

An ecosystem model to assess the ecotoxicological impacts of endocrine disruptors released by WWTPs

SETAC
North America

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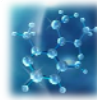
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K. Kidd and P.A. Vanrolleghem



*Canada Research Chair
in Water Quality Modeling*



WWTPs: Effluent characterization



- Researchers
- Engineers
- Decision-makers

Objective:

- Improve WWTP design/operation
- Minimize the impact on the receiving waters



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WWTPs: Ecotoxicological context

Protect ecosystem services

- Supporting services
- Provisioning services
- Regulating services
- Cultural services



WWTPs: Ecological criteria

Phyto: primary producer (N & P cycles)

- Production with min and max thresholds

Index of diversity (D) (Simpson 1949)

$$D = 1 - \sum (p_i)^2$$

$D_{\text{phyto}}, D_{\text{zoo}}, D_{\text{fish}}$

- D = values from 0 to 1
- p_i = proportion of individuals of species i

WWTPs: Ecological criteria

Effluent

?

WWTP

[MPs]

Typical ecosystem

Population dynamics



5



WWTPs: Ecological benchmarking

Effluent

?



[MPs] 1

Bio-effect 1



[MPs] 2

Bio-effect 2



[MPs] 3

Bio-effect 3

The best
WWTP?



6



Eco-benchmark: Micropollutants

Numerous micropollutants (MPs) & different effects

- Class with common mechanism (*e.g. endocrine disrupters*)
- Bio-effects rather than [MPs]



Eco-benchmark: Endocrine disruption

- Laboratory studies = individual
- Field studies = population
- Models = individual & population

What happens at the ecosystem level?

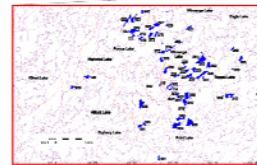


*Joanne Parrott

Endocrine disruption: Ecosystem study



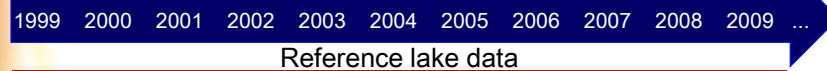
Experimental Lakes Area



Recovery

+ 17 α -ethinylestradiol (EE2)

Baseline data



9

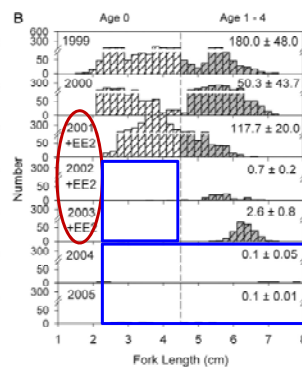
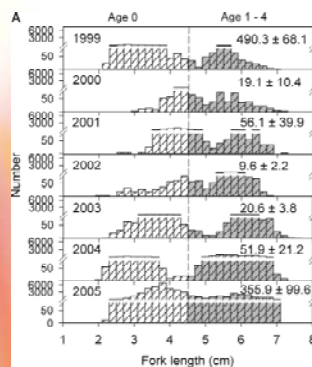


EE2: Collapse of *fathead minnow*

Reference Lake

Experimental Lake

Kidd et al., 2007



EE2 addition

Low reproduction

Low reproduction & adults number

Endocrine disruption in the other fish species



10



Endocrine disruption: Ecosystem

Ecosystem experimental study:

- Just one shot!



Ecosystem models:

- Required to better understand endocrine disruption and to be able to predict risk
- 0 ecosystem models found in the literature

