

Benchmarking of wastewater treatment technologies in an ecotoxicological context

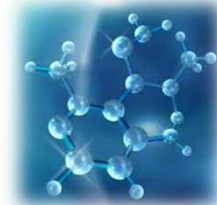
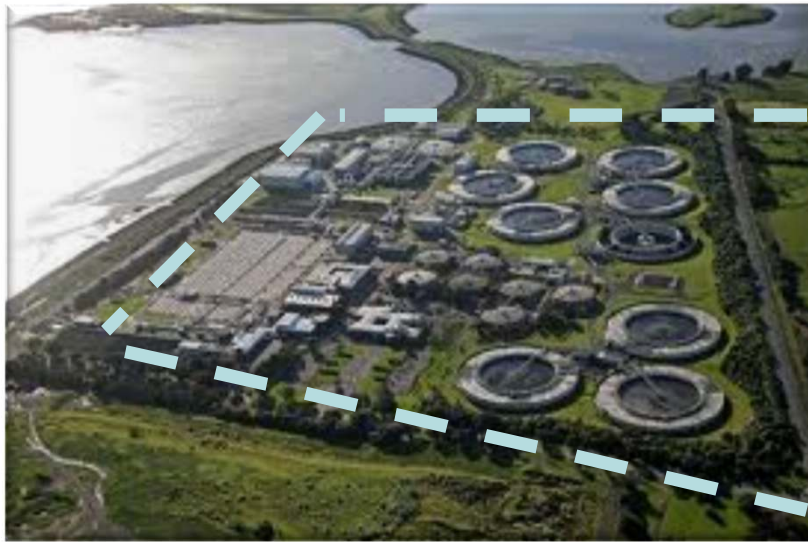
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International
Water Association

MP modelling through WWTPs

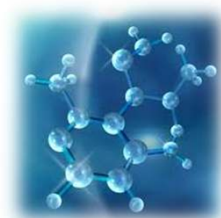
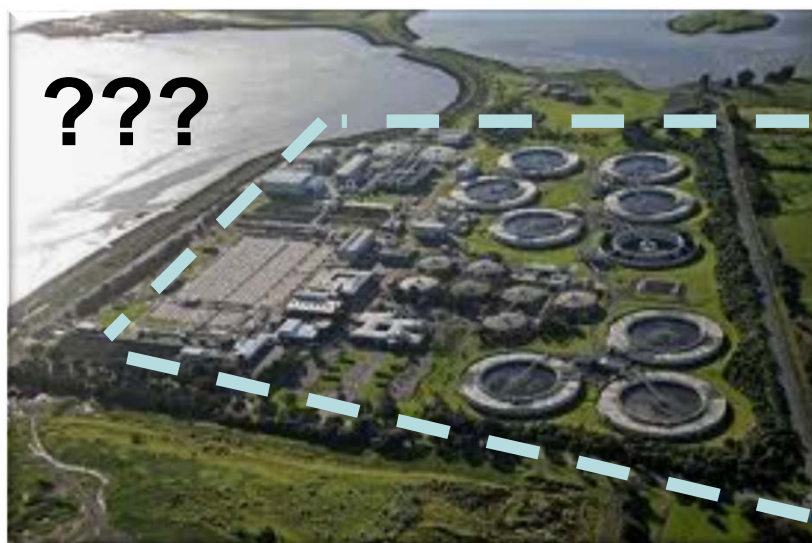


- Decision-makers
- Engineers
- Researchers

Objective:

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

MP modelling through WWTPs



Fate models

- Sorption
- Biodegradation
- Volatilization
- Photolysis

Ecological risk?

- Remaining MPs
- By-products

Ecotoxicological context

Protect Ecosystem services

- Water purification
- Habitat provisioning
- Recreational uses
- etc...

