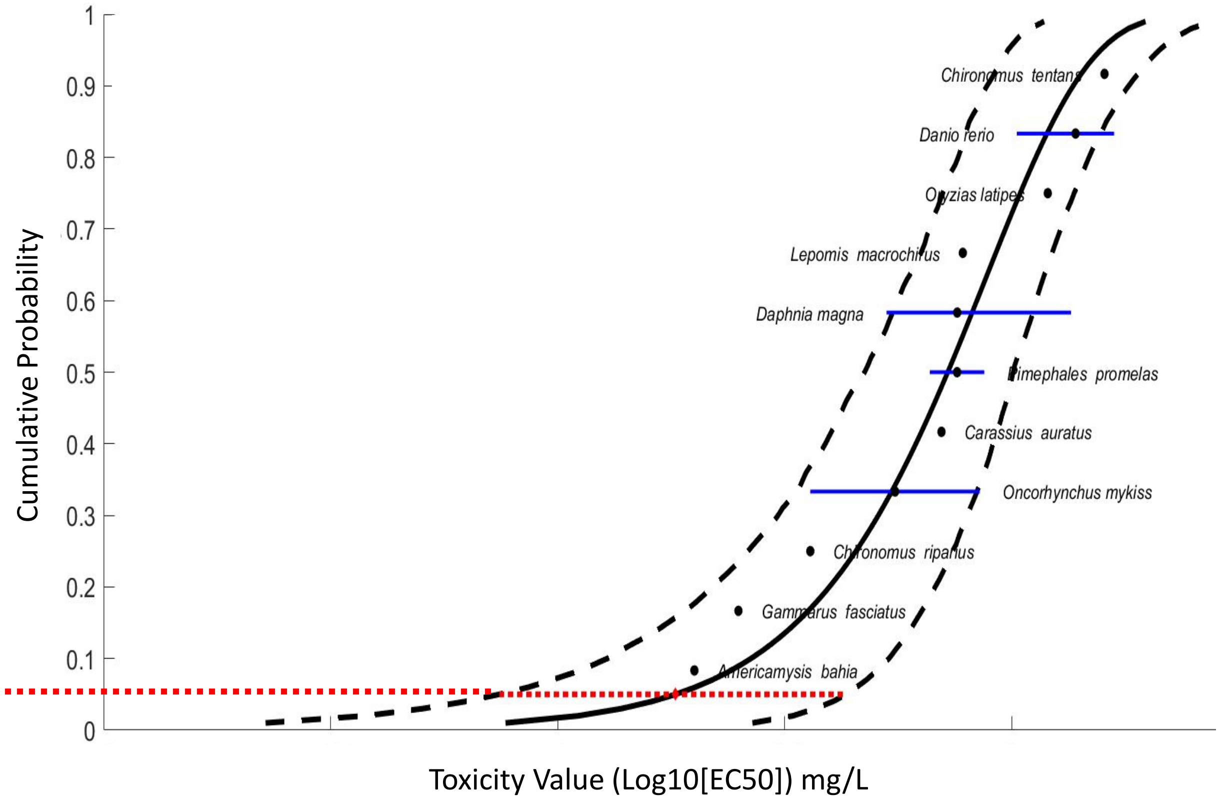
Chemical A: "Data rich"

Measured acute toxicity:

1. Mysid shrimp
2. Amphipod
3. Midge (2 species)
4. Rainbow trout
5. Goldfish
6. Daphnia
7. Fathead minnow
8. Bluegill
9. Medaka
10. Zebrafish

HC5 = Hazardous concentration of 5th percentile

Species Sensitivity Distribution (SSD)



