Exploration of Methods for Characterizing Effects of Chemical Stressors to Aquatic Plants

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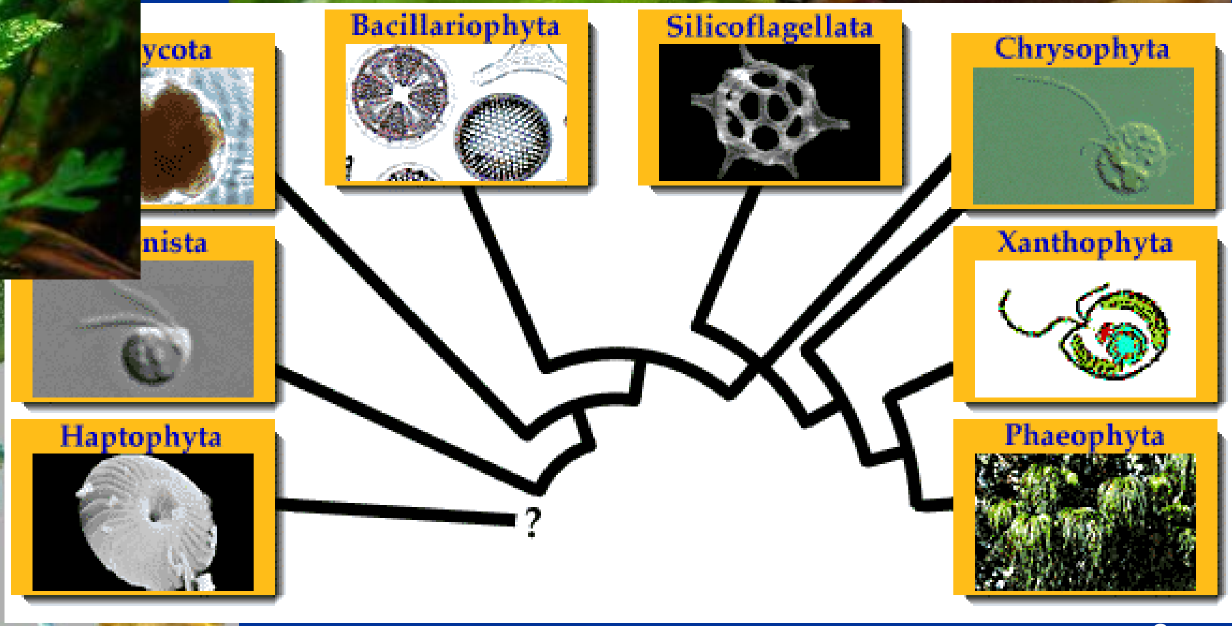
Outline

- Purpose and Scope
- Existing approaches
- Plant relative sensitivity
- Proposed approaches

Plant Community

What is a plant?



Scope of Plant Methodology

- Consider existing approaches used by OW, OPP and others for characterizing plant aquatic ecological effects

- Describe the best integrated use of existing tools for incorporating plant effects into aquatic community-level screening values

- Characterize the uncertainty and robustness of current data for aquatic plants

OPP's Approach to Evaluate Aquatic Plant Effects

- Tier I (Limit test)
  - Needed for all pesticides with outdoor uses
  - 4 microalgae + *Lemna:* laboratory tests with Technical Grade Active Ingredient (TGAI)
  - If >50% effect, Tier II testing required
- Tier II (Dose-response test)
  - Pesticides that are known phytotoxins also tested at Tier II
  - 4 microalgae + *Lemna:* laboratory tests with TGAI
- Tier III (Field test)
  - 4 vascular plant families, 3 seedless vascular plant families, 10+ families of algae, 1 bryophyte family tested with typical end-use product to determine detrimental effects at critical growth stages
  - Rarely required by the Agency

Typical Aquatic Plant Surrogates Used in US Regulatory Testing

Non-vascular plants

Pseudokirchneriella subcapitata

Anabaena flos-aquae

Navicula pelliculosa

Skeletonema costatum

***Lemna gibba*, a free-floating vascular macrophyte**

OW's Approach to Evaluate Aquatic Plant Effects

- Minimal plant data are required for the derivation of Water Quality Criteria
- "Results of tests with plants usually indicate that criteria which adequately protect aquatic animals and their uses will probably also protect aquatic plants and their uses."
  - May not be supported when addressing certain chemical classes (e.g., herbicides)
- Plant value based on a 96-hr test conducted with an alga or a chronic test conducted with an aquatic vascular plant
- Final Plant Value: lowest value from a test with an "important" plant species where test concentrations are measured, and endpoint is biologically "important".

