

# Bayesian Hierarchical Modelling

Acknowledging uncertainty within and among data to inform robust prior CPTs

- Raoul Wolf

# Context

- **WP1** data(bases) inform **prior CPTs** for all quantitative lines of evidence
- The prior CPTs must reflect the **chemical grouping**
- All data comes with **uncertainty** and multiple **sources of variation**
- **Hierarchical models** can help to incorporate and **generalize** all available information

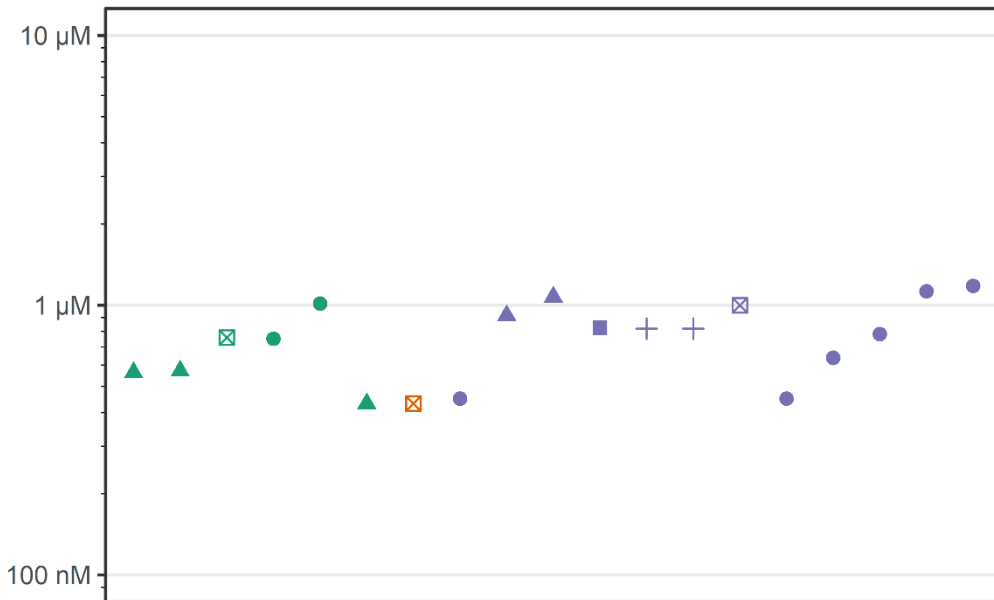
# Data Example

- **AFT** data from **WP1**
- Subset of revised and **extended** data
- **Modelling principles** apply to all other quantitative lines of evidence
- Data basis drives results and CPTs

# Data Example

## AFT Example: Pentachlorophenol

Overview of the reported LC<sub>50</sub> values (mean)



### Species

- *Lepomis macrochirus*
- *Oncorhynchus mykiss*
- *Pimephales promelas*

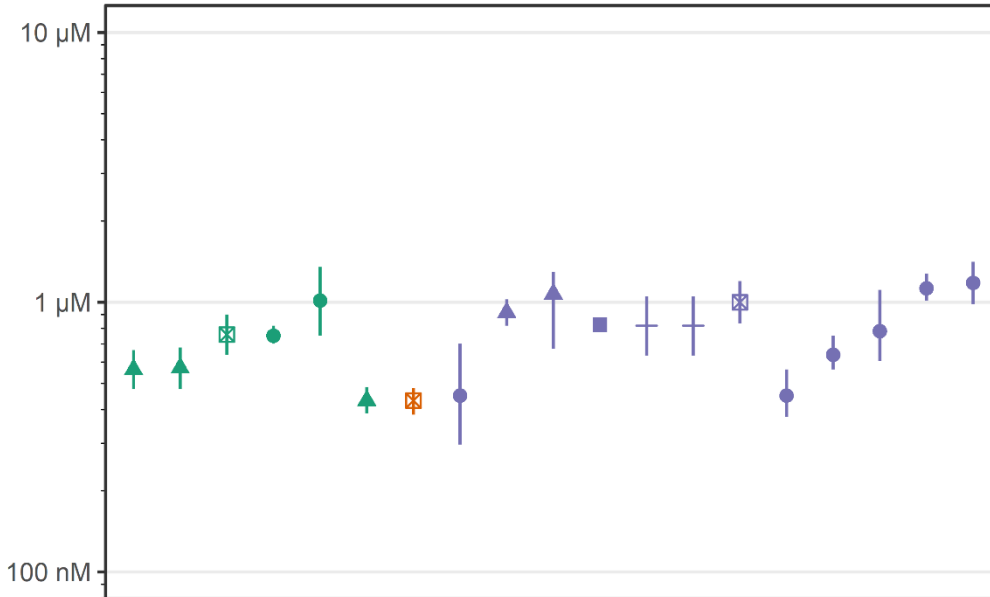
### Reference

- Hedtke et al. 1986
- ▲ Phipps and Holcombe 1985
- Phipps et al. 1981
- + Spehar et al. 1985
- ⊠ Thurston et al. 1985

