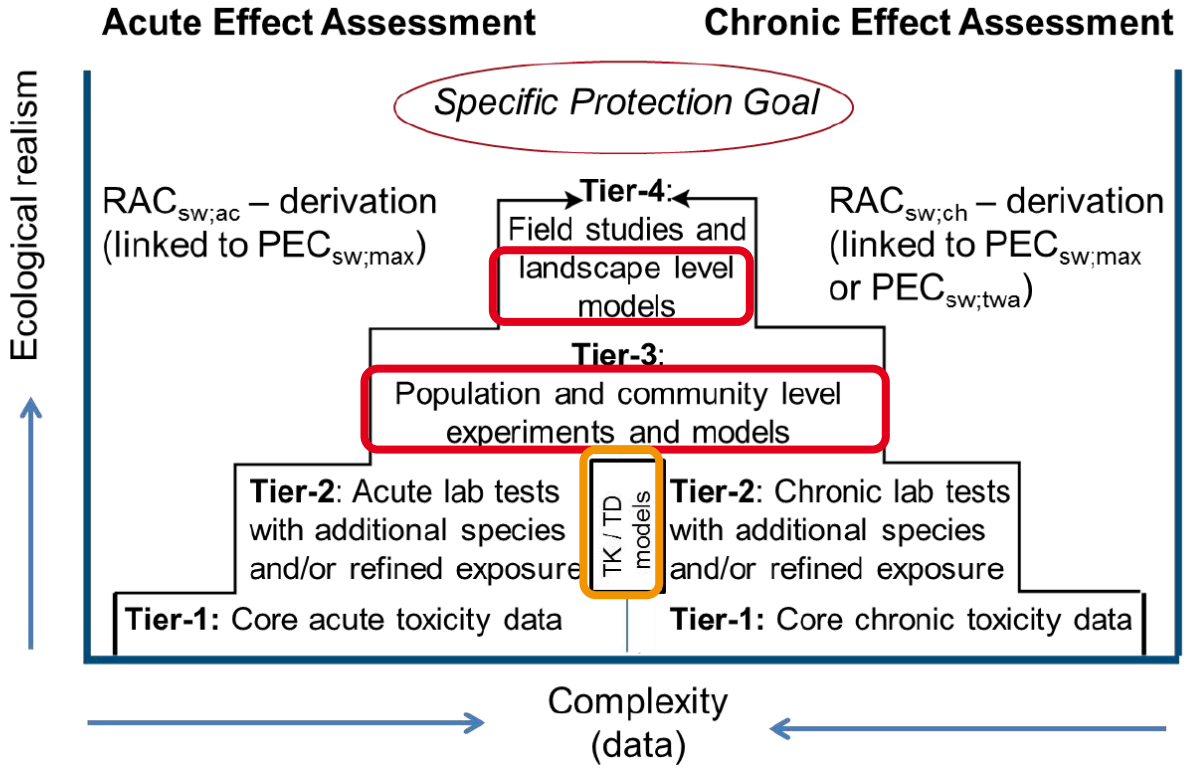
WHICH SPECIES SHOULD WE MODEL? EXAMPLES OF HOW TO DEFINE FOCAL SPECIES FOR THE RISK ASSESSMENT OF PLANT PROTECTION PRODUCTS

