Ecosystem-level risk of chemicals: From experimental data to a calibrated ecosystem model

SETAC-North America

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Ludiwine Clouzot
M. Paterson, A. Dupuis, P. Blanchfield, M. Rennie, K. Kidd and P.A. Vanrolleghem

Canada Research Chair in Water Quality Modeling

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Ecosystem model: Pesticides

Frederik De Laender
(PhD thesis, 2007)

Micro- & Mesocosm Experiments:

- Insecticides (Diflubenzuron, Esfenvalerate, Azinphos-Methyl, Fenthion)
- Herbicides (Atrazine, Metribuzin, Linuron)

Single-species toxicity data:

- Mortality & Growth – EC_{50}s

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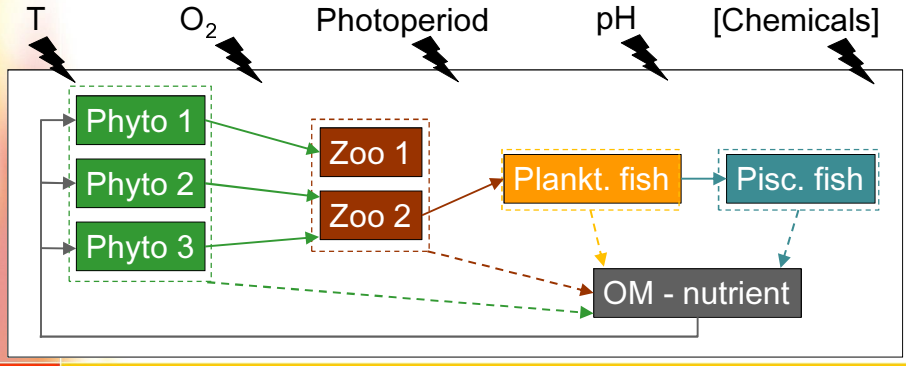
Ecosystem model: Object-oriented

Frederik De Laender
(PhD thesis, 2007)

AQUATOX-WEST



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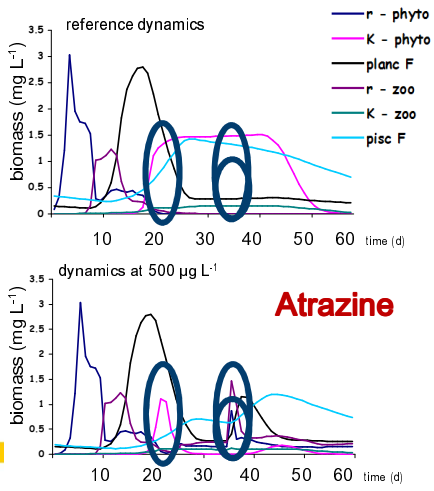
Example: Herbicide

Frederik De Laender
(PhD thesis, 2007)

- Disappearance of one phyto
- Appearance of another phyto
- Appearance of one zoo



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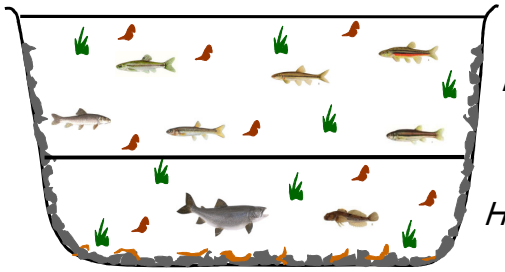
Objective of the study

Extending the developed ecosystem model to a stratified lake



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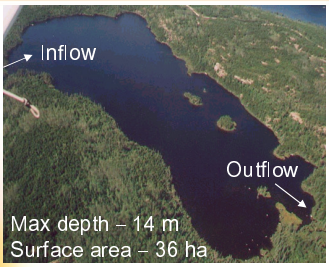
Kidd et al., 2007

