Development of Toxicity Translator Models for Population Level Risk Assessment

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TOXICITY TRANSLATORS are environmental decision-making tools that use linked models to translate toxicity test observations into predictions of population-level effects of anthropogenic stressors

Addressing 3 major extrapolation challenges

1. **Lab-to-field**
   Predicting effects on real populations based on data from laboratory studies
2. **Individual-to-population**
   Predicting effects at the population level based on observed effects on individuals
3. **Inter-species**
   Predicting effects on untested species, including threatened and endangered ones, based on effects observed in a few standard test species

Evaluating the effects of intermittent pesticide exposure scenarios on populations

- Timing of exposure in relation to presence of vulnerable life stages
- Effects may depend on exposure history

This poster presents an update on four toxicity translators in various stages of development. Each taxonomic group has a different set of vulnerabilities, requiring a different computational approach to structuring the simulated population:

Birds
Distinct, sequential breeding phases are present; success at each checkpoint is directly tied to population-level endpoints

Fish
Reproduction and survival may be dependent on fish size; e.g. winter survival is decreased among fish <X mm length. Toxic exposure may cause decreased growth.

Invertebrates
Timing and variability in toxic exposure may affect the distribution of juveniles and adults in a population via impact on survival and reproductive capacity. This in turn will affect the population growth rate.

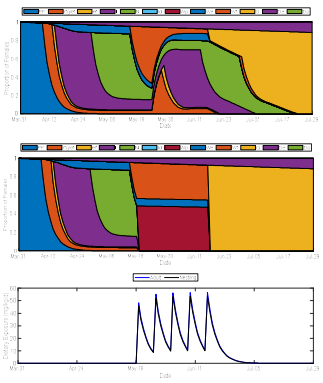
Amphibians
Stage-based developmental delay may impede transition to subsequent life stages. Life stages inhabit different environments and are susceptible to different exposure routes.

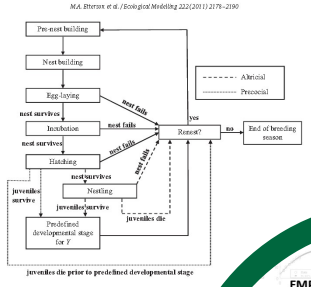
Applications of toxicity translators

- How might changes to pesticide application dates effect population growth of species X?
- Which life history traits are associated with vulnerability at the population level?

U.S. Environmental Protection Agency
Office of Research and Development

BIRDS MCnest Markov Chain Nest Productivity Model





- Currently in use by USEPA for pesticide risk assessment since 2014
- MCnest divides nesting attempts into discrete phases and uses information from toxicity tests to estimate adverse effects of exposure at each stage
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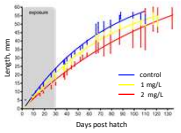
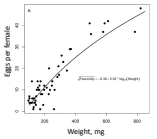
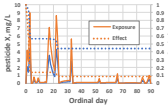
  https://www.epa.gov/chemical-research/markov-chain-nest-productivity-model
- Also see platform presentation XXXX

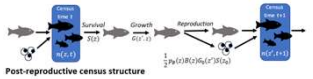
FISH Size-structured integral projection model (IPM)

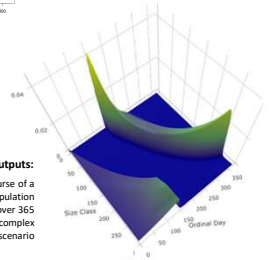
Model inputs: Growth effects | Reproduction effects | Survival effects | Species life history











Model outputs:
Simulated time-course of a fathead minnow population size distribution over 365 days under a complex exposure scenario

- Presently under development for fathead minnow (*P. promelas*) exposed to carbaryl or diazinon. Graphical user interface (GUI) allows users to explore other species/chemical combinations (See platform presentation XXXX).
- Features:
  - Size-dependent parameters and response relationships
  - Model parameters can be represented by distributions instead of single values
  - Model parameters can change on a daily basis in response to exposure concentrations or seasonal stressors
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INVERTEBRATES Matrix projection model

- A toxicokinetic-toxicodynamic (TKTD) model for effects of endosulfan on mysids (*A. bahia*), coupled with a time-variable exposure scenario, incorporates the exposure history of each age class.
- This effects model is linked with a matrix projection population model with a daily time step, based on Thursby et al. (2018).
- An expansion is under development for other invertebrates.
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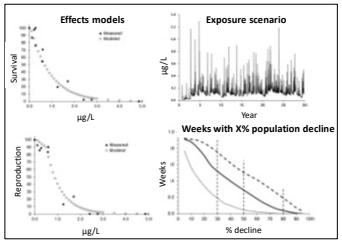
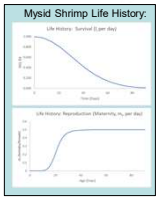
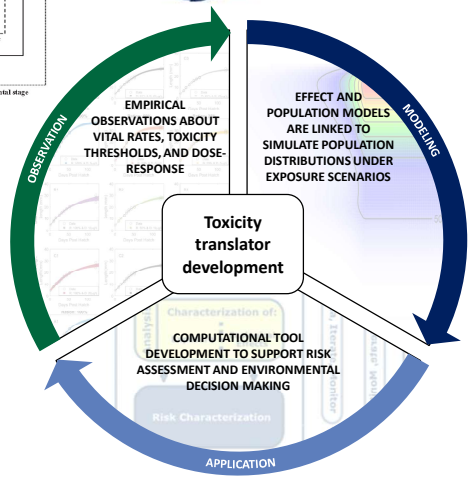
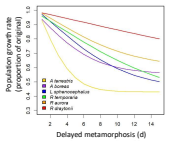


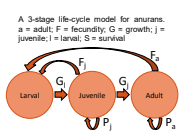


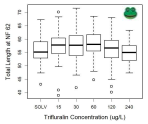


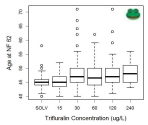
AMPHIBIANS Model development guidelines



- Awkerman et al 2019 has outlined amphibian population model development guidelines: a first step toward developing a toxicity translator that addresses amphibian-specific risk assessment challenges







- Also see Raimondo et al. 2017 for a step-wise model framework selection guide based on data availability
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References

Awkerman et al. (2019) IEAM 16(2): 223-233

Etterson and Bennett (2013) IEAM 9(4): 590-599

Raimondo et al. (2017) IEAM 14(3): 369-380

Thursby et al. (2018) ET&C 37(10): 2633-2644