Udo Hommen

All photos: wikipedia.org

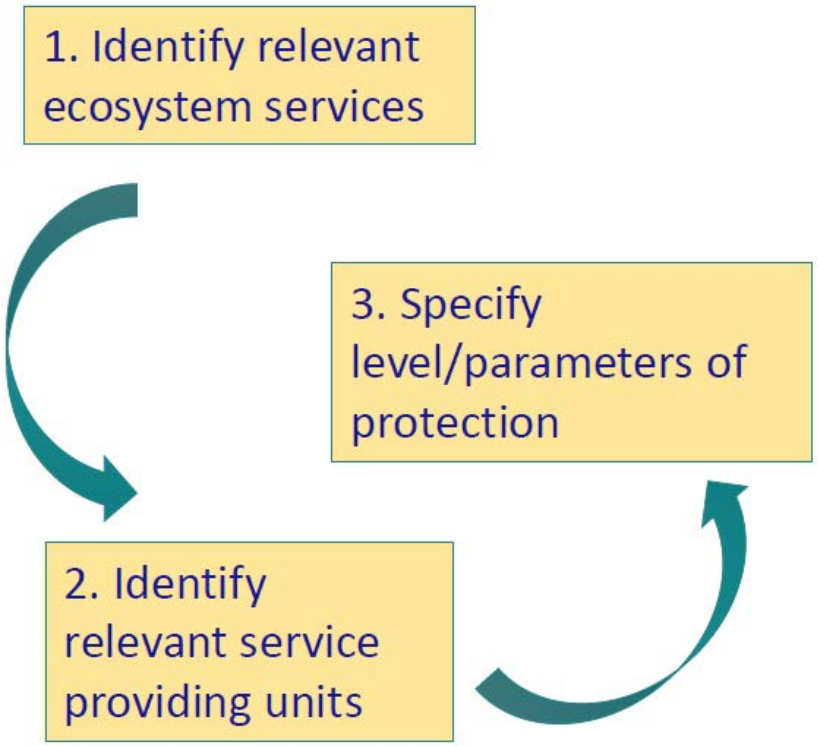
OUTLINE

- What do we want to protect?
  - Vulnerability concept
- Focus on population models
- Four approaches to select the species to be modelled
  - Standard species
  - Protected species
  - Species identified in higher tier tests
  - Species selected based on trait analysis
- Summary



Aquatic Guidance Doc, EFSA PPR panel (2013)