Approaches Used Internationally

- Canada
  - At least one vascular plant or alga to derive guidelines (if the compound is highly phytotoxic, 4 species are required)
  - SSDs
  - Safety factors
- European Union
  - Requires a green algae test (for herbicides, tests on an alga and a vascular plant)
  - SSDs
  - Safety factor

State Approach (MN)

- Derivation of standards for herbicides acetochlor and metolachlor
- Protection goals:
  - Protect overall integrity of plant community, avoiding negative shifts in species composition
  - Protect most sensitive species, if it is ecologically important
  - Target 20^{th} percentile level of protection (5^{th} percentile of EC50 values or 20^{th} percentile of MATC values)

State Approach (MN)

- Acute criterion derived using Great Lakes Initiative Tier II methodology with standard animal data
- Chronic criterion derived using distribution of plant data only
- Both EC_{50} values and/or maximum acceptable toxic concentration (MATCs) were collected and put in separate distributions

State Approach (MN)

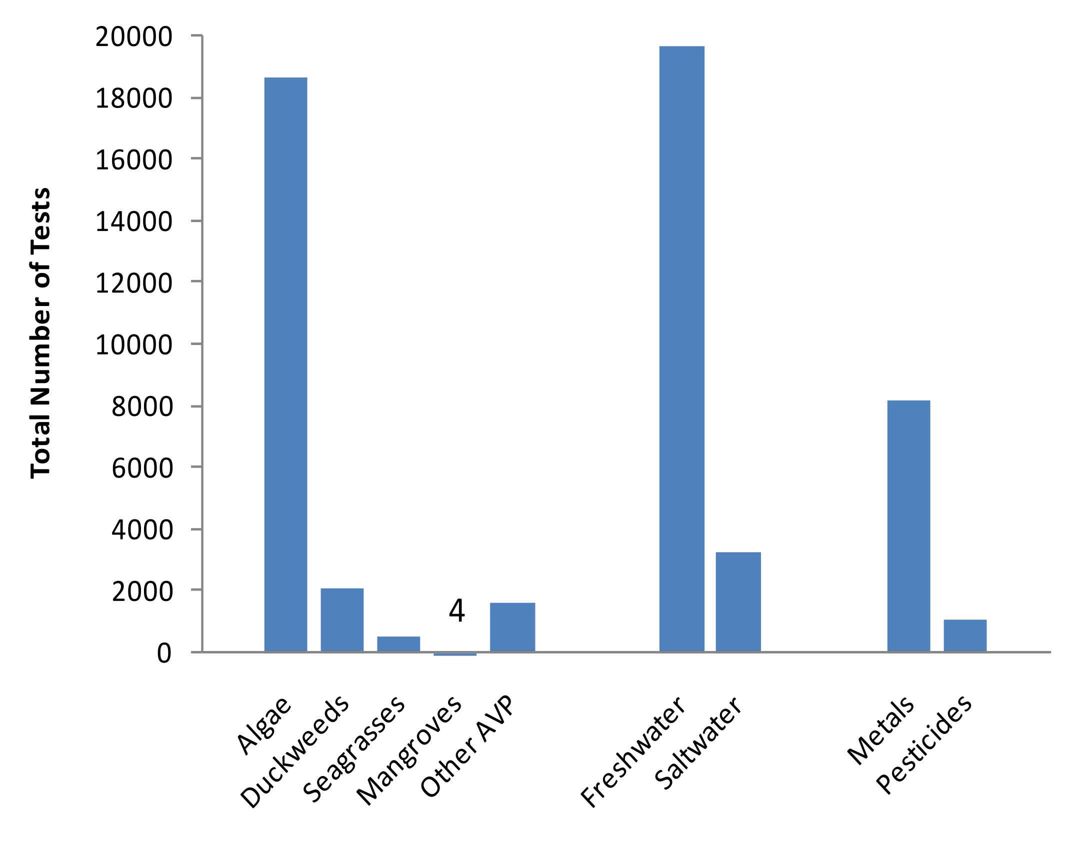
- Different endpoints and durations were combined to create SSDs
- Percentile value was chosen based on data set robustness or statistical considerations

Parameter	Acetochlor		Metolachlor	
	N	Value (ug/L)	N	Value (ug/L)
5^{th} %tile of EC50	8	0.093	18	35.6
20^{th} %tile of MATC	8	1.74	9	11.1
Final Criterion		3.6		23

