

# Impacts of endocrine disruptors on aquatic ecosystems: A whole ecosystem model of an impacted lake

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**Ludwine Clouzot**

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



Canada Research Chair  
in Water Quality Modeling



## Endocrine disruption

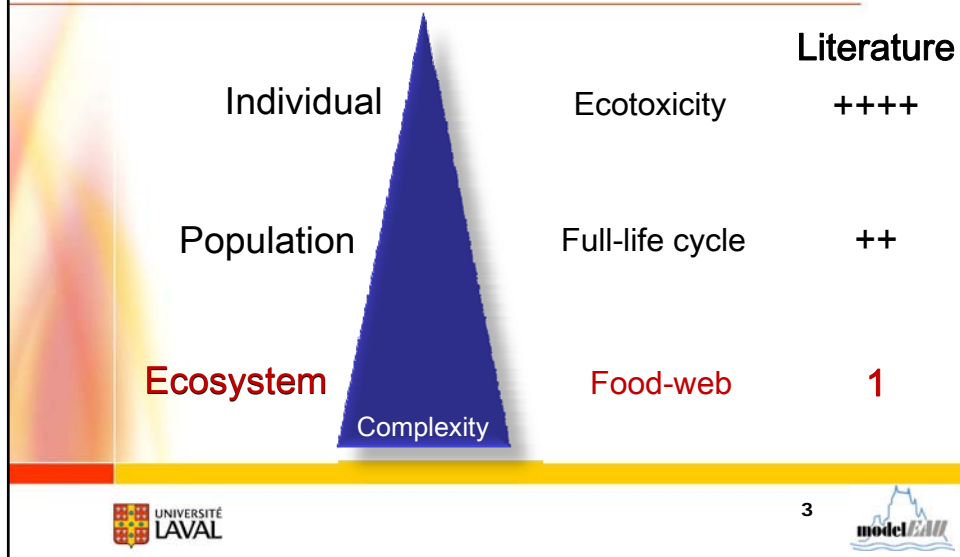
- Intersex fish
- Reproductive disturbances
- Etc...