# Data Example

## AFT Example: Pentachlorophenol

Overview of the reported LC<sub>50</sub> values (mean & 95% CI)



### Species

- *Lepomis macrochirus*
- *Oncorhynchus mykiss*
- *Pimephales promelas*

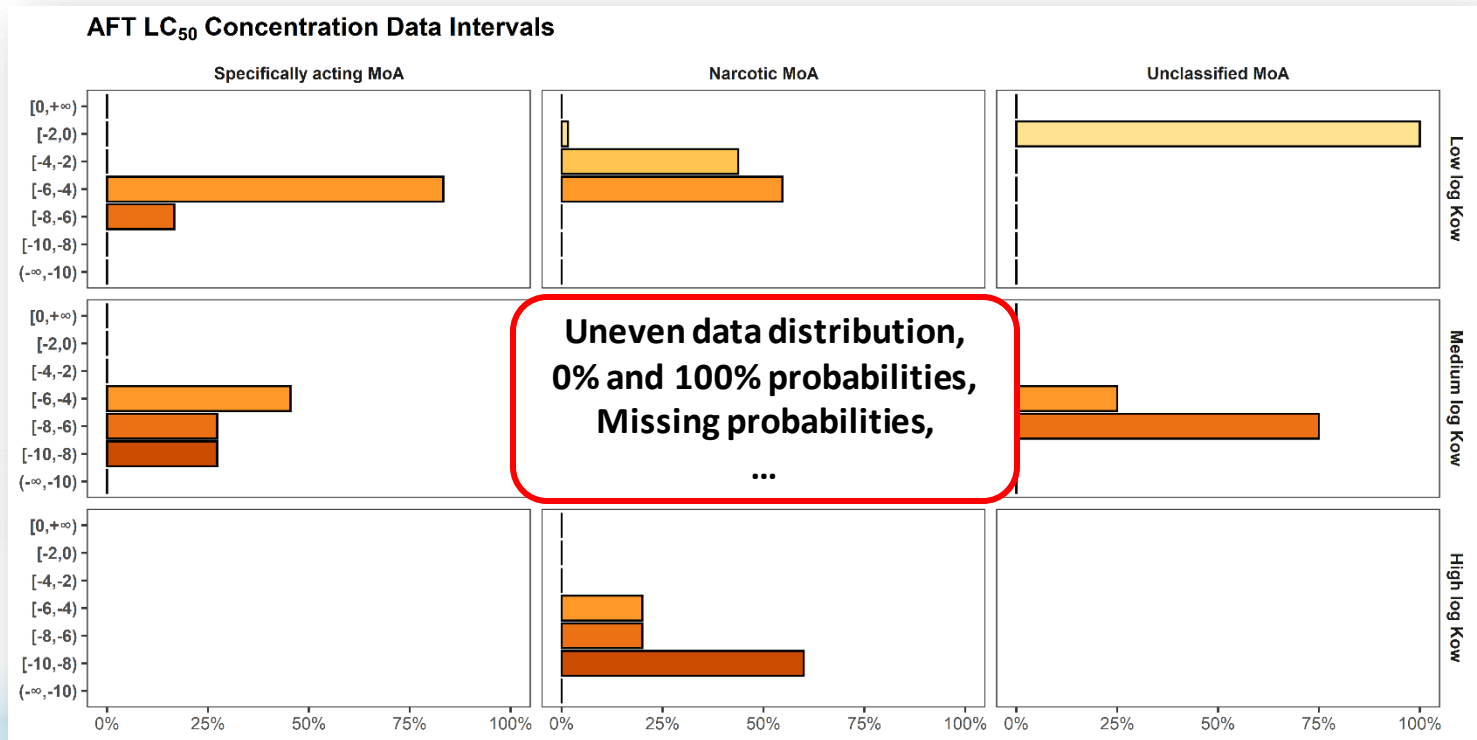
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# Data Example