The species to be modelled depends on the protection goal of the assessment

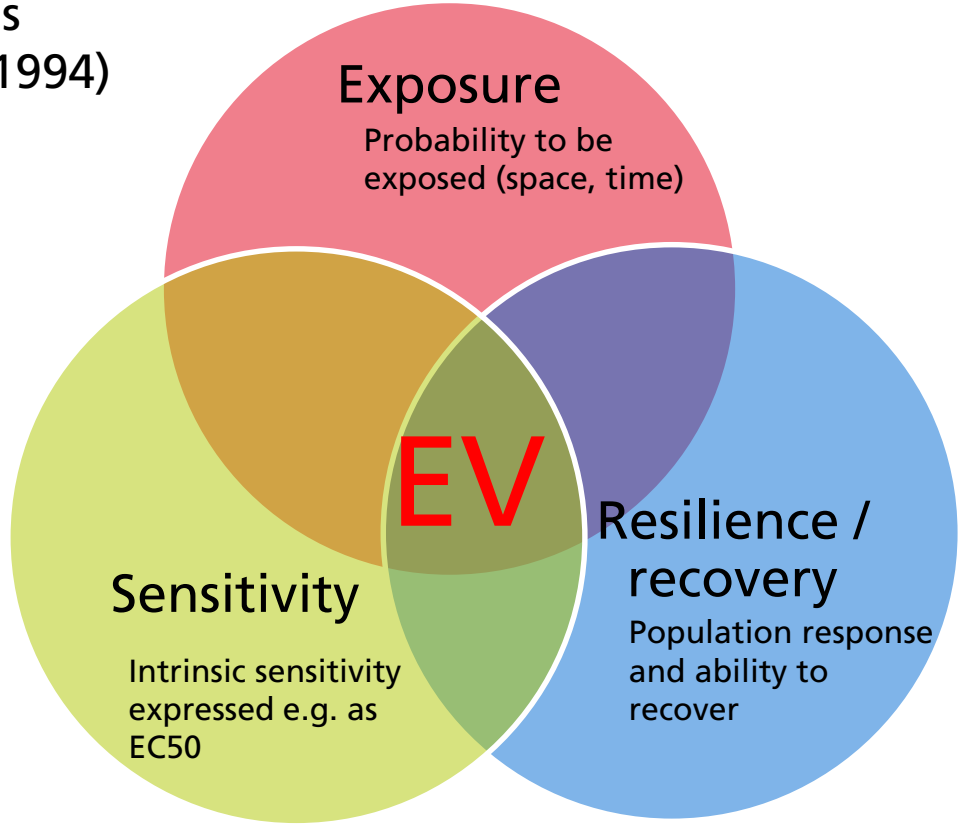


- General protection goals: '*no unacceptable effects on the environment…impact on biodiversity and ecosystem*' (Reg 1107/2009)
- Currently the EU is working on defining specific protection goals **based on the ecosystem services** approach (see EFSA GD 2016)
- This includes the identification of services which might be affected and the 'service providing units' or 'key drivers' which are most relevant for the services
- The approach has been used already e.g. in the aquatic guidance document (EFSA PPR panel 2013)
- However, this definition stops at a relatively high level since only groups are listed as aquatic key drivers, i.e. algae, plants, invertebrates, vertebrates and microbes
- Thus, if models should be used for risk assessment it is often still to be decided which species should be considered

EC SPG Workshop, 5 Feb 2021

Species to be modelled should be vulnerable to the stressor

- The vulnerability concept was introduced by van Straalen (1994)



There are four approaches (in my view) to select the species for modelling in pesticide risk assessment

- Reed *et al*. (2018):
  '*When choosing the species to model, a conflict is seen between species with good laboratory toxicity data, species with good field data, and ecologically relevant species*.'
- For the following approaches examples will be given

1. Using the standard test species
2. Considering status of protection of species
3. Evidence from higher tier tests
4. Trait based approaches

At the lower tiers, there is no need to define a focal species

- The **Tier 1** species are defined by the legal data requirements
- They are most often surrogate test species to measure intrinsic sensitivity
- Intrinsic sensitivity is not related to geographical distribution and also not necessarily to the recovery potential
- Thus, practicability of culturing and testing in the lab is an important criterion for selection
- The protection of vulnerable species is assumed to be achieved by the use of assessment factors

Tier 1 species

All photos: wikipedia.org

- This is also the case for the lowest level of effect models, toxicokinetic-toxicodynamic models (**TKTD models**) used to address time variable exposure
- The modelling is usually done for the most sensitive tier 1 species and thus, the Tier 1 assessment factor is still be used

Also population models can be developed for the standard species, but…

Standard species

E. fetida

Focal species?

A. calliginosa

L. terrestris

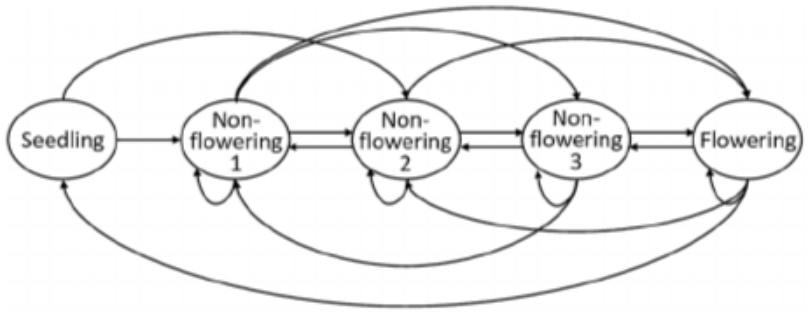
All photos: wikipedia.org

- Population modelling standard test species is attractive since information on the performance of control organisms and toxicity data available
- On the other hand, field data on population dynamics might not be available for the test species
- Test species are often not vulnerable with respect to reproduction → predictions of recovery under field situation can be misleading
- Thus, such models can be useful to extrapolate from individual level to population level effects but the uncertainty in the extrapolation to the species to be protected in the field has to be considered with care
- Reed *et al*. (2018):
- *Population modeling should address ecologically relevant species.*

The status of protection can be a criterion, e.g. inthe US, the Endangered Species Act can trigger population modelling in pesticide risk assessment

