

Predicting the impact of endocrine disruptors on environmental health: An ecosystem model

SETAC-Europe

Glasgow, Scotland

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Canada Research Chair
in Water Quality Modelling



Endocrine disruption: Review

- Laboratory studies limited to individual level



*Joanne Parrott



Endocrine disruption: Modelling

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

Complexity

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model

Endocrine disruption: Review

- What happens at the ecosystem level?

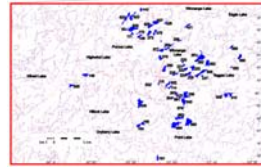


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Ecosystem study: EE2



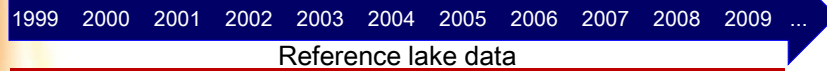
58 Designated Research Lakes and their Watersheds Detailed Monitoring since 1969



Recovery?

+ 17 α -ethinylestradiol (EE2)

Baseline data



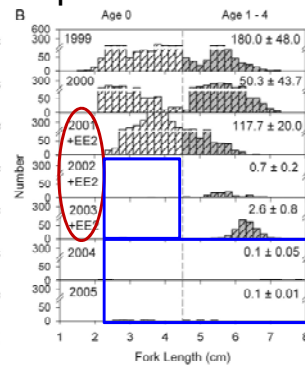
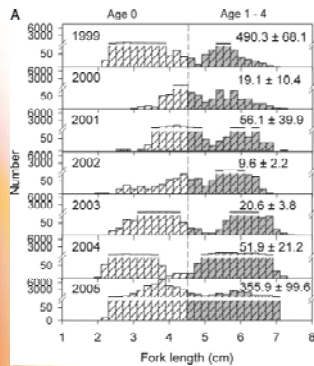
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EE2: Collapse of *fathead minnow*

Reference Lake

Experimental Lake



EE2 addition

No reproduction

No reproduction & No adults

- Endocrine disruption in the other fish species



Kidd et al., 2007

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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 assessing environmental health after exposure to endocrine disruptors

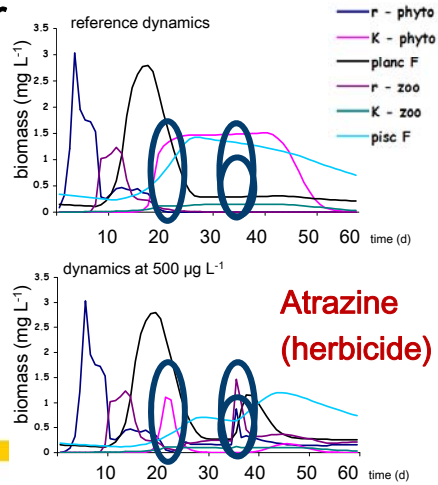


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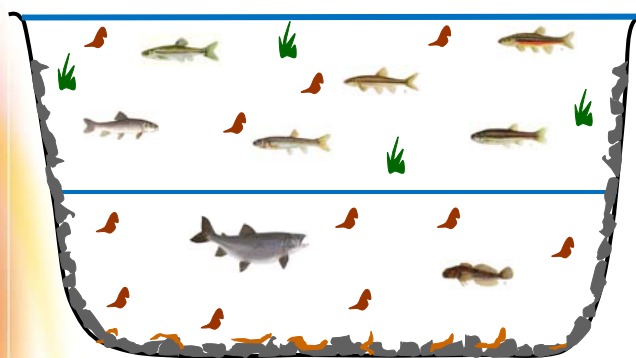
Ecosystem model: Acute toxicity

Frederik De Laender
(PhD thesis, 2007)

