

PCB effects on a wood frog meta-population

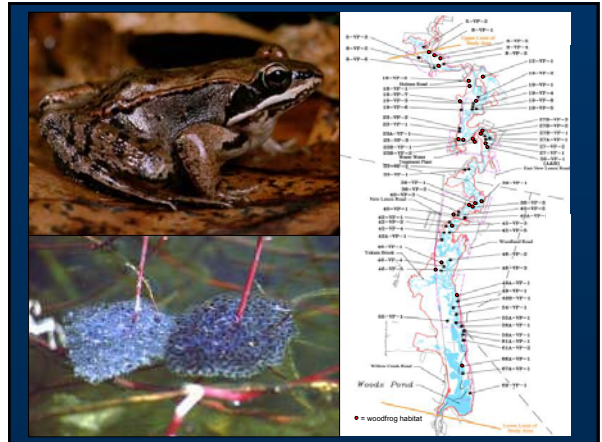
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Background

- Frog populations are in distress globally
habitat loss, UV radiation, pollution
- Individual-level PCB impacts at Housatonic
- What do they imply about the population?

Population-level risk assessment

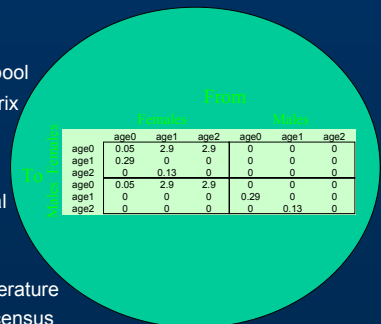
- Dose-response studies
Housatonic field observations
Laboratory studies
- Demographic model
10-year projection
- Variation
Environmental noise
Demographic stochasticity
Correlation among vernal pools

Modeling approach

- Spatially explicit meta-population
27 suitable vernal pools
Young disperse to nearby pools
- Closed population
Fidelity to natal pools
- Generic and site-specific data
Abundance and PCB concentrations on site
Vital and dispersal rates from literature

Population model

- Single vernal pool
- Projection matrix
- Values from literature
- Pre-breeding census



Dispersal

- Used dispersal equation for wood frogs from literature

$$y = 0.4392 \times 10^{(-0.00056 \times x \text{ meters})}$$

where y is the proportion of frogs dispersing distance x

- Also used their estimate of dispersal rate

Only age-zero frogs disperse

~20% disperse

No sex difference

Density dependence

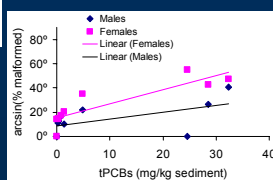
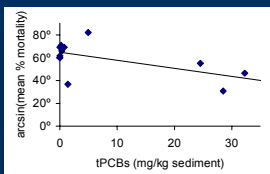
- How vital rates change with density
- Some suggest it occurs at larval stage (adults don't really compete much)
- No evidence in literature or on-site
Two scenarios: Ceiling-type and Ricker

What are the impacts?

Mortality impacts

- Larval survival increases with PCB
Used linear relationship (on transformed data)
- Malformation rate increases with PCB
Used sex-specific linear relationship
Two scenarios: 50% and 100% mortality among malformed metamorphs

Mortality impact regressions



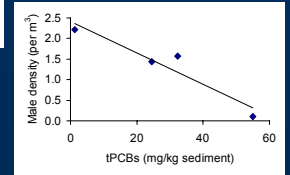
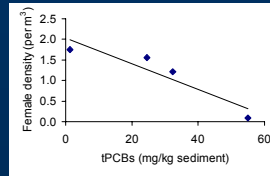
Fertility impact

- Gonadal abnormalities seen in 57% of malformed female metamorphs
Two scenarios: 50% and 100% of gonadally malformed females are sterile

Abundance impacts

- Adult density
 - Negatively related to PCBs
 - Used linear relationship to set initial populations
- Egg mass number
 - Negatively related to PCBs
 - Controlled for pool volume (multiple regression)
- Assumed stable distributions in each pool

Abundance impact regressions



$R^2 \sim 90\%$

What were the findings?

Two of the toxicity scenarios

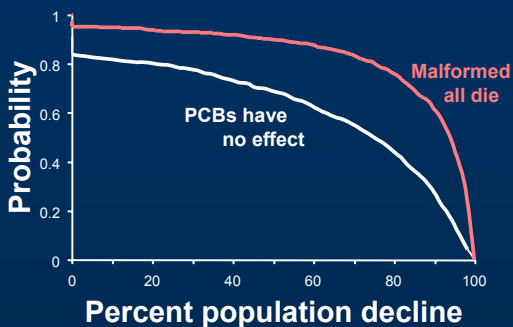
White

- No malformations
- No additional mortality
- No change in larval survival
- Higher initial abundance (from regression)

Red

- Malformations range from 0 to 50%
- 100% mortality among malformed
- PCB increases larval survival
- Observed initial abundance

Risk of decline after 10 years



Import

- How could there still be frogs here?
- This site is probably a population sink
 - Immigration from surrounding populations
- Density dependence could also be at play
 - No evidence for this

Sensitivity studies

Base demography

Stable and Declining

Vital rates

$\pm 5\%$ and $\pm 10\%$

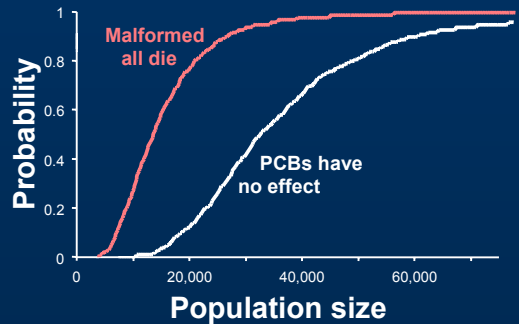
Correlation among pools

0.5 and 0.25

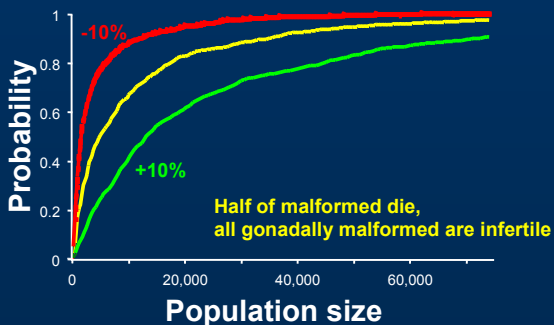
Density dependence

Ceiling model and Ricker model

Extinction risk under Ricker model



Extinction risk varying vital rates



Sensitivity study results

- Increasing vital rates helps
- Decreasing correlation helps
- Compensatory density dependence helps
- No manipulation removes PCBs' impact

Conclusions

- PCBs negatively impacts the Housatonic wood frog metapopulation
 - Hasten population decline
 - Reduce population size
 - Increase risk of extinction
- Impact seems biologically significant
- Impact smaller if population is declining, but then impact would be even graver

Acknowledgments

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Army Corps of Engineers



Review of assumptions

- Age-structured model with **maximum age of 3 years**
 - Time horizon of 10 years
 - Compensatory density dependence
 - Only zero-year olds disperse
 - **Vital rates cross-correlated within a time step**
 - **Males can breed with up to 10 females**
 - Housatonic data used for initial abundances
 - Maryland data used to determine vital rates
 - Virginia data used to determine dispersal
 - Gonadal abnormality causes 50-100% sterility
 - Malformation causes 50-100% mortality
 - **No effect of PCBs on sex ratio**
 - **tPCBs increase larval survival (seen in the lab)**
- conservative
- optimistic
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