Schmolke et al. (2018): Mead's Milkweed

Wikipedia.org



Environmental Toxicology and Chemistry—Volume 37, Number 8—pp. 2235–2245, 2018
Received: 2 March 2018 | Revised: 9 April 2018 | Accepted: 15 May 2018

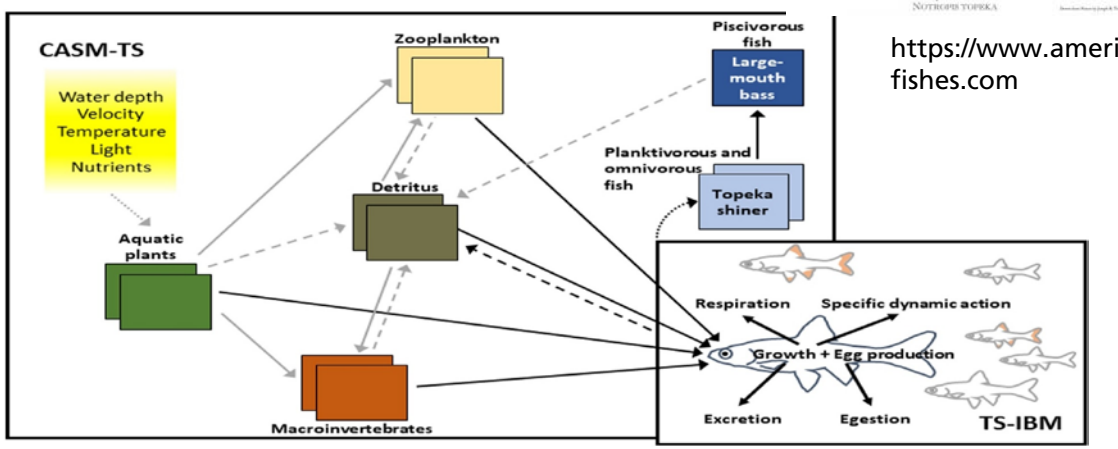
Hazard/Risk Assessment

Adapting Population Models for Application in Pesticide Risk Assessment: A Case Study with Mead's Milkweed

Amelie Schmolke,[a,*] Colleen Roy,[a] Richard Brain,[b] and Valery Forbes[c]

Schmolke et al. (2019): Topeka shiner

https://www.americanfishes.com



Environmental Toxicology and Chemistry—Volume 38, Number 10—pp. 2243–2258, 2019
Received: 17 April 2019 | Revised: 16 May 2019 | Accepted: 13 June 2019