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



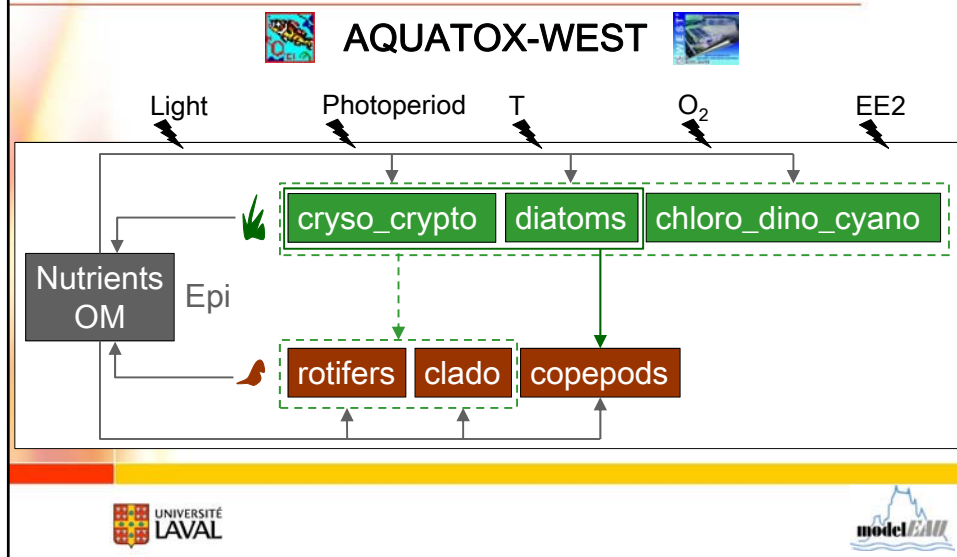
Ecosystem model: Lake



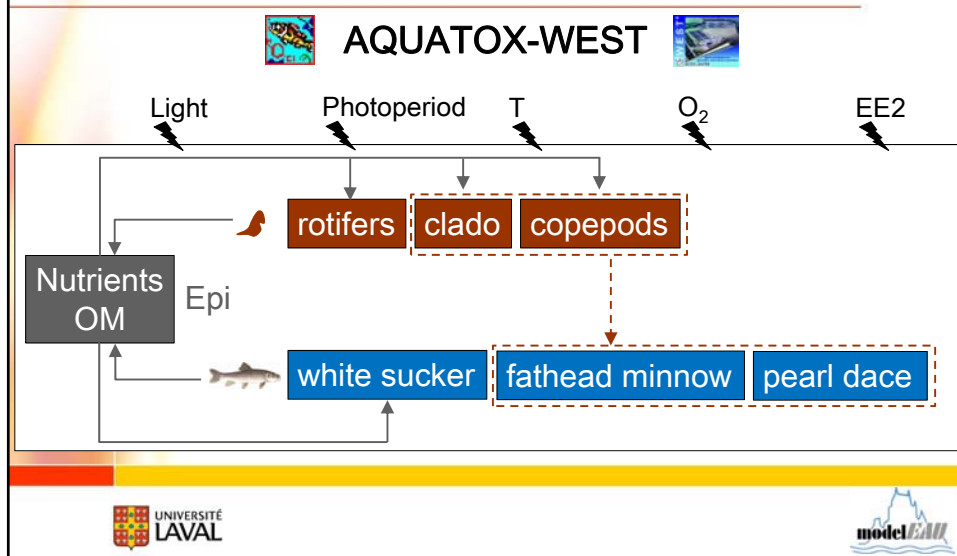
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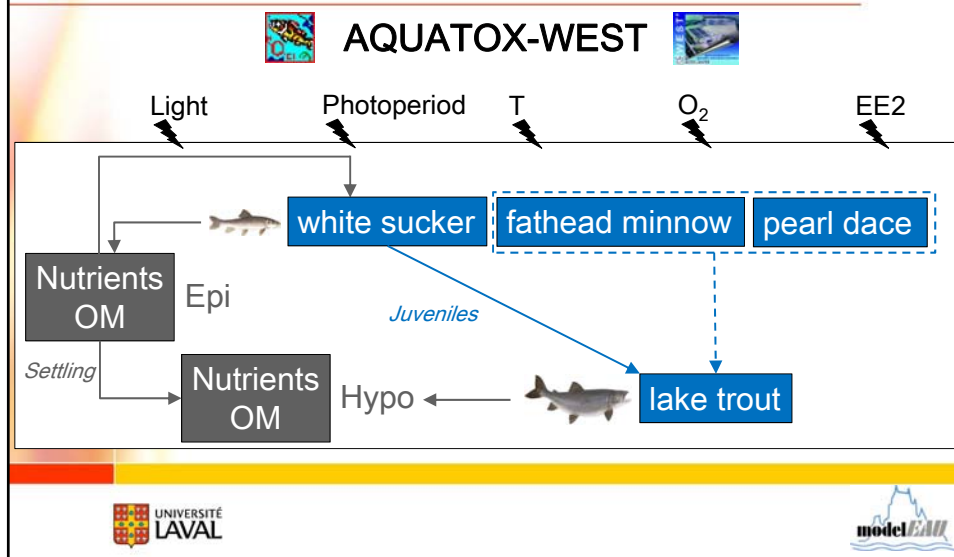
Ecosystem model: Object-oriented