Ecosystem services



Benchmarking of WWTPs

Ecological metrics

Changes in the ecological status

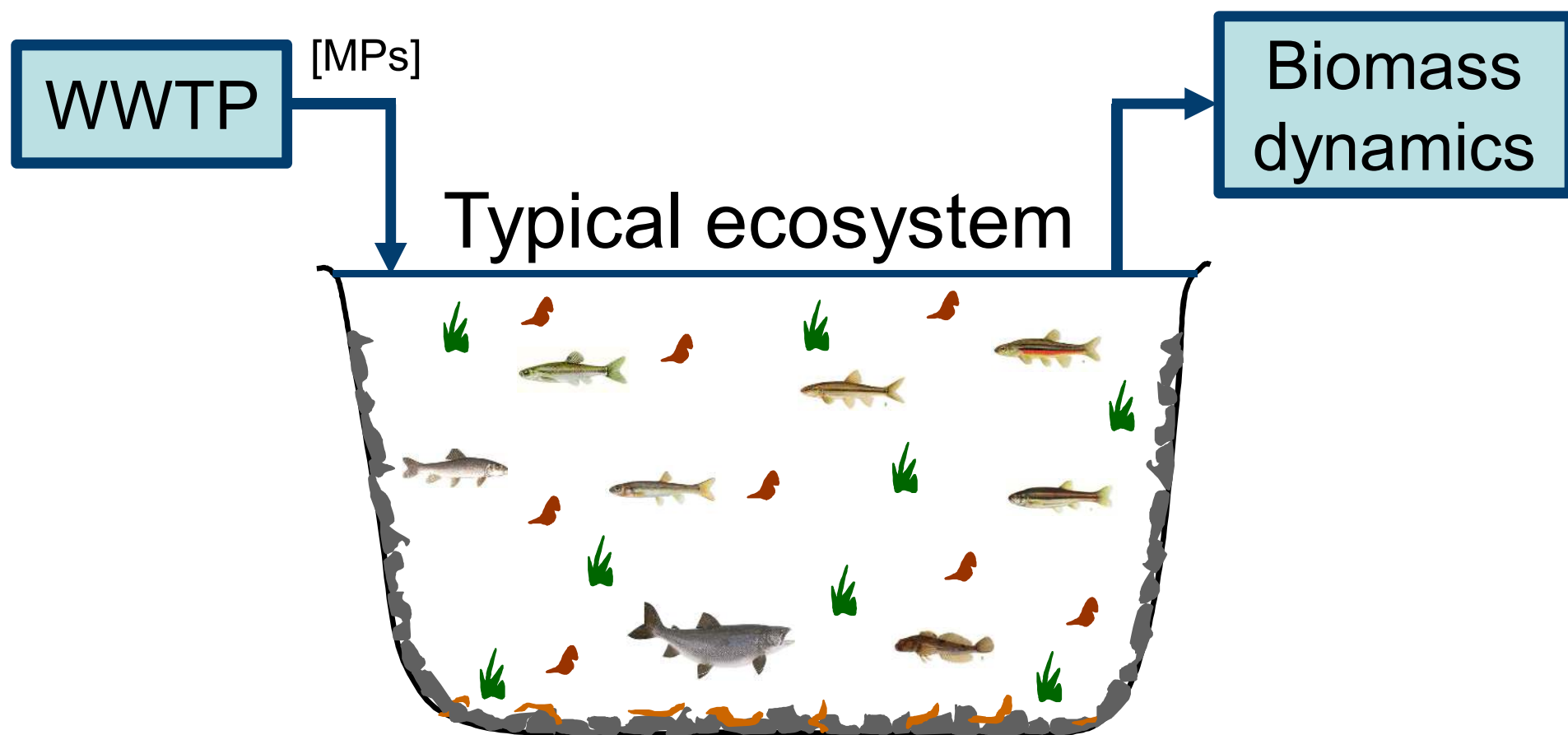
- Biodiversity and extinction
- Fish population
- N & P cycles
- etc...

Ecological models!