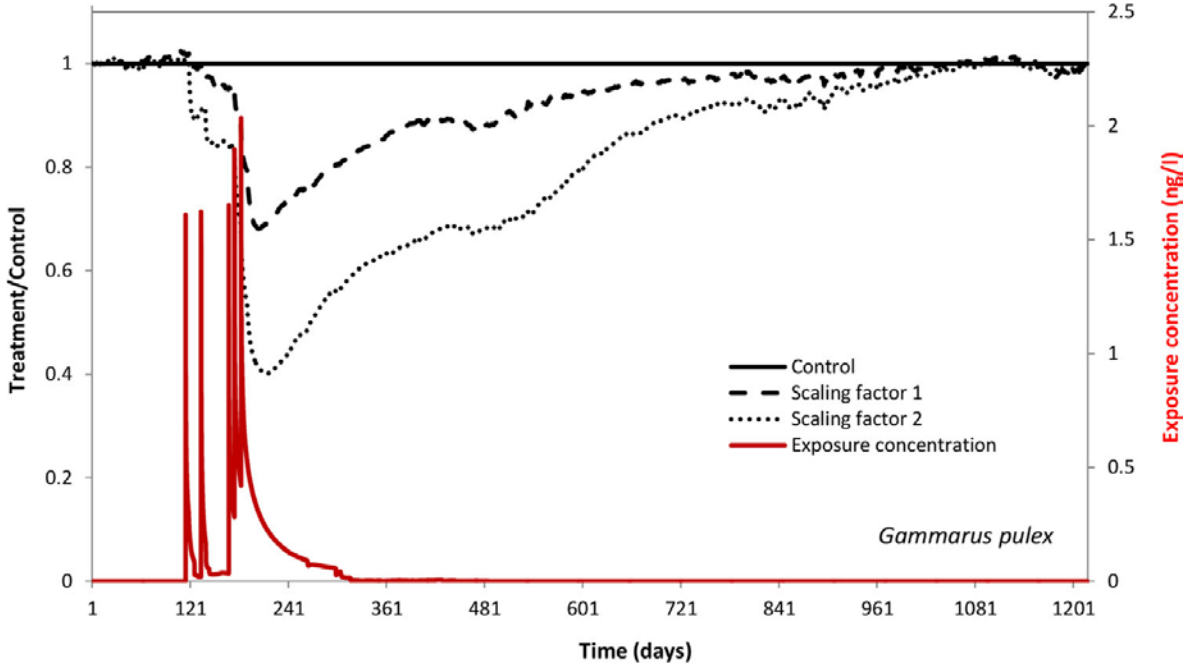
Hazard/Risk Assessment

A Hybrid Individual-Based and Food Web–Ecosystem Modeling Approach for Assessing Ecological Risks to the Topeka Shiner (*Notropis topeka*): A Case Study with Atrazine

Steven M. Bartell,[a,*] Amelie Schmolke,[b] Nicholas Green,[b] Colleen Roy,[b] Nika Galic,[c] Dan Perkins,[b] and Richard Brain[c]

Higher tier data can suggest species to be modelled

- Aquatic mesocosm studies, soil or arthropod field tests or monitoring studies can identify vulnerable species
- Population modelling can be used to extrapolate from these tests, e.g.
  - to other exposure patterns
  - to other environmental conditions (e.g. other weather conditions)
  - to longer-term dynamics and recovery
- Examples:
  Models for *Daphnia, Chaoborus, Asellus, Gammarus, …*



Integrated Environmental Assessment and Management — Volume 12, Number 1—pp. 67–81

Population-Level Effects and Recovery of Aquatic Invertebrates after Multiple Applications of an Insecticide

G Peter Dohmen,† Thomas G Preuss,‡§ Mick Hamer,‖ Nika Galic,#†† Tido Strauss,‡‡ Paul J van den Brink,#§§ Frederik De Laender,‖‖ and Stephanie Bopp##*

Focal species for pesticide risk assessment are already defined for birds and mammals

Effect assessment

e.g. Japanese quail

Exposure assessment

Relevant traits

Distribution & habitat - presence in crop?

Diet and foraging - feeding on contaminated food?

Feeding rate / body weight?

Focal species

depending on crop, zone and type of ppp

e.g. sky lark as focal omnivorous species in cereals

EFSA (2009) B&M guidance doc

photos: wikipedia.org

The focal B&M species can be considered to be relevant vulnerable species for risk assessment and thus, some models have already been developed

- Almass (Animal, Landscape and Man Simulation System) includes population spatial explicit population models for several birds & mammal (but also other) species in EU agricultural landscapes, e.g.
  - Eurasian Skylark (*Alauda avensis*)
  - Field Vole (*Microtus agrestis*)
  - Grey Partridge (*Perdix perd*ix)
  - European Brown Hare (*Lepus europaeus*)
- But also other models are available, e.g. for
  - Common vole (Wang M. 2013)
  - Wood mouse (Liu et al. 2013)
  - an others…