Sources of Uncertainty

- Toxicity study endpoints
  - Type of effect
  - Summary statistics
  - Duration
- Relative Sensitivity of standard test species
  - Physiology
  - Habitat

Standard Plant Data

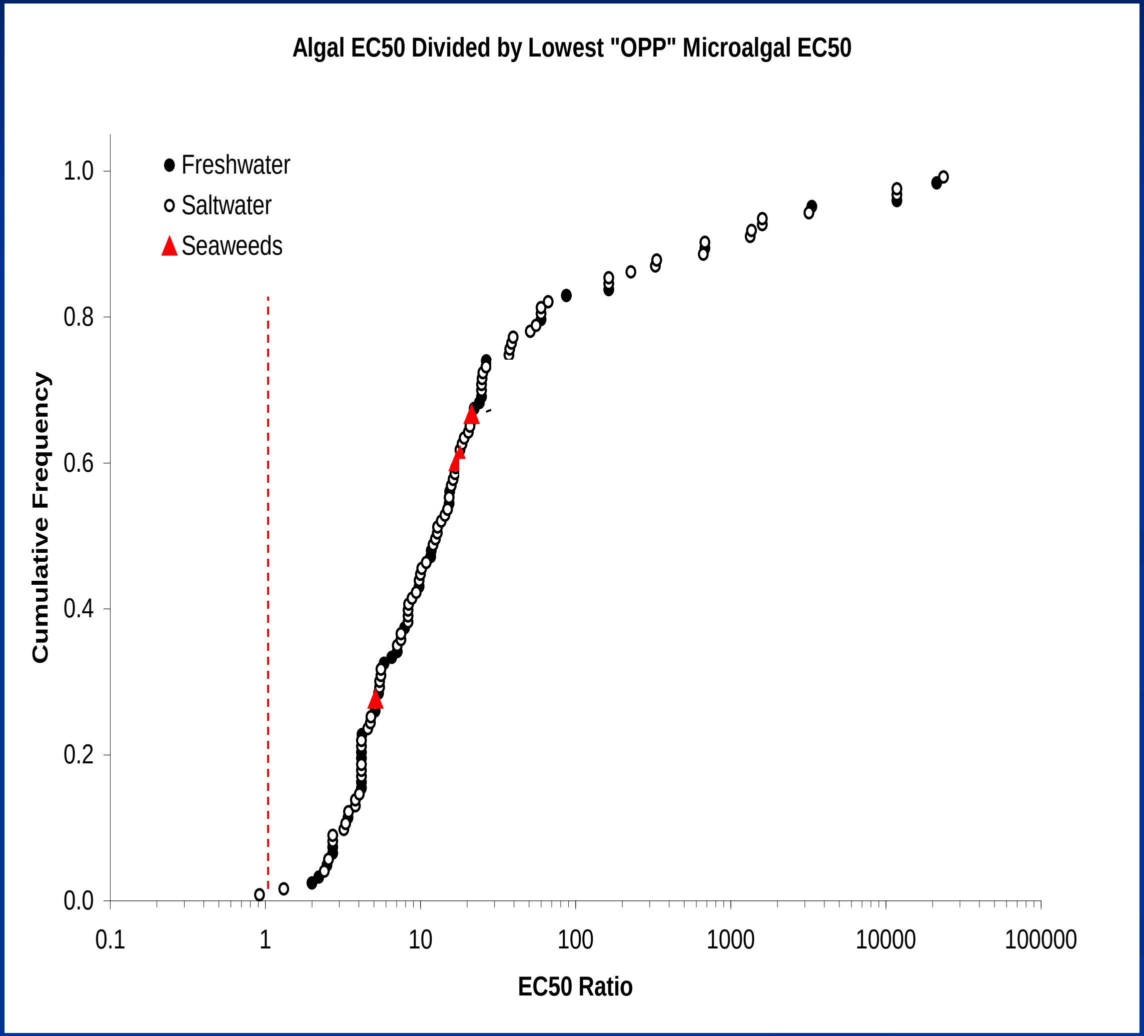


- Most plant studies conducted using freshwater species, especially microalgae

Non-vascular

- Are the sensitivities of current microalgal species representative of non-vascular plant sensitivities?
  - Limited information available for comparison of sensitivities of standard algal species to other non-vascular families such as mosses and liverworts
  - Many tests compared sensitivities of various freshwater microalgal species - great variation (2 to 10-fold differences) between species for same toxicant
  - Sensitivities of freshwater vs. saltwater algae are not well understood