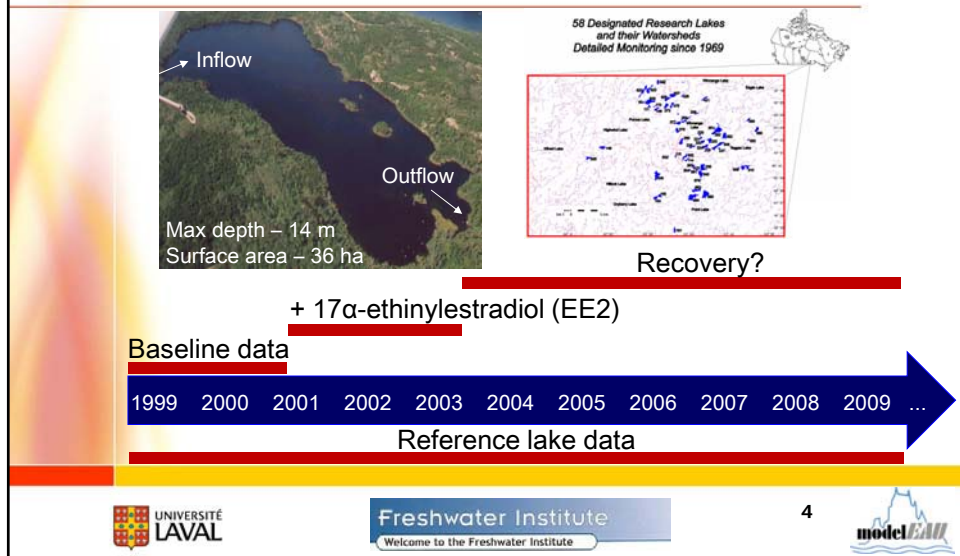
\*Joanne Parrott



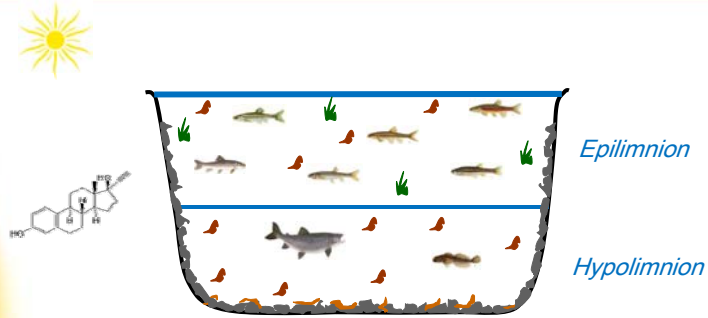
## Endocrine disruption: Experiments



## Ecosystem study: EE2



## Ecosystem study: Results

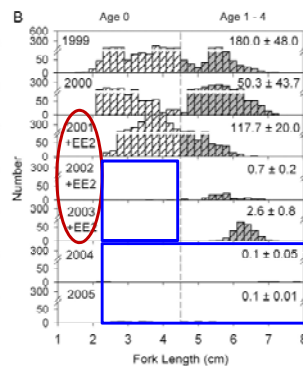
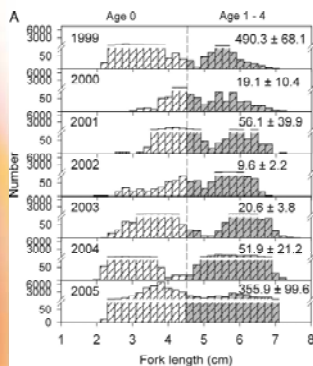


- Endocrine disruption in fish species

## EE2: Collapse of *fathead minnow*

Reference Lake

Experimental Lake



EE2 addition

No reproduction

No reproduction  
& No adults

Kidd et al., 2007

## Endocrine disruption: Modeling

		Literature
Individual	Testing hypotheses Data analysis	+
Population	Distribution-based structured model	++
<b>Ecosystem</b>	<b>No model</b>	<b>0</b>

Complexity

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7

model

## Ecological risk assessment (ERA)

### Ecosystem services concept

- Ecosystem experimental study:
  - Just one shot!
- Ecosystem models:
  - Required to better understand endocrine disruption and to be able to predict risk

## Objective of the study

- Developing an ecosystem model that can be used in ERA of endocrine disruptors

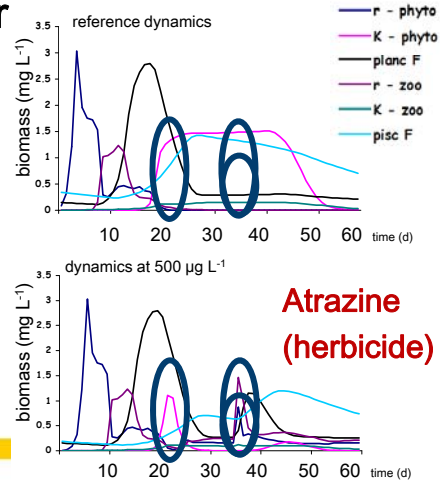


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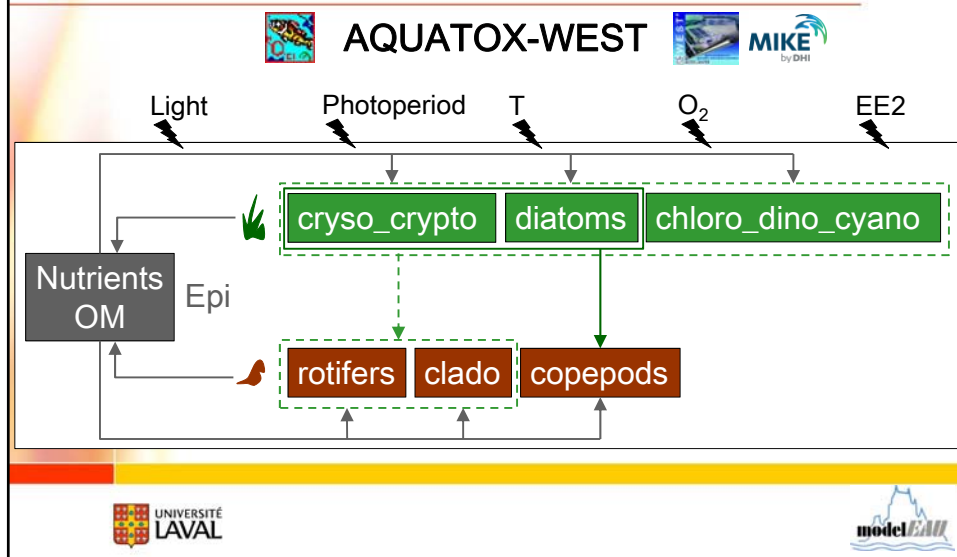
## Ecosystem model: Example

Frederik De Laender  
(PhD thesis, 2007)