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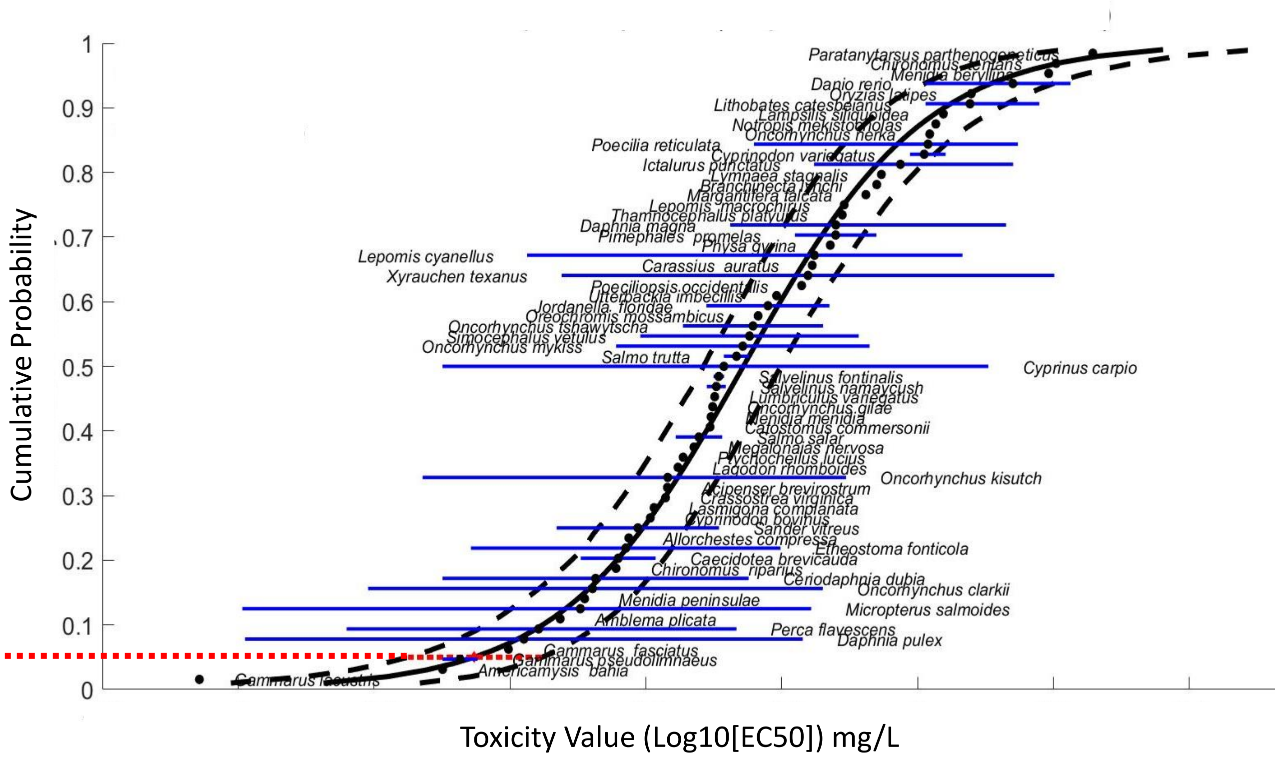
Chemical A Supplemented by ICE

> 60 diverse species:
- Fish
- Amphibians
- Molluscs
- Insects
- Crustaceans
  - Benthic
  - Planktonic

HC5 =
Hazardous concentration of 5th percentile



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Chemical B: “Data poor”

Measured acute toxicity:

