Can population modelling answer urgent unresolved questions for ecological risk assessment - lessons learnt from daphnia

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Introduction

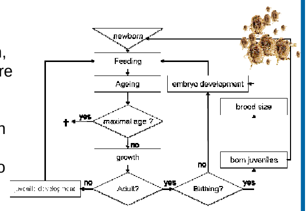
Within a survey of the SETAC Europe Advisory group MeMoRisk the following questions were identified as most relevant in the environmental plant protection products risk assessment :

1) Extrapolation of effects from individual to population
2) Extrapolation of effects between different exposure scenarios
3) Extrapolation of effects from laboratory to the field
4) Analysis and extrapolation of recovery in the field

Here, an individual based population model for *Daphnia magna* (IDamP) was used to investigate if these questions can be answered using a mechanistic modelling approach.

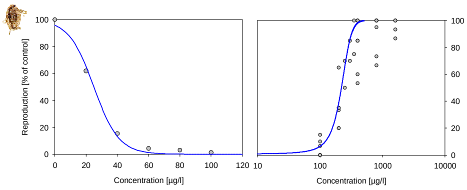
Methods

We used an individual based population model for *Daphnia magna* (IDamP) to extrapolate measured effects at the individual level, such as mortality and inhibition of reproduction, to the population level. In this model the individual daphnids are explicitly modelled and population dynamics emerge directly from the individual life cycles . The model was validated for control (i.e. unexposed) conditions on individual and population level at different food and temperature scenarios .
For extrapolations between exposure scenarios and from lab to field, IDamP was coupled with a Damage Assessment Model (DAM) and a lake model (StoLaM) respectively.

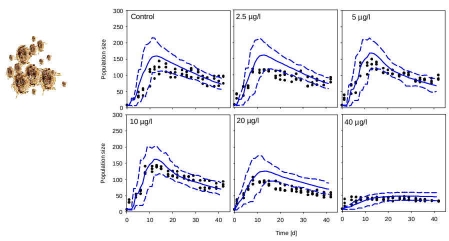


Individual to population

Example 3,4-Dichloroaniline at constant exposure and environmental conditions



Concentration-response curve of 3,4-dichloroaniline for inhibition of reproduction and acute toxicity (mortality) were implemented in IDamP

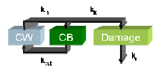


➔ **Successful extrapolation from individual to population level at constant exposure**

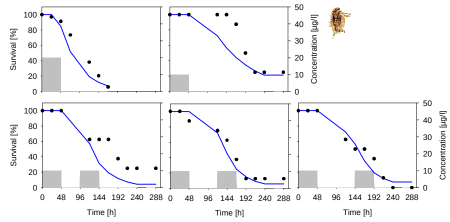
Different exposure scenarios

Example triphenyltin at time variable exposure on individual and population level, at constant environmental conditions

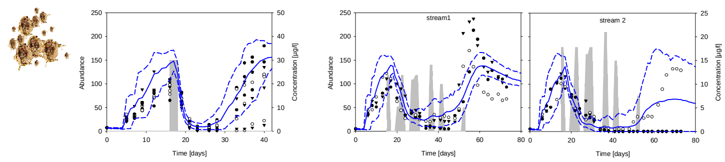
Damage Assessment Model (DAM)



Takes toxicokinetic and toxicodynamic into account, toxicity depends on internal concentration



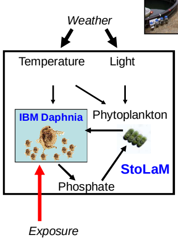
DAM was calibrated at individual level on constant (not shown) and time variable exposure. Effects of different exposure pattern were described successfully by DAM.

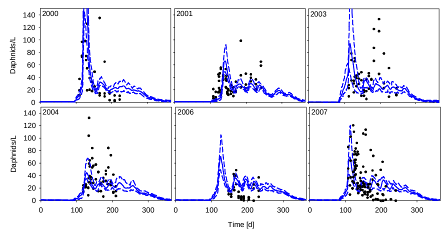


➔ **Successful extrapolation from individual to population level & between different exposure scenarios using DAM linked with IDamP under constant environmental conditions**

Laboratory to field

Linked IDamP with lake model (StoLaM) to predict population dynamics for control mesocosms at variable temperature and food supply



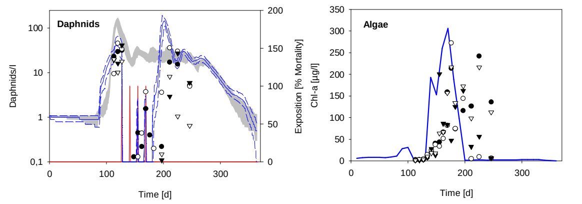


Simulated and measured daphnid abundance for control mesocosms
The measured density of daphnids in the controls of the mesocosm facility in Aachen during six years (three replicates each year) are shown as black dots and the simulation results, average and 95%-confidence limits, as blue lines.

➔ **Successful extrapolation from lab to field**

Recovery in the field

Linked IDamP with lake model (StoLaM) to predict recovery and indirect effects for treated mesocosms at variable temperature and food supply



Comparison of simulation and measured data for direct and indirect effects of insecticide-treated mesocosms (4 high dose replicates)
Data from mesocosm study are shown as symbols, the exposure as red lines, and the simulation as blue lines (average and 95% confidence limit). The simulation of the control range is shown as grey shade.

➔ **Successful prediction of recovery patterns and indirect effects**

Conclusion

➔With adequate mechanistic models sensitivity of populations, as well as population sustainability, can be predicted for different environmental conditions on the basis of measured data at individual level alone

➔ Mechanistic models are a suitable tool to answer urgent questions in environmental risk assessment

➔ It is necessary to include the main driving mechanisms:

➔ Using dynamic effect models for predicting effects at time variable exposure if indicated by data

➔ Integrate interaction with food source and impact of temperature to extrapolate from lab to field

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