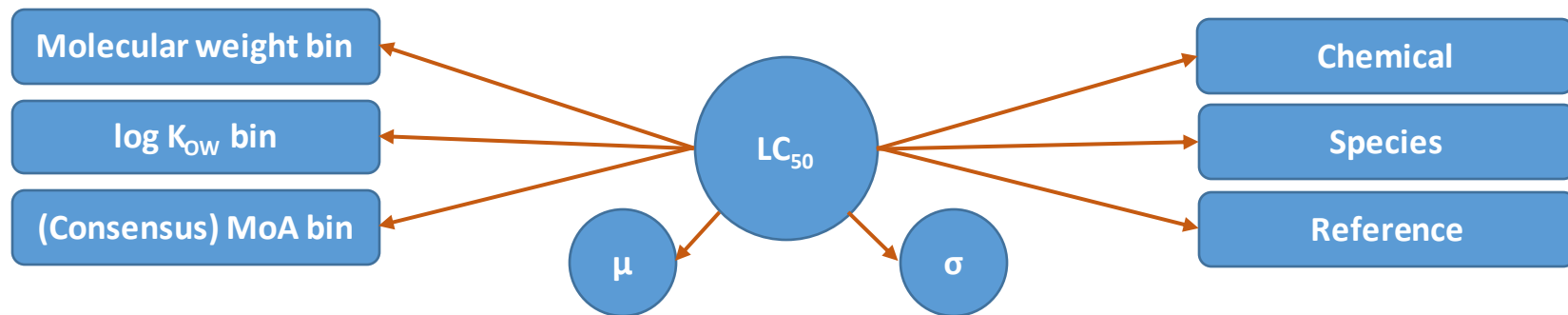
# Data Example



# Example Model Structure

*“fixed effects”*

*“random effects”*



$$\text{LogNormal}(\mu|\theta, \sigma)$$

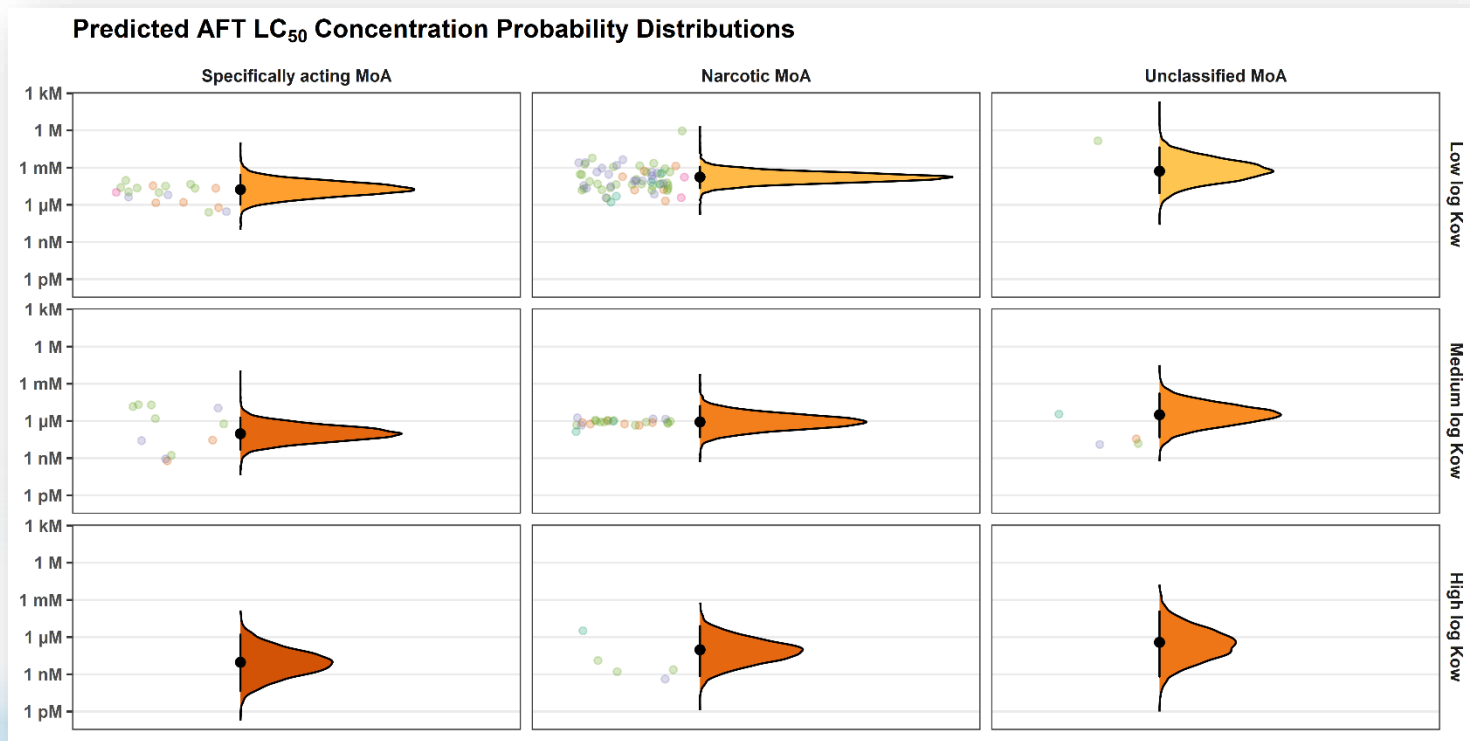
$$\text{LogNormal}(\theta|b_{mw} + b_{\log P} + b_{MoA} + r_{chem} + r_{species} + r_{ref}, \tau)$$