Ecological benchmarking of WWTPs

Fate model

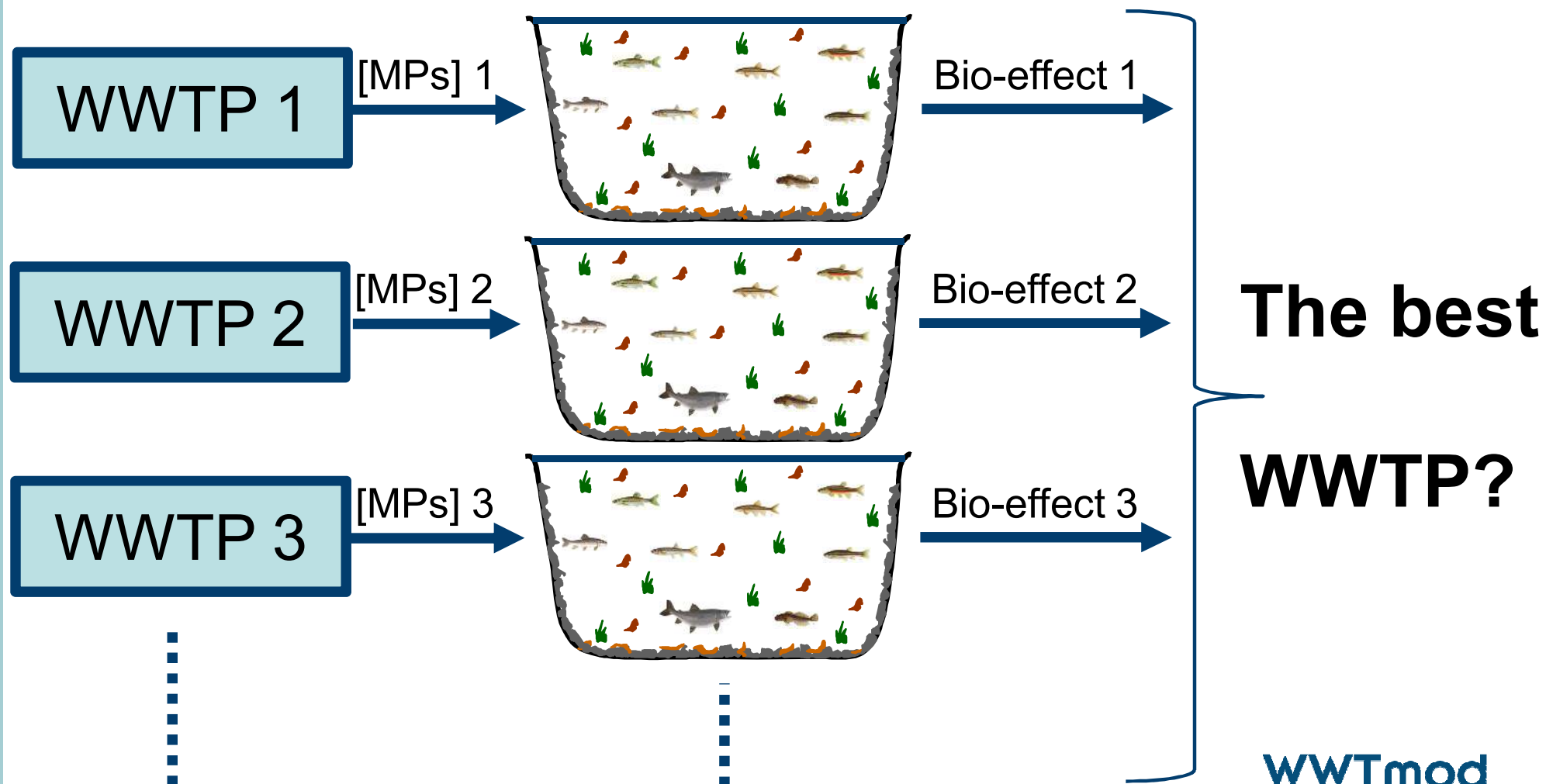
Ecological model



Ecological benchmarking of WWTPs

Fate model

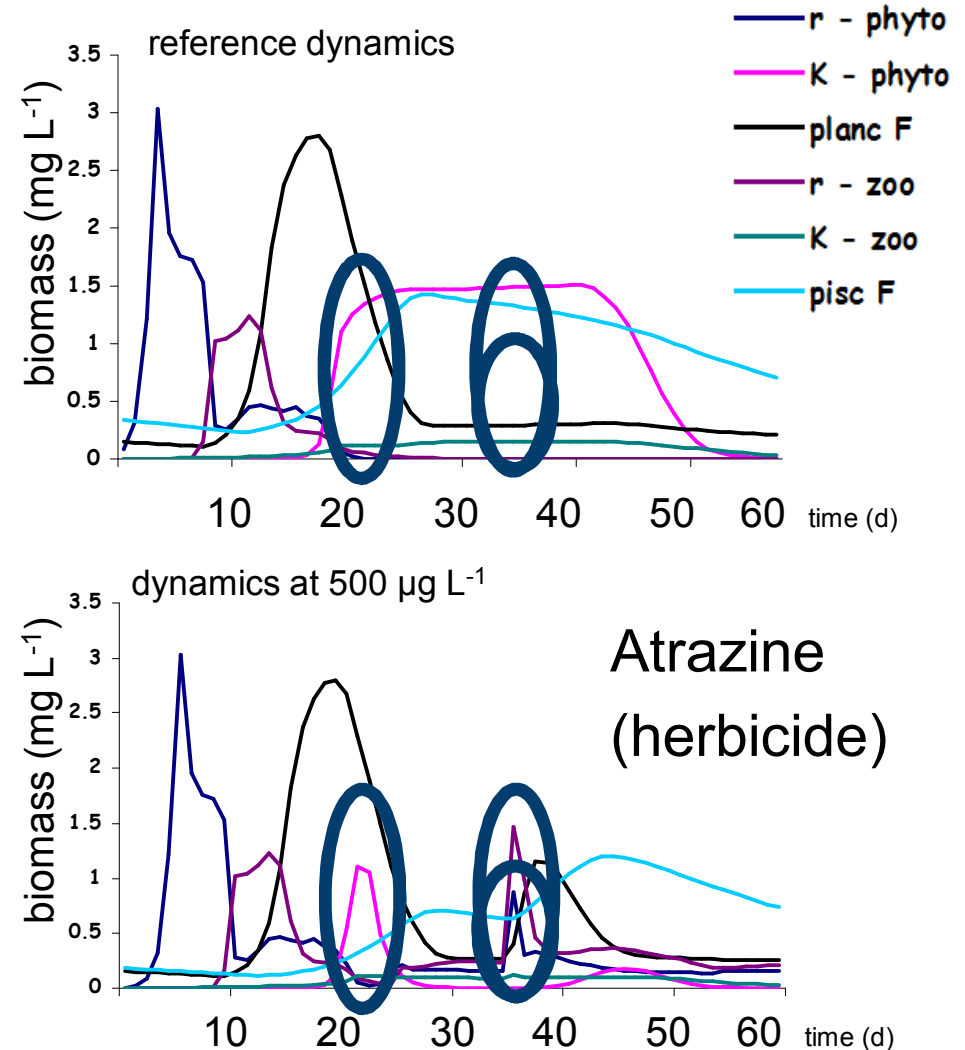
Ecological model



Ecological modelling of acute toxicity

Frederik De Laender
(PhD thesis, 2007)

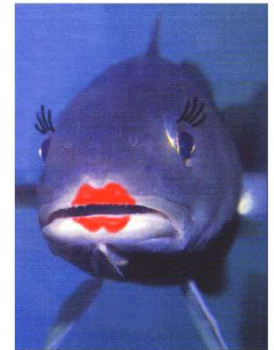
- Disappearance of one phyto
- Appearance of another phyto
- Appearance of one zoo



Ecological modelling of endocrine disruptions

Mechanism rather than endpoint:

- Intersex fish
- Reproductive disturbances

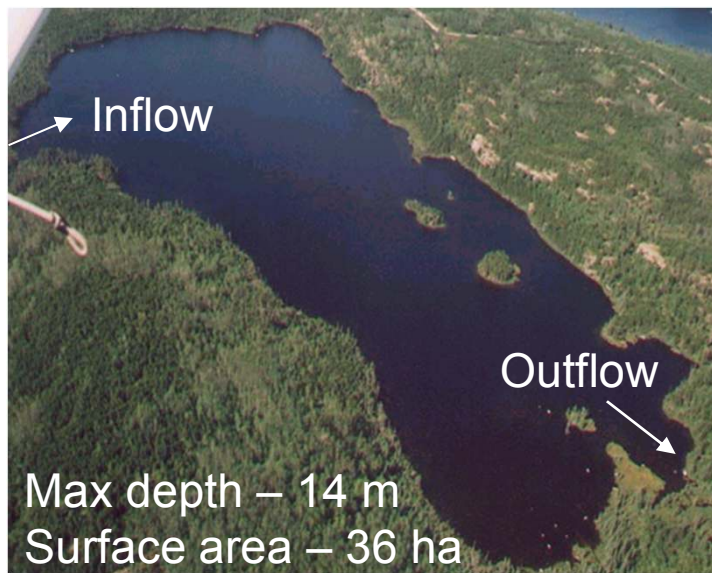


**Joanne Parrott*

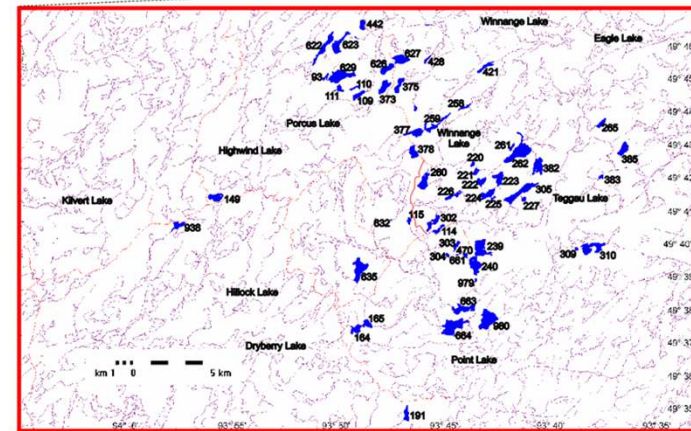
0 ecosystem model found in the literature:

- Require experimental work on ecosystem

Experimental Lake Area (ELA)



58 Designated Research Lakes
and their Watersheds
Detailed Monitoring since 1969



Data on individuals & populations

Recovery?

+ 17 α -ethinylestradiol (EE2)

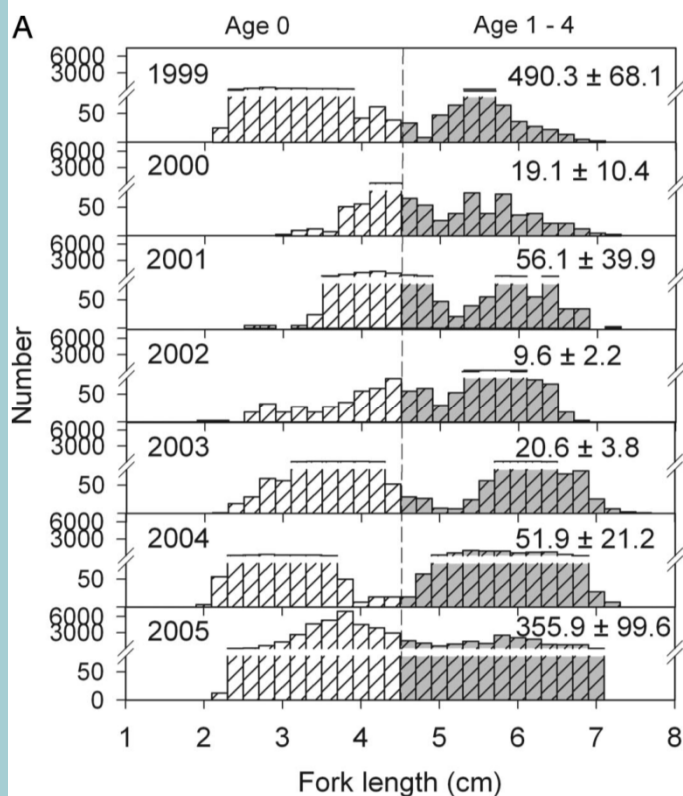
Baseline data

1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 ...