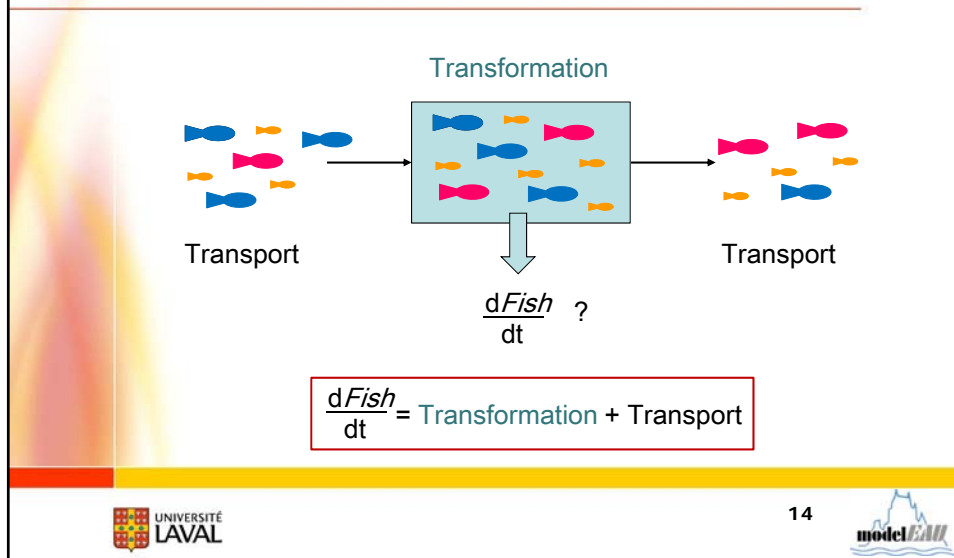
Ecosystem model: Object-oriented



Ecosystem model: Object-oriented



Zoom on fish: Equations



Zoom on fish: Equations

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

Transformation

- + Consumption
- Defecation
- Respiration
- Excretion
- Mortality
- Predation
- + Recruitment
- Promotion
- Gamete Release

Transport

- ~~± Diffusion_{seg}~~
- ~~+ Loading~~
- ~~- Wash_{out}~~
- ~~+ Wash_{in}~~
- ~~± Migration~~
- ~~- Entrainment~~
- ~~- Fishing~~