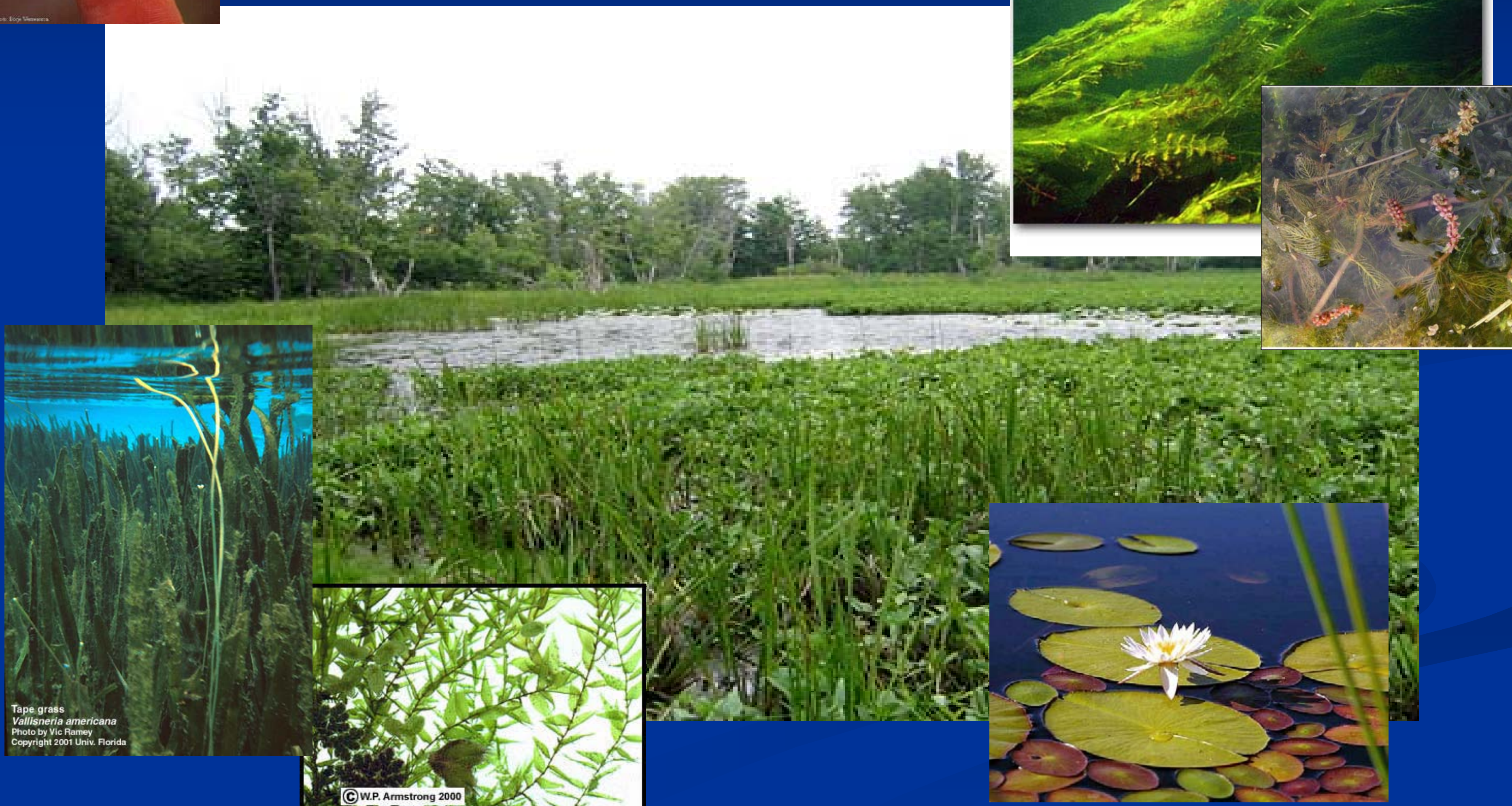
Non-vascular



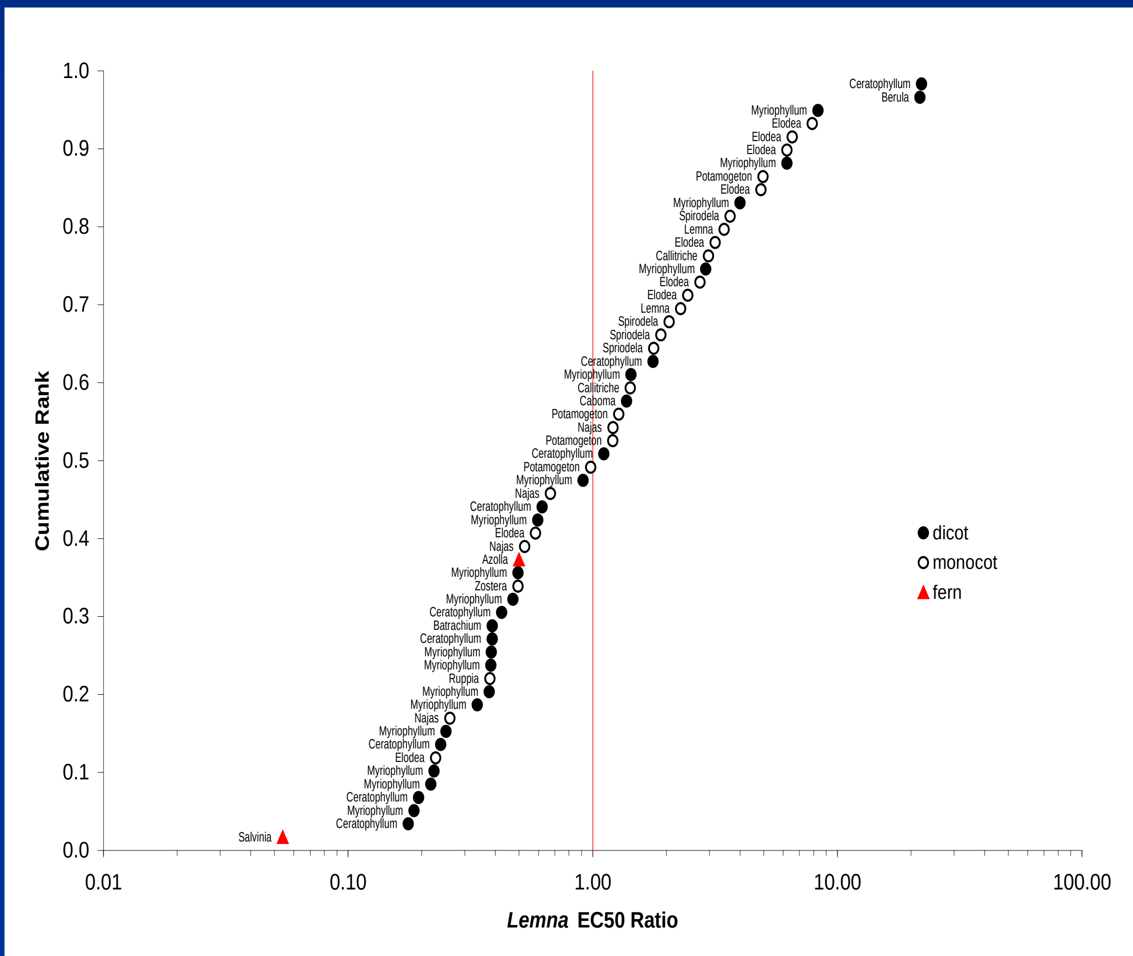
- Ratios of non-vascular species EC50s to lowest OPP microalgal species EC50s

Vascular Plants

Is the sensitivity of *Lemna* representative of vascular plants sensitivity?