1. Daphnids (2 species)
2. Fathead minnow
3. Sheepshead minnow
4. Medaka

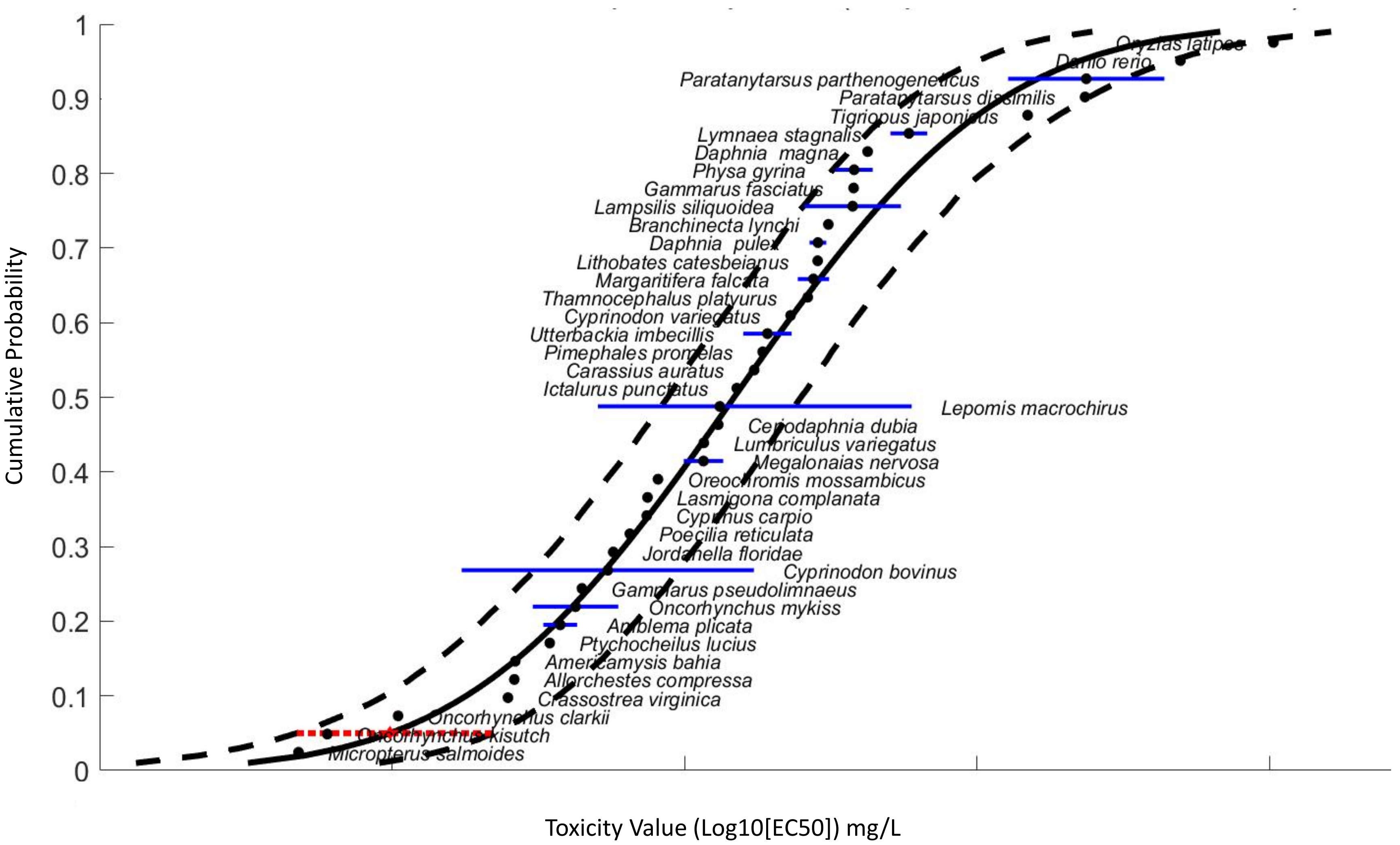
Assessment factor

$$\frac{\text{Most sensitive species} = 3.6 \text{ mg/L}}{\text{AF} = 5} = 0.72 \text{ mg/L}$$

[HC?]

Web-ICE

Chemical B Supplemented by ICE



Web-ICE Tutorial

www3.epa.gov/webice

Web-ICE Version 3.4 Coming in 2023!

- Updated models for aquatic animals:

	Models		Taxa	
Model level	v3.3	v3.4	v3.3	v3.4
Species	1550	2294	126	175
Genus	854	1077	43	66
Family	887	1350	41	66

Taxa	New Species in v3.4
Amphibian	2
Bryozoan	3
Crustacean	24
Fish	6
Insect	3
Worm	14

- Additional species and models significantly advance the ability to reduce animal testing for acute toxicity through interspecies extrapolations.

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Contact

Sandy Raimondo
Senior Research Ecologist
Center for Environmental Measurement and Modeling
US EPA Office of Research and Development
Raimondo.sandy@epa.gov
850-934-2424

Visit Web-ICE at: www3.epa.gov/webice

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