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

$$+ Recruitment - Promotion - Gamete Release$$

Zoom on fish: Reproductive endpoints

$$GameteRelease = PctGamete \times Adults$$



Gamete release

Gametes

Nutrients
OM



Zoom on fish: Reproductive endpoints

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

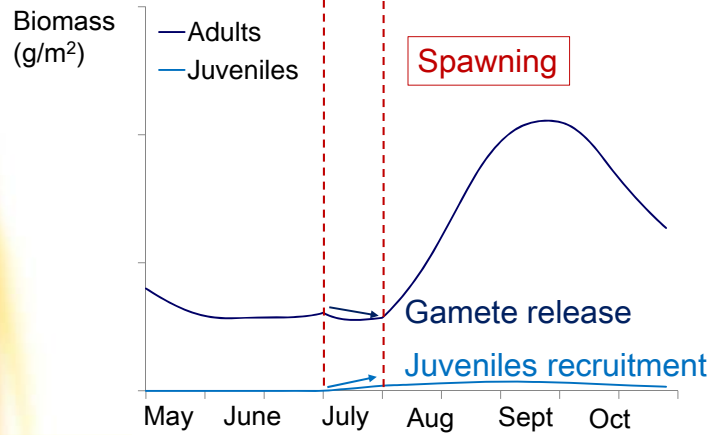


Zoom on fish: Reproductive endpoints

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



Zoom on fish: Reproductive endpoints



Zoom on fish: Reproductive endpoints

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



Adults recruitment

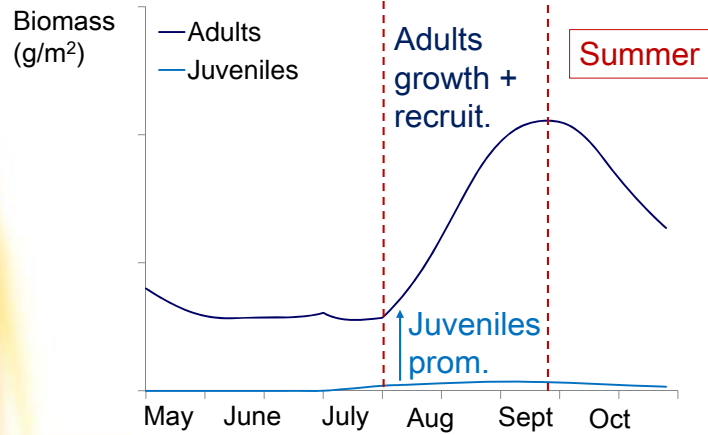
Nutrients
OM

Juveniles promotion

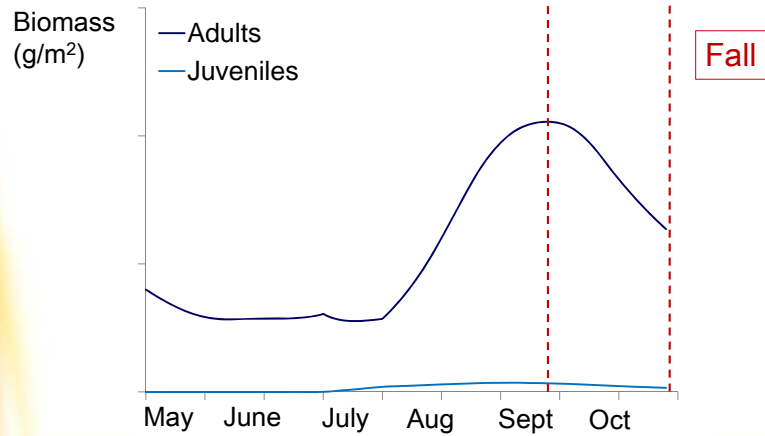


Juveniles
(no reproduction)

Zoom on fish: Reproductive endpoints



Zoom on fish: Reproductive endpoints



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

Biomass
(g/m²)

— Adults
— Juveniles
— Ad_IncrMort
— Juv_IncrMort

IncrMort

May June July Aug Sept Oct

Zoom on fish: Endocrine disruption

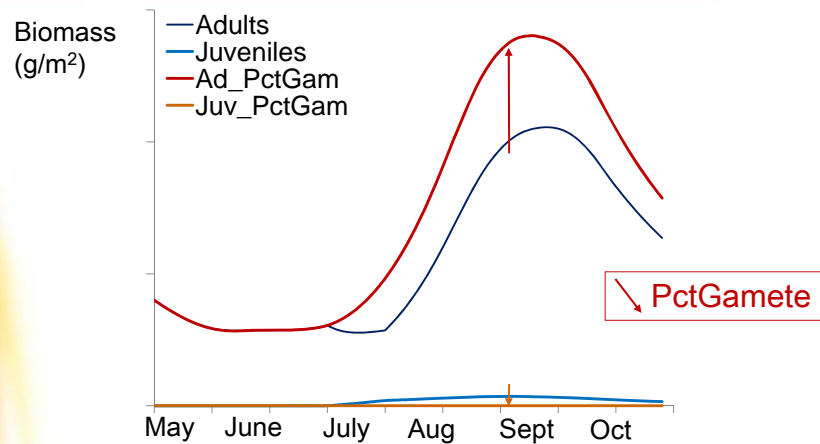
- Increase of gamete mortality

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

- 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

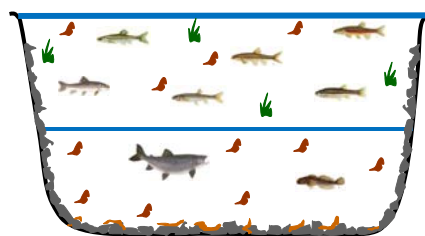
↘ Gamete production



↗ Fish mortality

↗ Gamete mortality

Conclusion: Ecosystem model



Epilimnion

Hypolimnion

- Model structure = ready
- Model calibration = to be done

Acknowledgement

Freshwater Institute
Welcome to the Freshwater Institute



Canada Research Chair
in Water Quality Modelling



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The Toronto Star, 29 avril 2013, page A10

EXPERIMENTAL LAKES AREA

Ontario wades in

Raise a glass to little guy

Those interested in the protection of the environment, the advancement of scientific knowledge or the practice of good government got a bit of welcome news last week. Ontario Premier Kathleen Wynne vowed to help undo one of the federal government's most bewildering recent initiatives, the planned closure of the Experimental Lakes Area.

Set out in the 2012 federal budget, the plan was simple, if profoundly strange. The ELA, the world's most important freshwater research centre, had become inconsistent with the Department of Fisheries and Oceans' increasingly practical priorities and would be closed at a savings of \$2 million per year. Never mind that remediating the lakes in the area would cost Canadians roughly \$50 million – enough to keep the centre open for 25 years – or that the science produced by the facility on acid rain and the environmental effects of lake pollutants had shaped policy in Canada and around the world for

Kathleen Wynne announced last week that Ontario, Manitoba and Ottawa had worked out a deal to buy the ELA a one-year reprieve



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