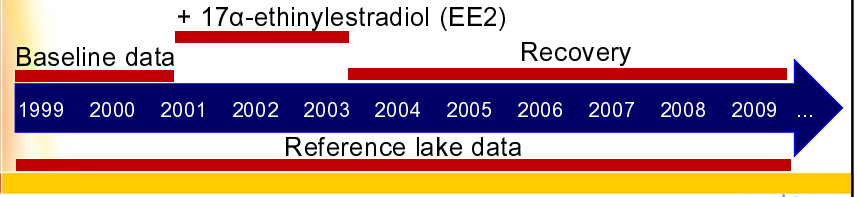
Experimental Lakes Area in Canada



Ecosystem study with EE2

Collapse of fathead minnow

Endocrine disruption in other fish species



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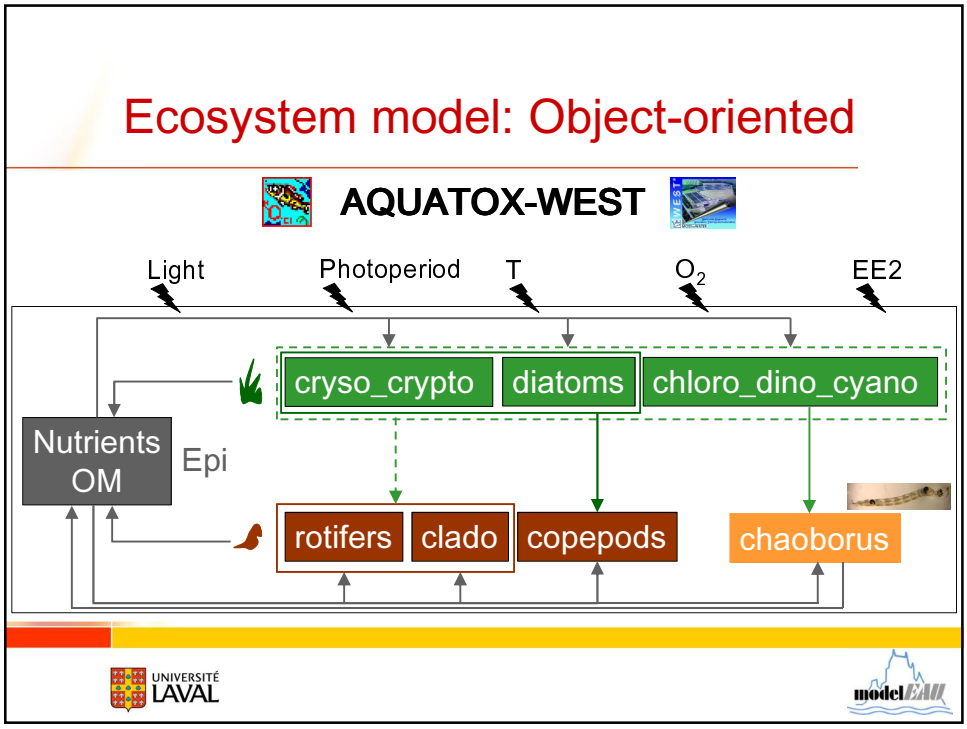
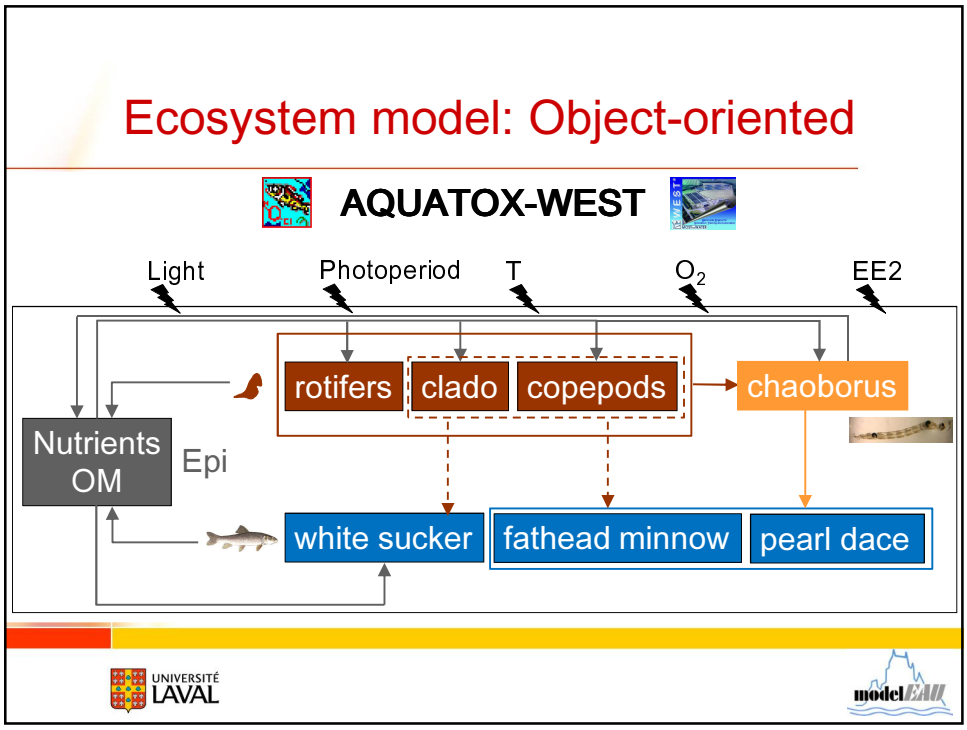
Ecosystem model: Object-oriented