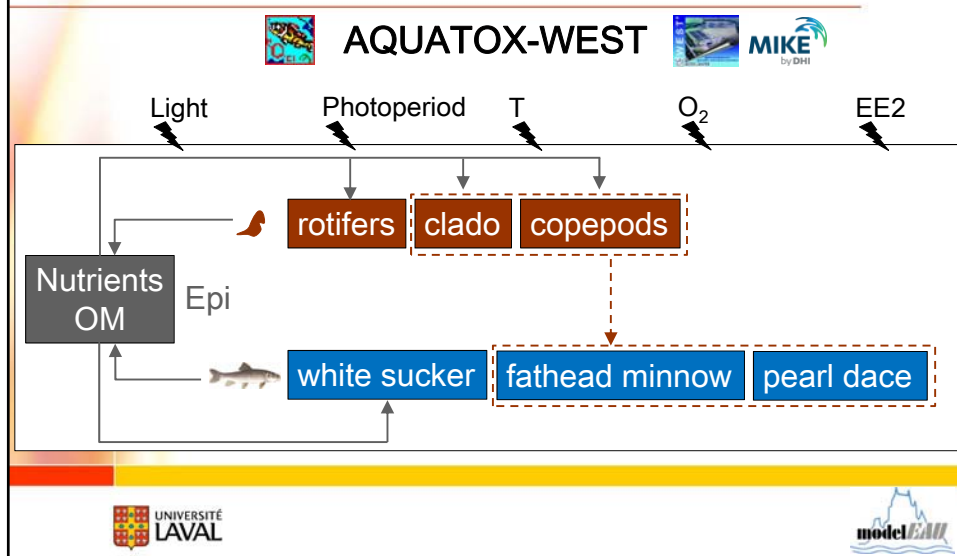
- Disappearance of one phyto
- Appearance of another phyto
- Appearance of one zoo



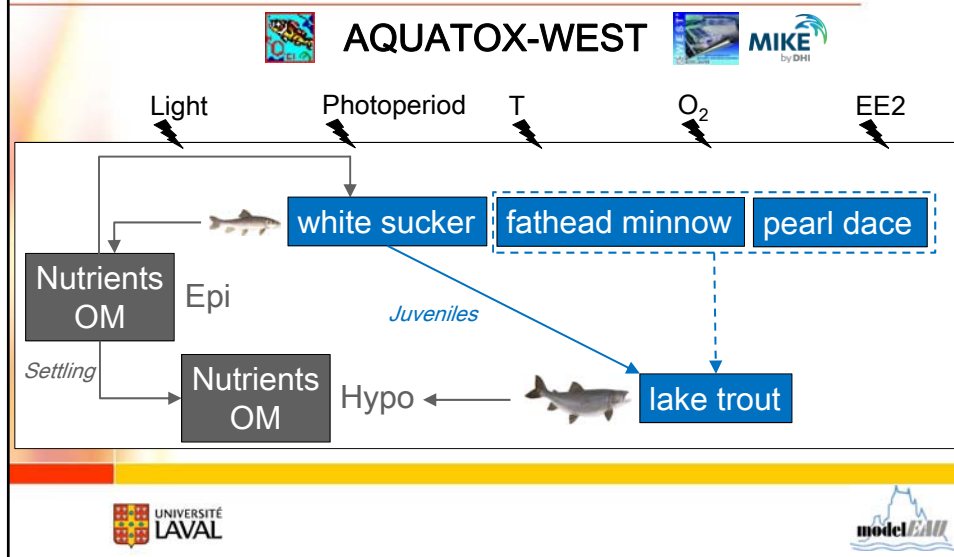
## Ecosystem model: Lake with EE2



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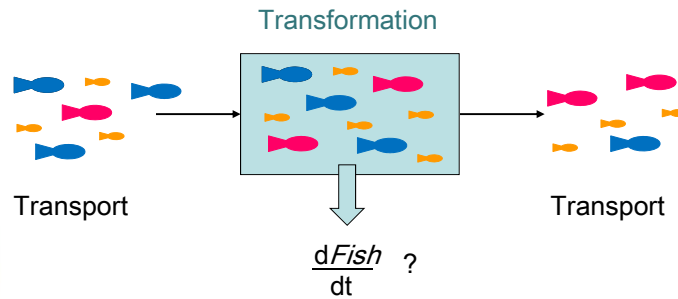


## Ecosystem model: Lake with EE2



## Zoom on fish: Equations

- Mass balance:



$$\frac{dFish}{dt} = \text{Transformation} + \text{Transport}$$

## Zoom on fish: Frederik De Laender

$$\frac{dFish}{dt} =$$

### Transformation

- + Consumption
- Defecation
- Respiration
- Excretion
- Mortality
- Predation
- ~~+ Recruitment~~
- ~~- Promotion~~
- ~~- Gamete Loss~~