Objective of the study

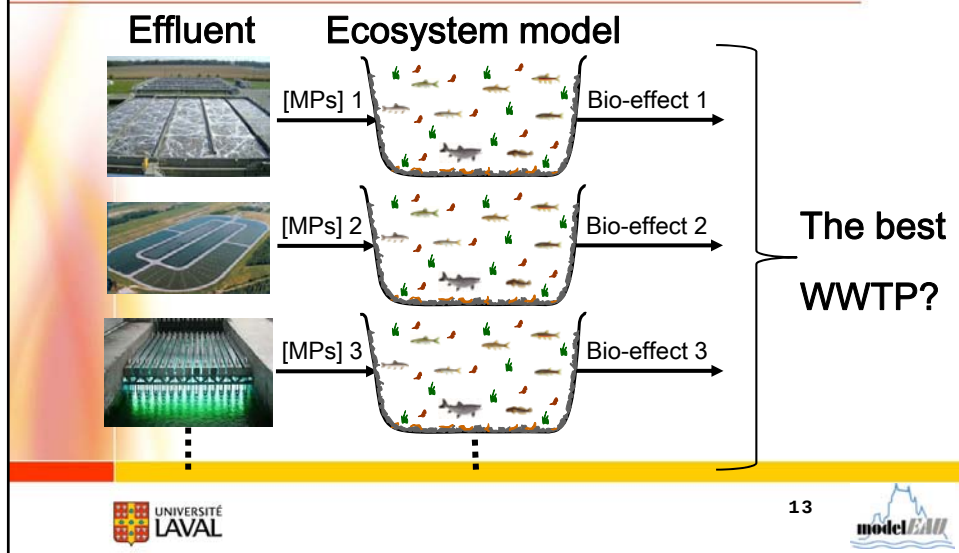
Developing an ecological benchmark criterion for characterizing WWTP effluents:

- Modelling a typical aquatic ecosystem
- Predicting the impact of endocrine disrupters