Almass.dk

wikipedia.org

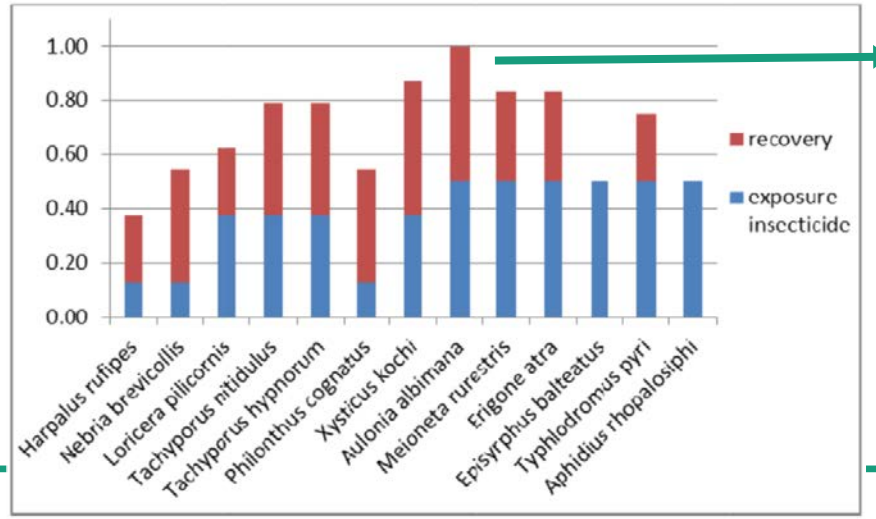
wikipedia.org

Species traits driving exposure and rec[illegible]n be used to rank species based on ecological vulnerability

- Multi-criteria approach, using weight factors assigned through expert judgment, to weigh the relative contribution of each ecological characteristic to overall vulnerability
- Results for NTA example (De Lange *et al.*, 2012)
  - For insecticides, herbicides and fungicides, the average vulnerability of typical off-crop species was higher than that of typical in-crop species.
  - The difference between off-crop and in-crop species can be explained by differences in exposure and especially recovery.
  - The standard test non-target arthropods were found to be less vulnerable

For trait based approaches in more detail, see presentation by Andreu Rico: *What to model? Selecting vulnerable species and landscape parameters for the development of ecological scenarios*

			Score
			0
	food		
		vegeta[illegible]	
	breeding period	autumn	
		spring	
Recovery	dispersion	flying	
		ballooning	0.333
		walking and flying	0.667



A. albimana, wikipedia.org

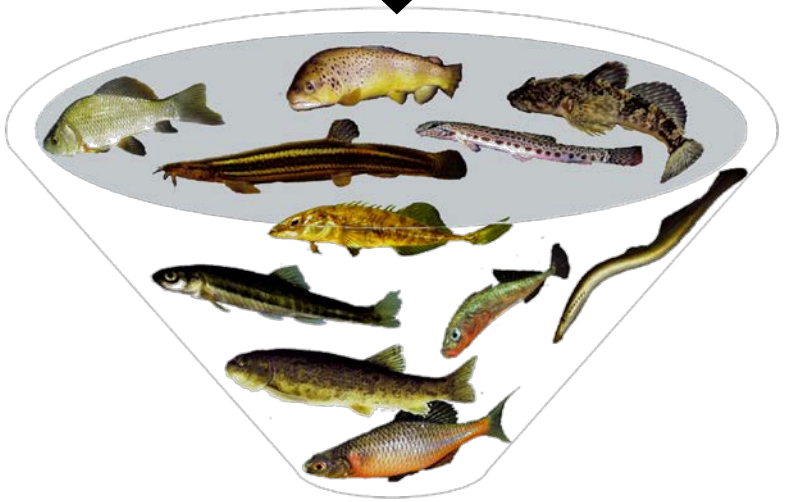
Simple population models can support the identification of focal species

- Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)
- What could be focal fish species for pesticide risk assessment in the EU?

1. Exposure potential
   - Review information on geographical distribution and habitat preferences of freshwater fish in Europe
     - Native to Europe?
     - Inhabit streams, ditches or ponds?
     - Widespread in at least 1 of the 3 EU mutual recognition zones ?
     - Living in streams, ditches or ponds?