Vascular Plants



- Ratios of vascular plant EC50s to *Lemna* EC50s

Aquatic Life Screening Values

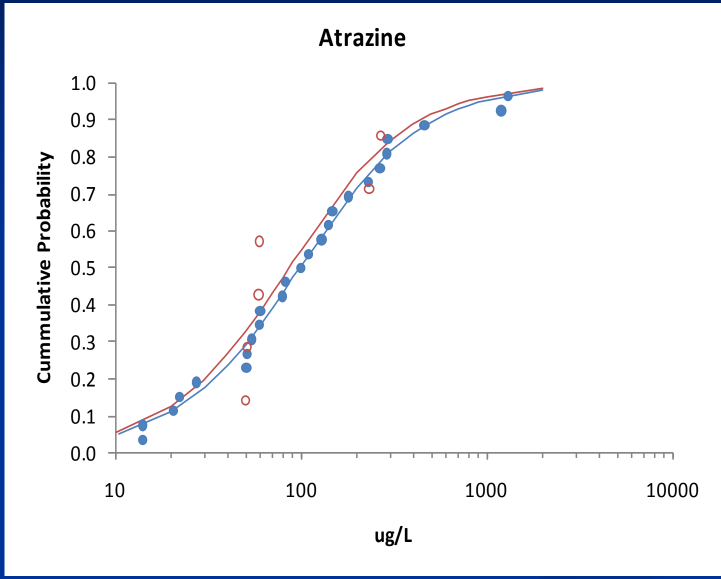
- Represent a means of reflecting the sensitivity of vulnerable aquatic plant species in an aquatic community