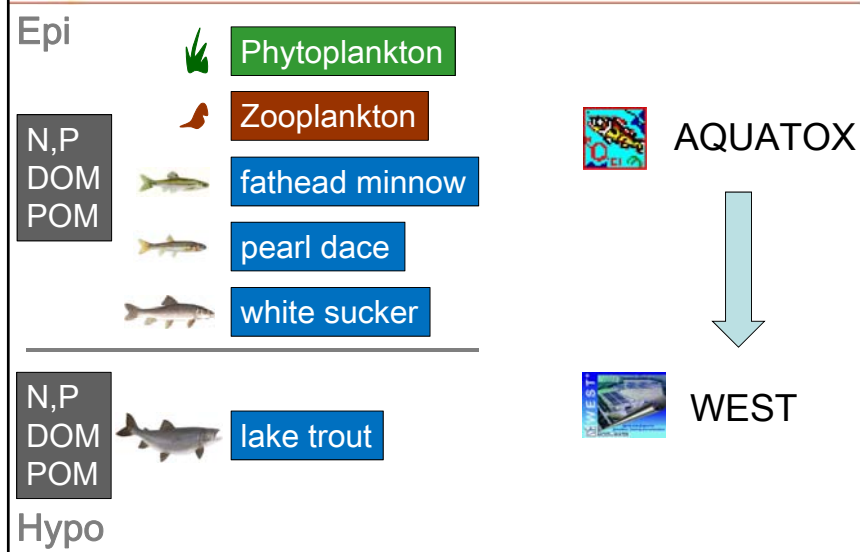


**Joanne Parrott*

WWTPs: Ecological benchmarking



Modelling results: Calibration



Modelling results: Calibration

Epi



Phytoplankton



Zooplankton

N,P

DOM

POM



fathead minnow



pearl dace



white sucker

N,P

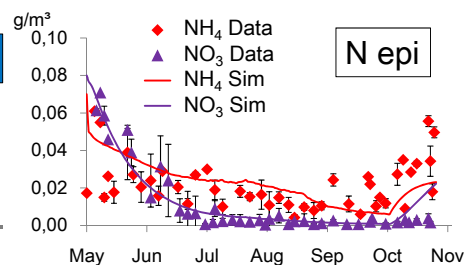
DOM

POM



lake trout

Hypo



Modelling results: Calibration

Epi



Phytoplankton



Zooplankton

N,P

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fathead minnow



pearl dace



white sucker

N,P

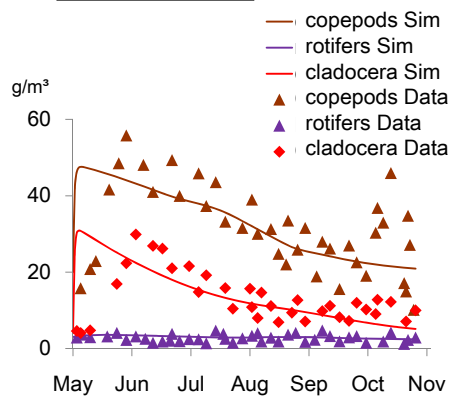
DOM

POM

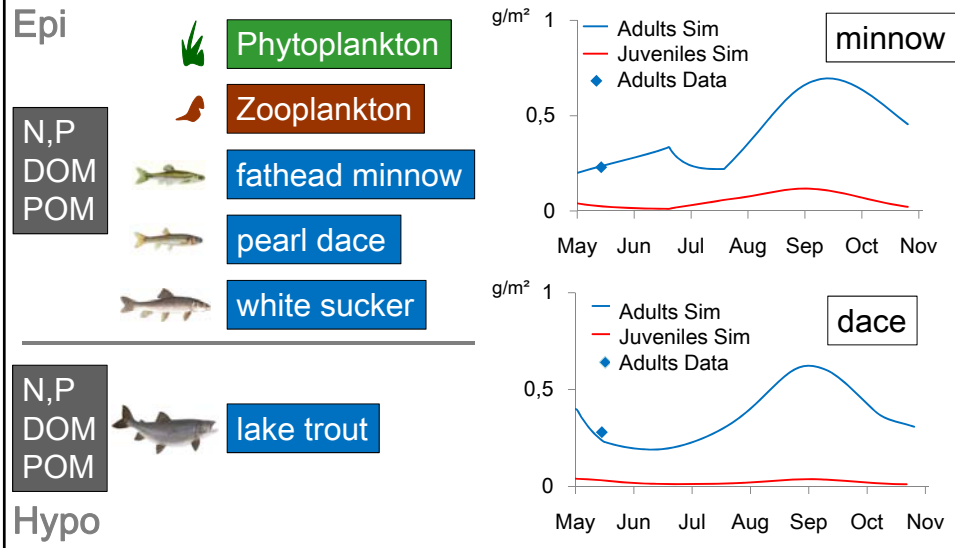


lake trout

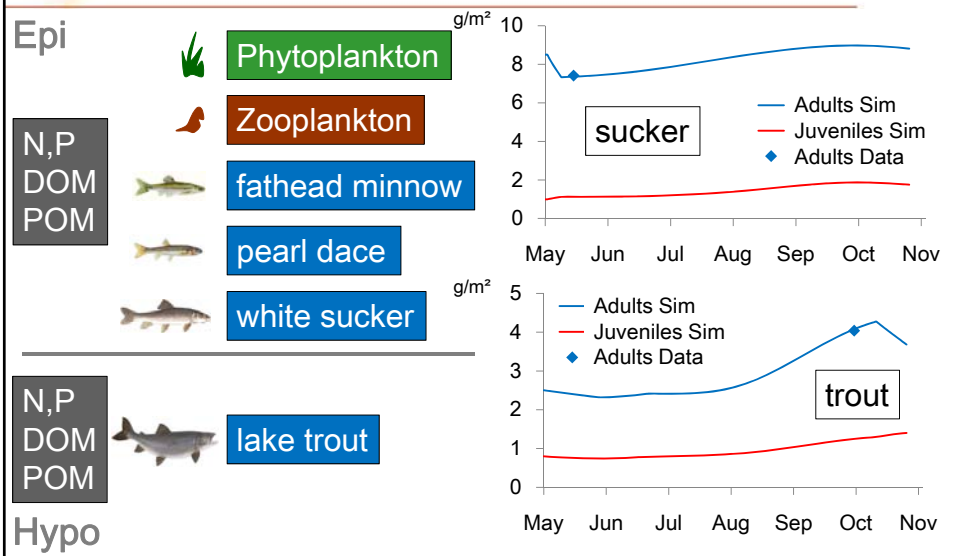
Hypo



Modelling results: Calibration



Modelling results: Calibration



Modelling results: Conclusion

Calibration:

- Modelling results fit experimental data

Sensitivity analysis:

- Initial population x 5 and / 5 for each species
- Changes in the ecosystem dynamics
- Great consistency