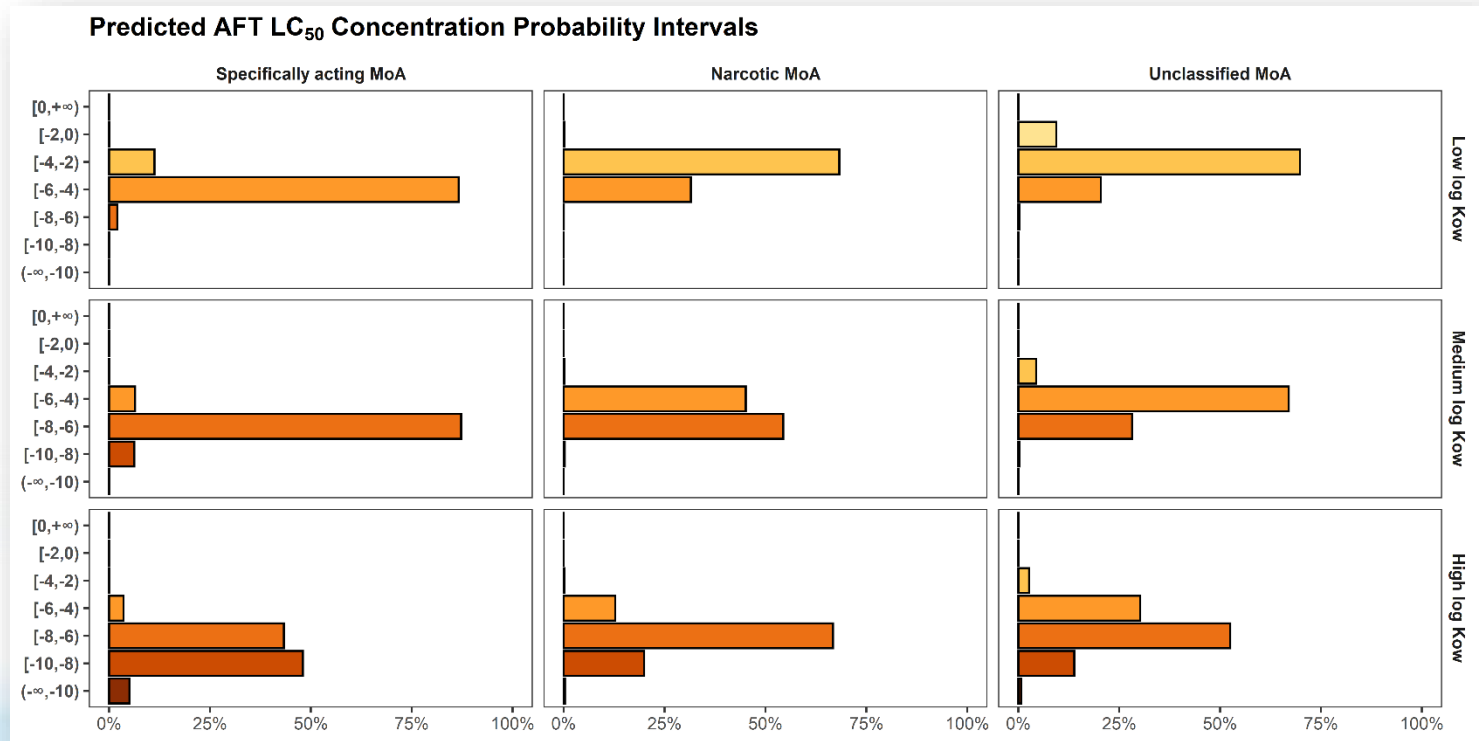
# Model Environment

- **Stan** *via* {cmdstanr} in **R**
- **Weakly informative** priors
- 5 Markov chains, Hamiltonian Monte Carlo
- **10,000** posterior samples

# Example Results



# Example Generalization



# Summary

- Use **all available information** to generalize quantitative information for all lines of evidence (**high flexibility**)
  - FET, *Daphnia*, algae, gill cytotoxicity, ...
- **Robust** predictions for **prior CPTs**
  - Reflect availability and variability, no zero probabilities, ...
- Additional information, *e.g.*, which species is most sensitive in AFT testing
- Better comparison of the BN results with the AFT data
- (Quality assurance heaven)

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