- Derive ALSVs using input gathered from stakeholders
  - Using lowest test value
  - Extrapolation factors
  - Species Sensitivity Distributions (SSDs)
  - QSAR

SSDs

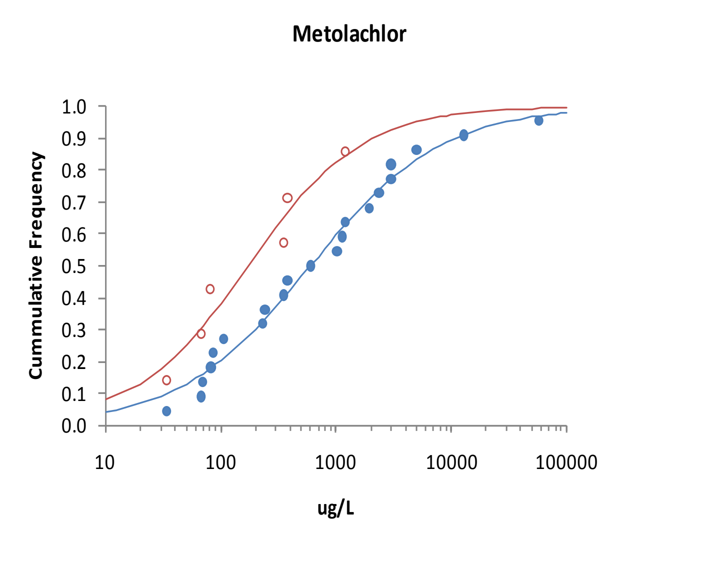
- Data from ECOTOX and draft atrazine document
- Six pesticides with large data sets
- EC50 chosen as effects endpoint
- Benchmark values calculated by non-linear regression and using 1985 Guidelines methods
- Comparison of endpoints derived from robust dataset to less robust dataset (OPP species only)

Example SSDs



Compound	N	Calculated HC_5		FAV 5th percentile		Standard OPP data	
		Full data set	Partial Data	Full data set	Partial Data	Lowest EC_{50}	Species
Atrazine	25	10.37	9.69	13.79	50.52	50.5	*Lemna gibba*

Example SSDs



Compound	N	Calculated HC_5		FAV 5th percentile		Standard OPP data	
		Full data set	Partial Data	Full data set	Partial Data	Lowest EC_{50}	Species
Metolachlor	21	12.47	6.02	38.88	29.69	34.2	*P. subcapitata*

SSDs

- Most sensitive OPP species was around the HC_{10} in most examples
- Most sensitive species was not consistent between chemicals
- Using non-linear regression analysis with full data set was the only method that utilized all available data
- Equation and percentile chosen not necessarily the preferred approach

Proposed Next Steps for Plant ALSV Methods

- No consensus on data set that is representative of aquatic plant community
- Six example chemicals have large enough data sets that are likely robust enough to characterize a variety of sensitivities
- No consensus on appropriate exposure durations or appropriate measurement endpoints

Proposed Next Steps for Plant ALSV Methods

- Expand upon the six SSDs already developed
- Add large datasets that are inclusive of OPP species, maximizing chemicals represented
- Explore development of extrapolation factors that could potentially allow limited datasets to represent protection of the larger aquatic plant community
- Other vascular plants (besides *Lemna*) may be important species needed to develop a robust dataset

Desired Stakeholder Input

- Data sets, unpublished data
- Comments on the most appropriate HCx level to select for the comparison between large data sets and smaller, less diverse data sets
- Comments on the most appropriate sigmoid curve equation to use in non-linear regression of SSDs
- Comments on how to address uncertainties in the data

Summary

- The white paper for aquatic plants provides an overview of plant toxicity data and examples of how the data may be used to derive ALSVs.
- Uncertainties exist in the data (e.g., duration, effects endpoints), which are important to consider when combining into an SSD.
- All approaches need to be further assessed, and the amount of available data should be considered in each case.