Modelling results: *Fathead minnow*

Endocrine disruption

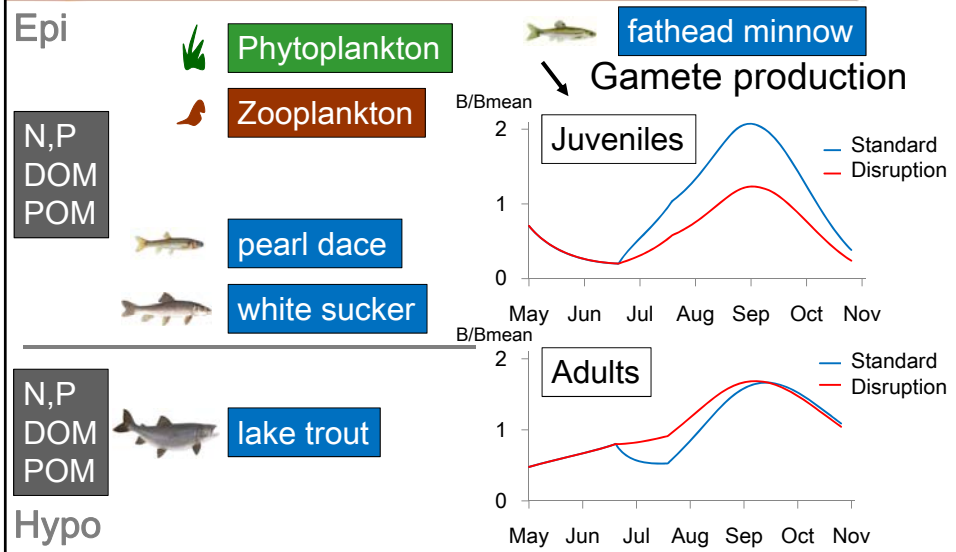
↘ Gamete
production



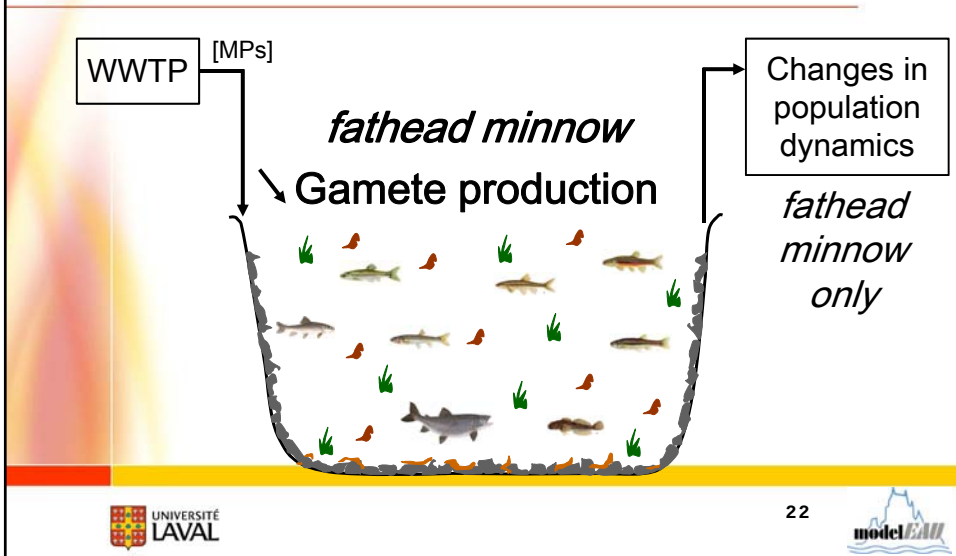
↗ Fish
mortality

↗ Gamete
mortality

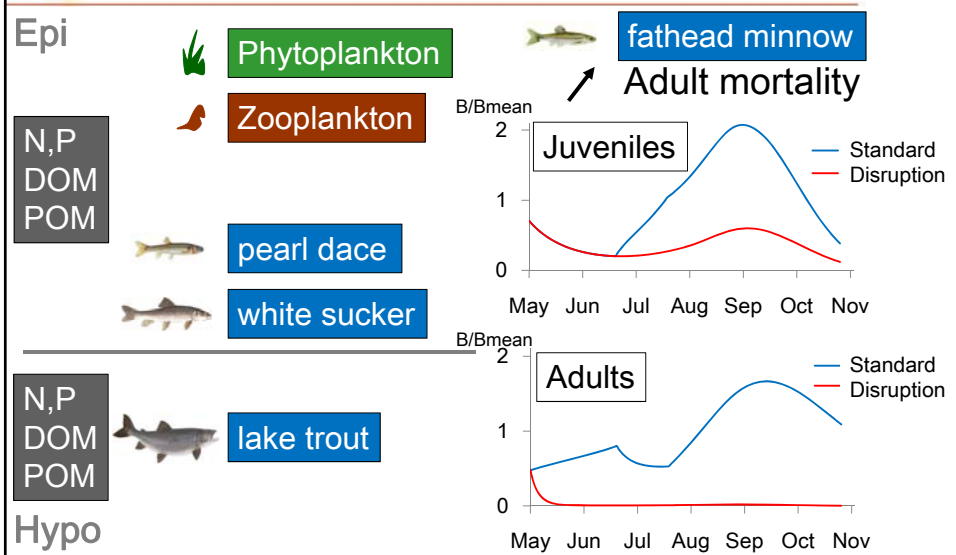
Modelling results: *Fathead minnow*



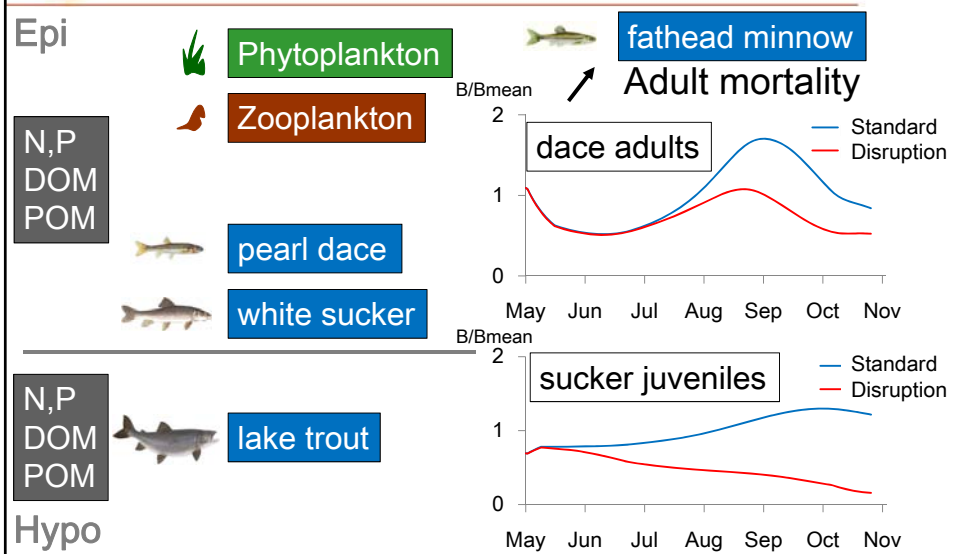
WWTPs: Ecological criteria



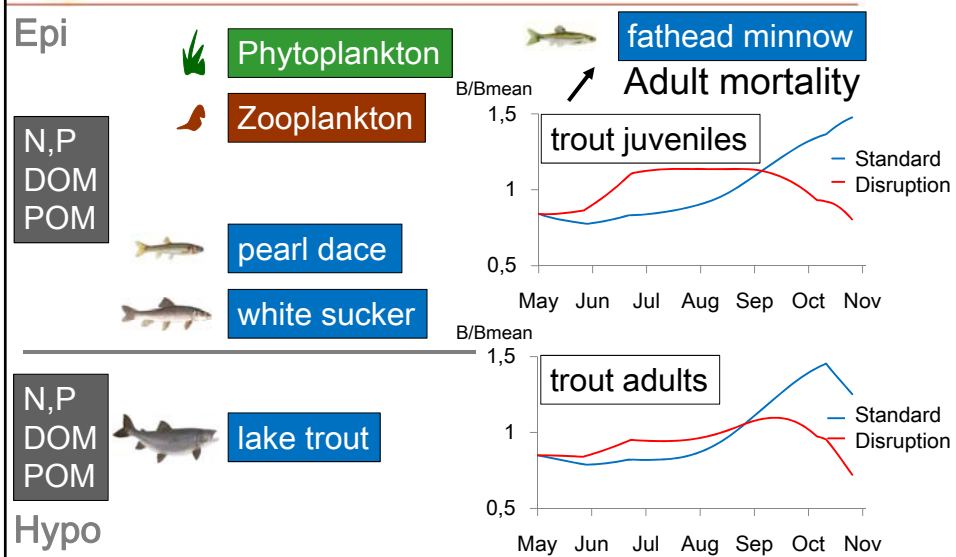
Modelling results: *Fathead minnow*