### Transport

- ~~+ Loading~~
- ~~- Wash\_out~~
- ~~+ Wash\_in~~
- ~~± Diffusion<sub>seg</sub>~~
- ~~± Migration~~
- ~~- Entrainment~~
- ~~- Fishing~~

$$\frac{dBiomass_{animals}}{dt} = Consumption - Defecation - Respiration - Excretion - Mortality - Predation$$

## Zoom on fish: Lake with EE2

$$\frac{dFish}{dt} =$$

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± Stratification

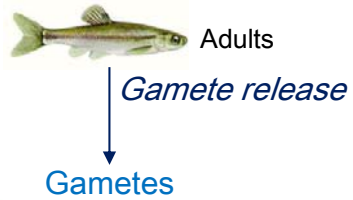
$$\frac{dBiomass_{animals}}{dt} = Consumption - Defecation - Respiration - Excretion - Mortality - Predation$$

$$+ Recruitment - Promotion - GameteLoss \pm Stratification$$



## Zoom on fish: Reproductive endpoints

$$\mathbf{GameteRelease = PctGamete \times Adults}$$

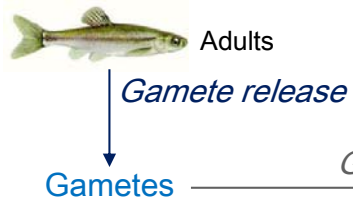


Nutrients  
OM

Juveniles  
(no reproduction)

## Zoom on fish: Reproductive endpoints

$$\mathbf{GameteLoss = (GMort + IncrMort) \times PctGamete \times Adults}$$



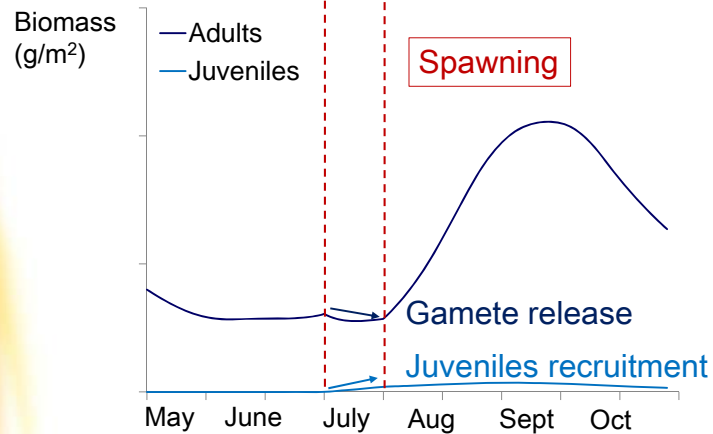
Juveniles  
(no reproduction)

## Zoom on fish: Reproductive endpoints

$$\text{Recruitment} = (1 - (\text{GMort} + \text{IncrMort})) \times \text{PctGamete} \times \text{Adults}$$



## Zoom on fish: Reproductive endpoints



## Zoom on fish: Reproductive endpoints

$$\text{Promotion} = K_{Pro} \times \text{GrowthRate}$$



Adults recruitment

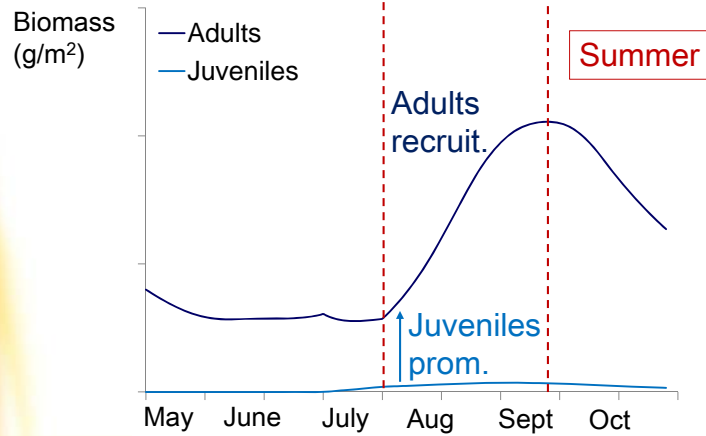
Nutrients  
OM

Juveniles promotion

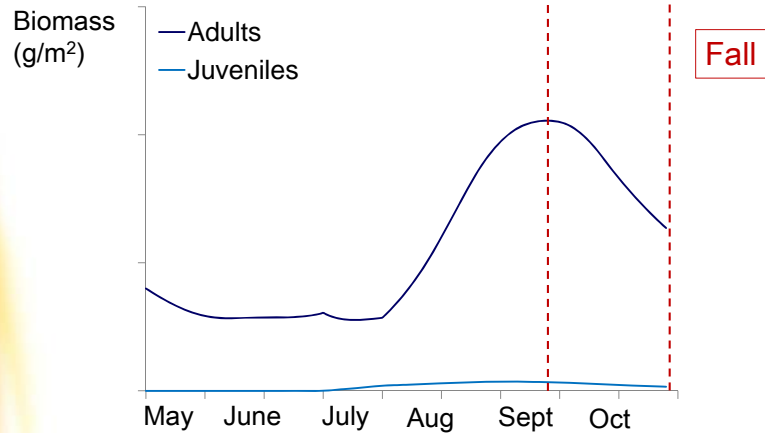


Juveniles  
(no reproduction)