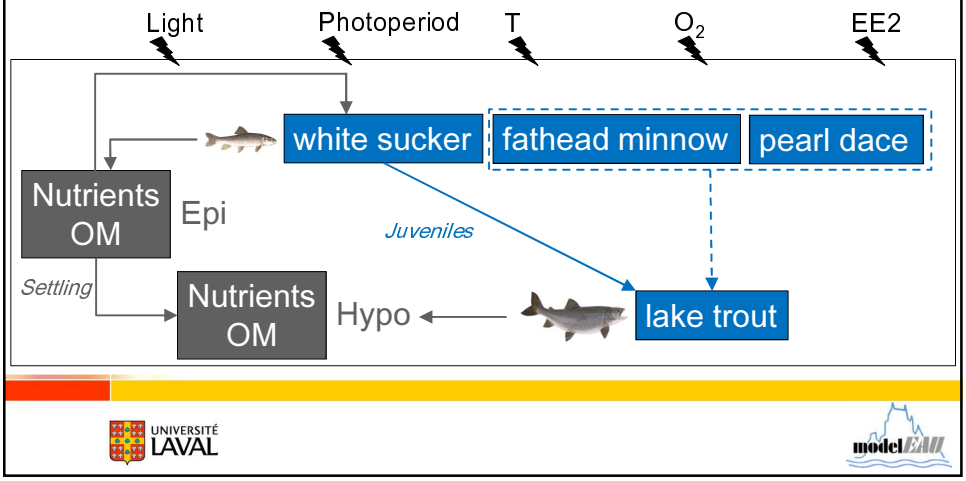


Ecosystem model: Object-oriented



Ecosystem model: Object-oriented

AQUATOX-WEST



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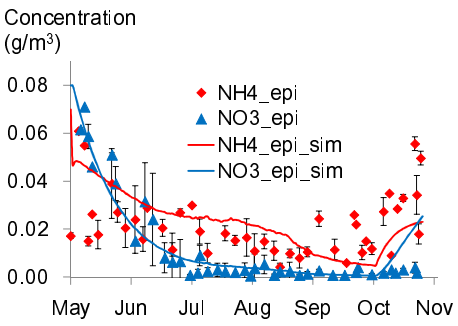
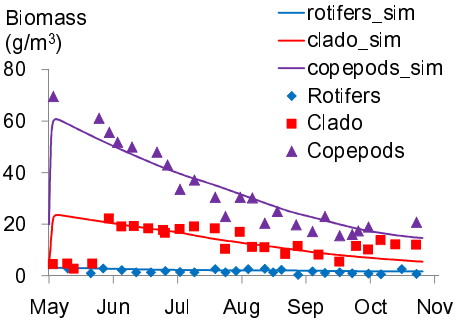
Modelling results: Calibration