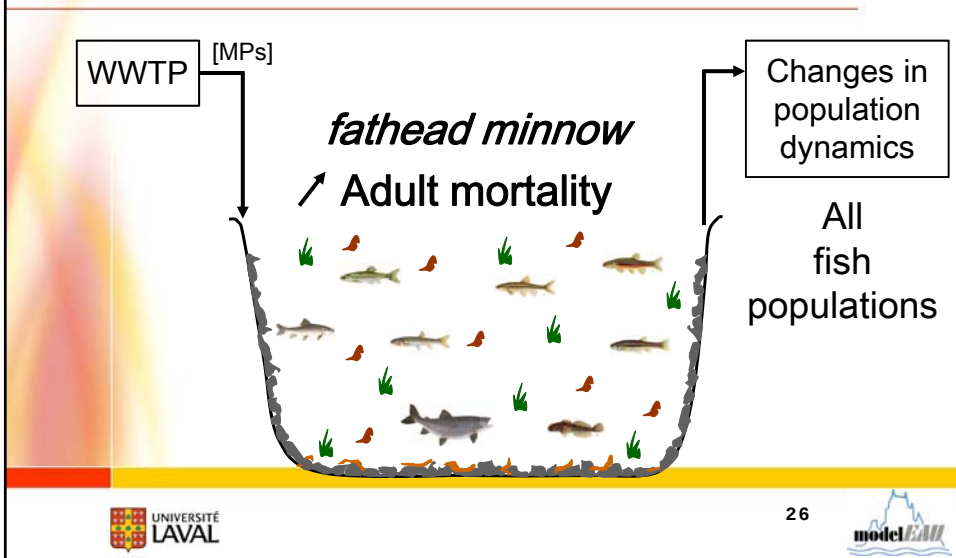
Modelling results: *Fathead minnow*



Modelling results: *Fathead minnow*



WWTPs: Ecological criteria



Conclusion

Calibration:

- Good fit with experimental data (no EE2)

Sensitivity analysis to EE2:

- Great consistency within the ecosystem
- Shows the potential of the model

Next steps:

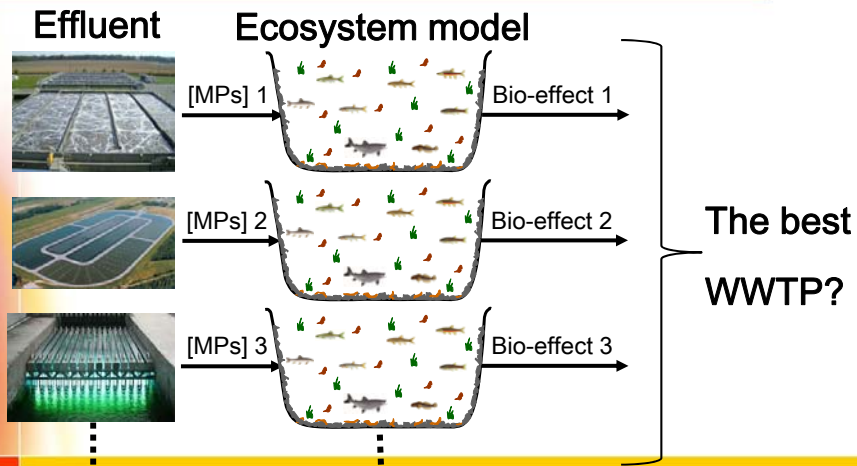
- Calibrating EE2 impact on fish and the ecosystem

Conclusion

Final step = Ecological benchmarking of WWTPs

- **STRUCTURE** = A typical aquatic ecosystem
- **INPUT** = WWTP effluents for different configurations
- **OUTPUT** = Ecosystem changes next to the exposure to MPs

WWTPs: Ecological benchmarking



Acknowledgement

Freshwater Institute
Welcome to the Freshwater Institute



Canada Research Chair
on Water Quality Modelling

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