## Zoom on fish: Reproductive endpoints



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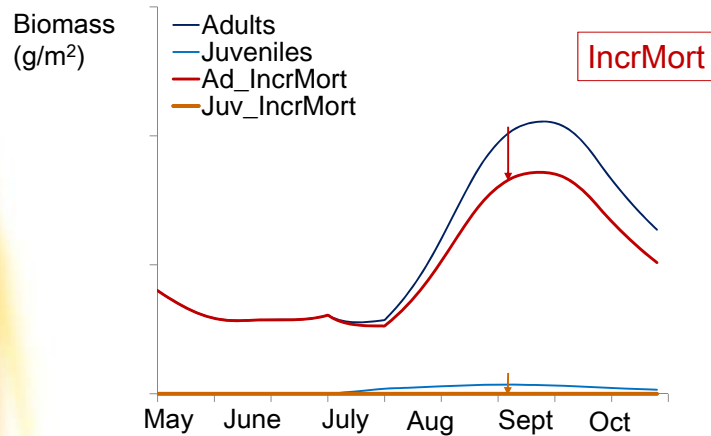


## Zoom on fish: Endocrine disruption

- Increase of gamete mortality

$$\text{GameteLoss} = (\text{GMort} + \text{IncrMort}) \times \text{PctGamete} \times \text{Adults}$$

## Zoom on fish: Increase of mortality



## Zoom on fish: Endocrine disruption

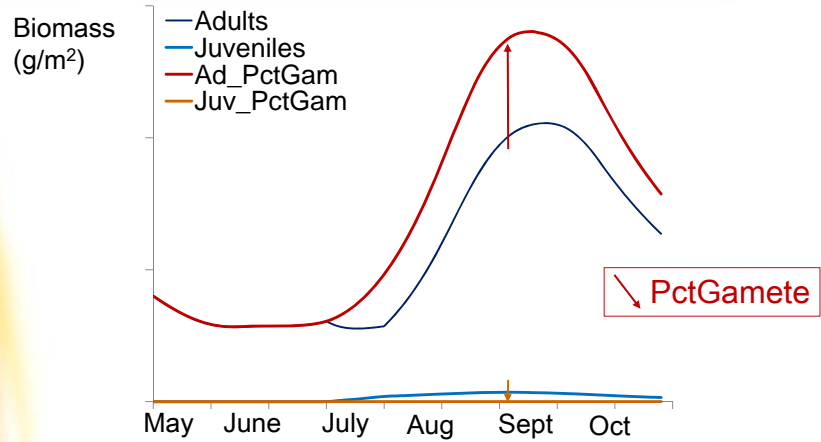
- Increase of gamete mortality

$$\text{GameteLoss} = (\text{GMort} + \text{IncrMort}) \times \text{PctGamete} \times \text{Adults}$$

- Decrease of gamete production

$$\text{GameteLoss} = (\text{GMort} + \text{IncrMort}) \times \text{PctGamete} \times \text{Adults}$$

## Zoom on fish: Decrease of production



## Zoom on fish: Endocrine disruption

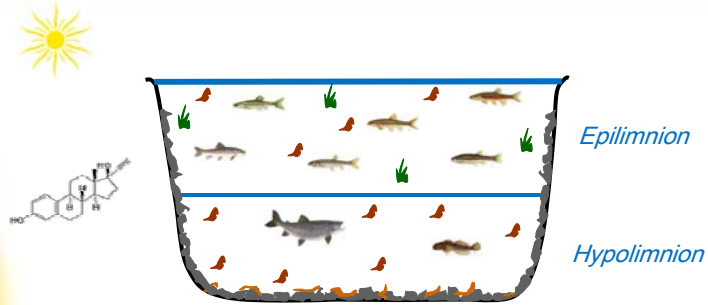
↓ Gamete  
production



↗ Fish  
mortality

↗ Gamete  
mortality

## Conclusion: Ecosystem model



- Model structure = ready
- Model calibration = ongoing

## Acknowledgement



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