Nutrients

Zooplankton

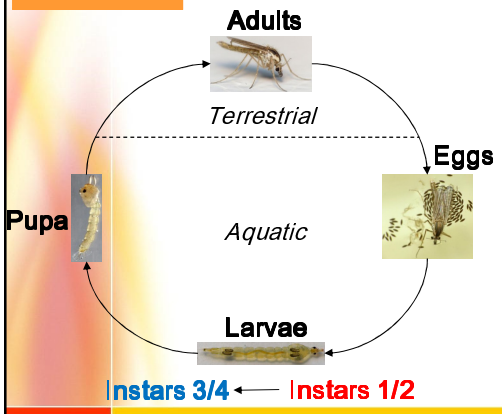




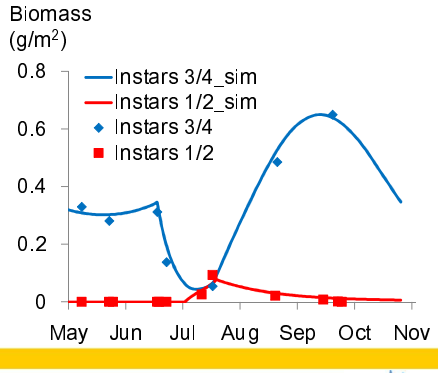
Modelling results fit experimental data

Modelling results: Calibration

chaoborus



Key species in ecological interactions

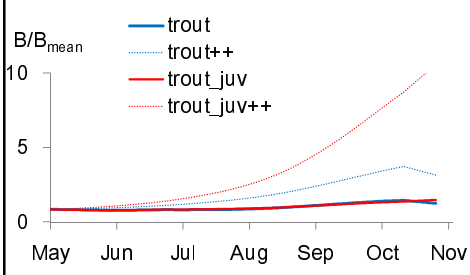


Modelling results: Sensitivity analysis

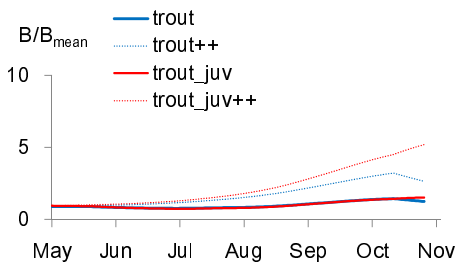
white sucker

Biomass x5

WITHOUT CHAOBORUS



WITH CHAOBORUS



More ecological interactions → More stable ecosystem

Model Development: Conclusion

Calibration:

- Modelling results fit experimental data

Sensitivity analysis:

- Initial population x5 and ÷5 for each species
- Great consistency within the ecosystem
- Shows the potential of the model

EE2: Ecosystem-level effects

Direct effects of EE2:

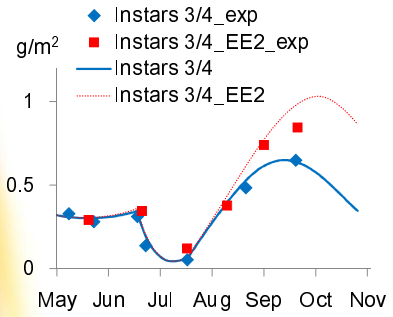
- Mainly on fathead minnow
- Pretty well understood

Indirect effects of EE2: *Kidd et al., 2014*

- Food web responses rarely studied
- Experimental data show some indirect effects
- More answers with the ecosystem model

EE2: Indirect effects

chaoborus



Predation changes

Plankton and nutrients

2002

No significant changes
= compensatory mechanisms

After 2002

Increase of rotifers and cladocerans

Conclusion

Experimental & modelling results: Indirect effects

- Competitive interactions = prey / predator
- Compensatory mechanisms = plankton

Importance of ecosystem-level effects when assessing the risk of chemicals in aquatic environments.

Perspectives

Long term simulation:

- Modify the model to run over a whole year
- Run the model from 1999 to 2005
- Use the model to predict the effects of longer exposures

Perspectives

Extending the developed ecosystem model to a river system

NSERC Strategic Project

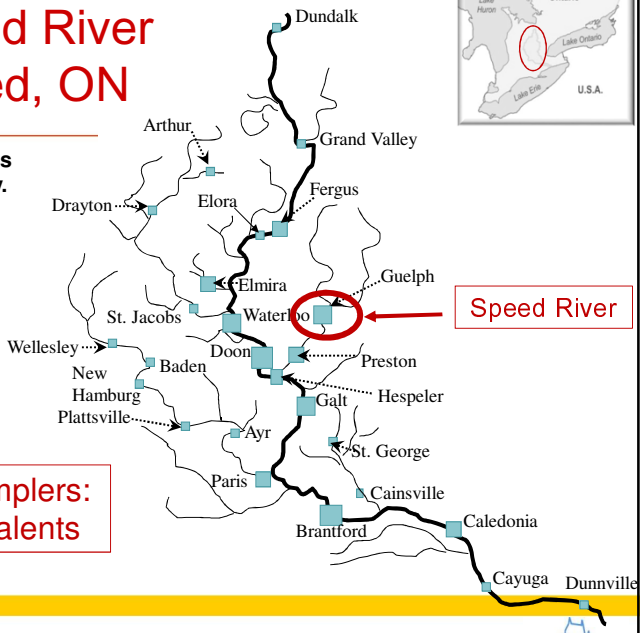
Viviane Yargeau (PI, McGill)
Chris Metcalfe (Trent)
Peter Vanrolleghem (ULaval)

The Grand River Watershed, ON

26 Wastewater Treatment Plants serve +/- 1 million people equiv.

- >100,000 people served
- 50,000 to 100,000 people served
- 5000 to 50,000 people served
- 0 to 5000 people served

Small river – low flows



Speed River

Passive samplers: EE2 equivalents

Perspectives

Speed River well characterized by Mark Servos and colleagues (U. Waterloo):

- Food web dynamics
- Biological effects
- Measurements of estrogens and estrogenic potency of effluents

Acknowledgement

Freshwater Institute
Welcome to the Freshwater Institute

NSERC
CRSNG

Canada Research Chair
on Water Quality Modelling

For more questions: ludiwine.clouzot.1@ulaval.ca