➔ List of 27 widespread and potentially exposed fish species in the EU

579 freshwater fish species in Europe



27 species highly susceptible to pesticide exposure

Ibrahim et al. (2013) ESPR 20(4): 2679-2687

Simple population models can support the identification of focal species

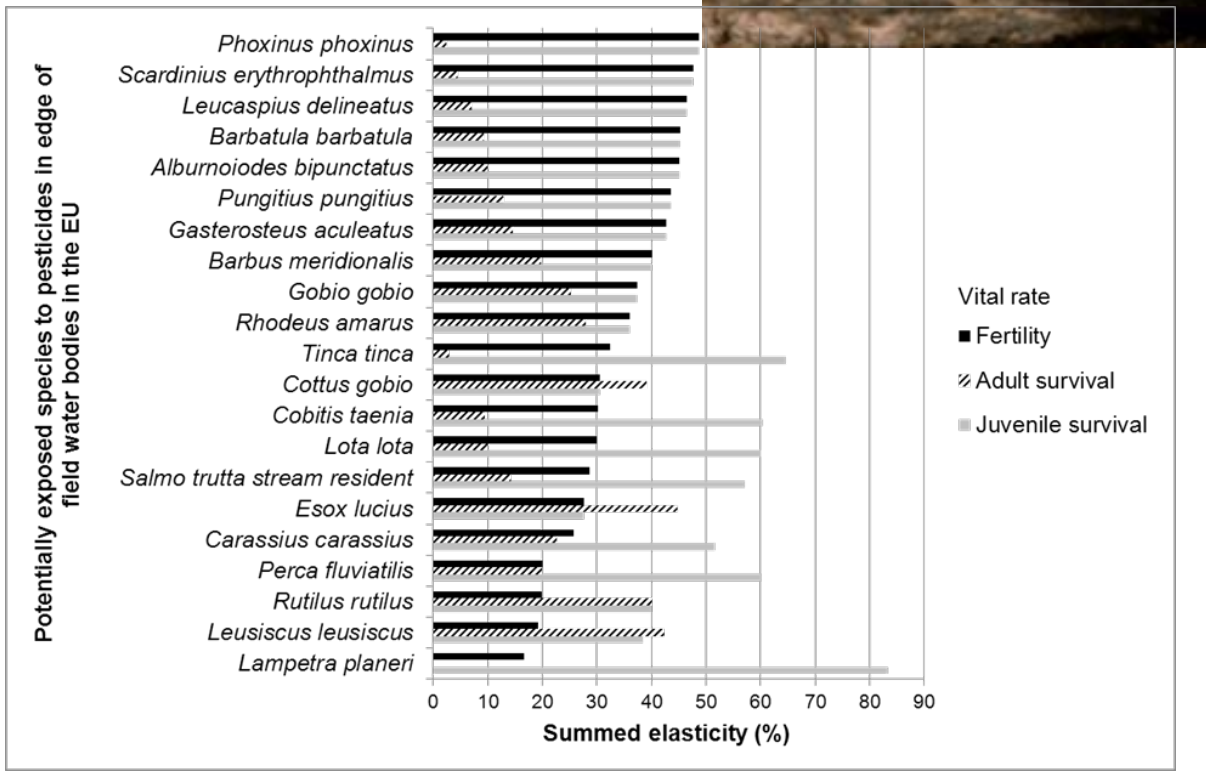
- Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)
- What could be focal fish species for pesticide risk assessment in the EU?

2. Population resilience/ recovery

- Using matrix models to assess the sensitivity of population growth rate to changes of
  - juvenile survival
  - adult survival
  - and fecundity

➔ If the focus is on effects on fecundity, the European minnow was found most vulnerable

Resilience



Ibrahim et al. (2013) ESPR 20(4): 2679-2687

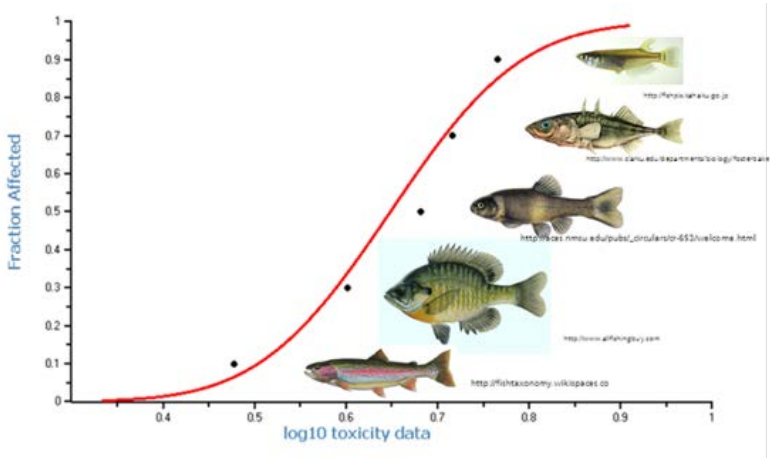
Simple population models can support the identification of focal species

- Fish tests are usually conducted with species not native to Europe (e.g. rainbow trout, zebra fish)
- What could be focal fish species for pesticide risk assessment in the EU?
- E.g. IBM of the minnow (Ibrahim 2015)

3. Sensitivity

- Usually no toxicity data available for focal species
  - Use the one of the most sensitive species
  - Use the one of the taxonomically closest species
  - Use models to extrapolate species sensitivity

Sensitivity



Summary: Which species should we model?

- TKTD models: need to stick to the test species and keep the standard assessment factors to deal with all the uncertainties not addressed by the model
- Population models: Often it is not the best idea to the standard test species if it is not vulnerable
- There is not only the '*Myth of the most sensitive species*' (Cairns 1986) – there is also no most vulnerable species within a taxonomic group:
  - The likelihood of exposure depends also on where and when the pesticide is used
  - Modes of action and species traits determine the species sensitivity
  - However, population resilience to different effects can be assessed in a generic way
- The selection of focal species for population modelling can be driven by
  - Status of protection, e.g. species listed in the Endangered Species Act in the US
  - Higher tier data, e.g. SSD or field tests identify an (ecologically) vulnerable species) also as sensitive
  - Trait based analysis of vulnerability

Where we are - a very first draft

Group	Typical tier 1 test species	Native in EU?	Ecol. vul-nerable	Focal species defined?	Available pop models for ERA (examples)
Bird & Mammals	Japanes or Bobwhite quail, Rat	No		Yes, EFSA (2009) for expo-sure assessment, very detailed,	several, e.g. skylark, common / field vole, hare
Amphibian & Reptiles	none			Proposed 6 species in EFSA PPR panel (2018)	in prep. (great crested newt)
Fish / amphibians	Rainbow trout, Zebrafish, Medaka, Fathead Minnow	No		Not officially	e.g. Zebrafish, Fathead, Stickleback, European minnow
Aquatic invertebrates	*Daphnia, Chironomus, Americamysis, Lumbriculus*	Yes, except *A. bahia*	No	No (but SSD and Mesocosms)	*Daphnia, Chaoborus, Asellus, Gammarus*
Macrophytes	*Lemna sp., Myriophyllum sp., Glyceria maxima*	yes	Partly	No (but SSD and Mesocosms)	*Lemna sp., M. spicatum*
Algae	Green algae (*P.subcapitata, 2nd species*	yes	?	No (but SSD and Mesocosms)	*P. subcapitata, D. subspicatus*
Soil	Earthworm (*Eisenia fetida*) Springtail (*Folsomia candida*) Predatory mite (*Hypoaspis aculeifer*)	yes	?	No (but field tests might help) EFSA SO (2017) with SPGs for other groups	*E. fetida, L. terrestris, L. rubellus, F. Candida*
Terrestrial plants	At least 6 species (usually crop species)	-	?	No. Focus in EFSA SO (2014) is more on test species	Community models
Non Target Arthropods incl beas	Honeybee, bumble bee Aphid parasitoid (*A. rhopalosiphi*) Predatory mite (*T. pyri*)	yes	?	Honey bee, but no official list of other focal species, groups of key drivers in EFSA SO (2015)	Honeybee Carabid beetle Linyphiid spider

I am happy to answer any further questions

Udo Hommen

Fraunhofer IME

Auf dem Aberg 1

57392 Schmallenberg

Germany

udo.hommen@ime.fraunhofer.de