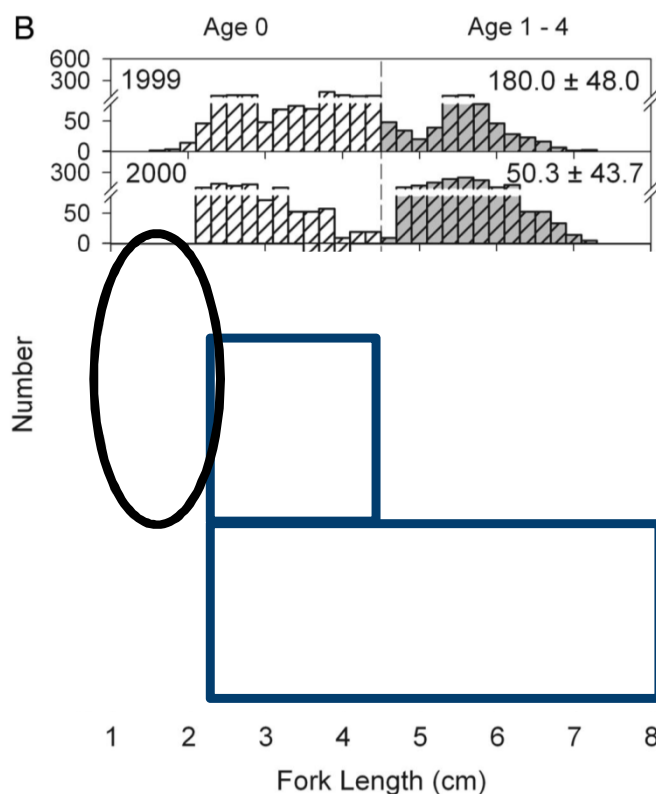
Reference lake data

ELA: Fish collapse

Reference Lake



Experimental Lake



EE2 addition

No reproduction

No reproduction
& No adults

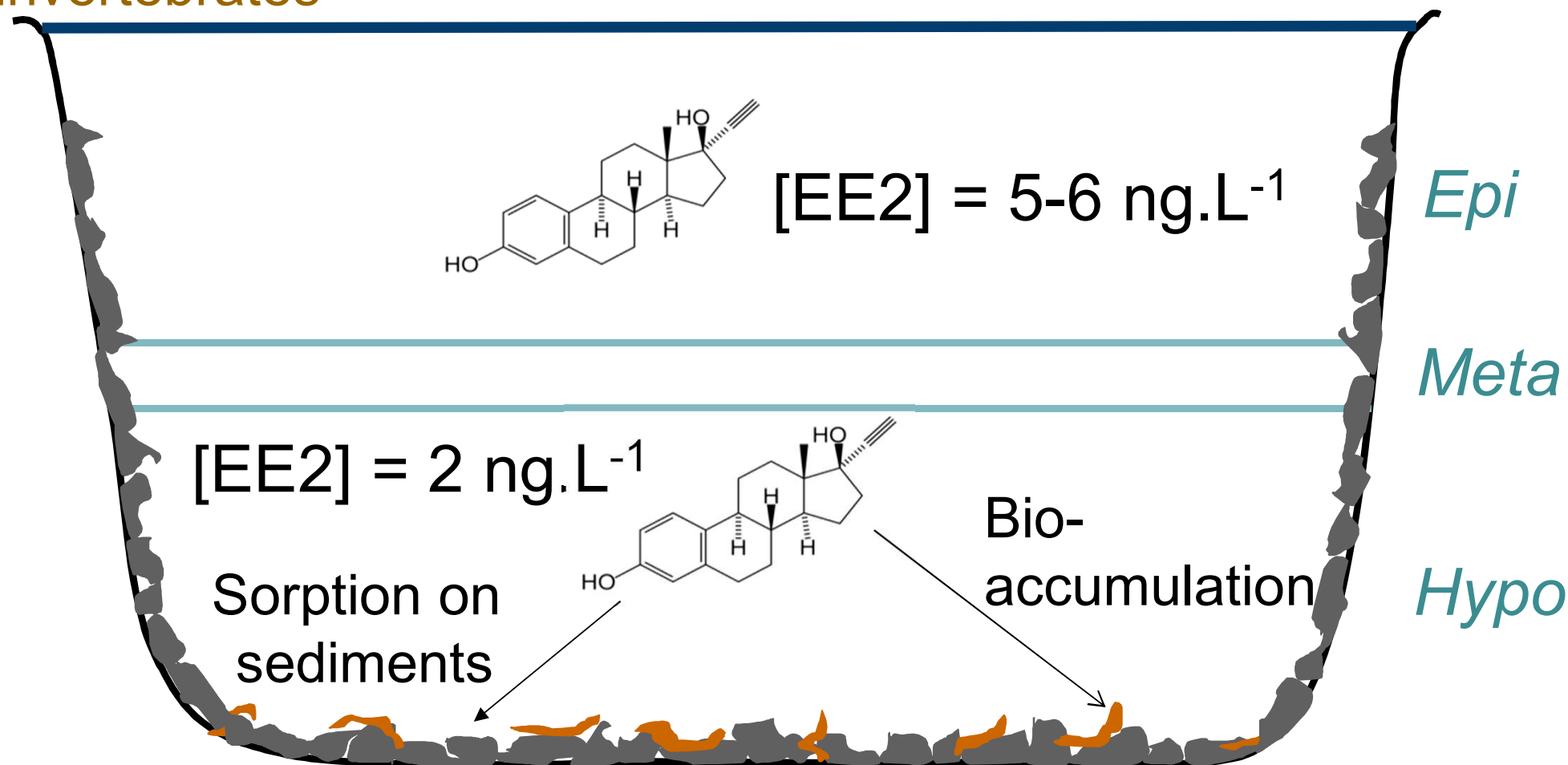
* K.A. Kidd, P.J. Blanchfield, K.H. Mills, V.P. Palace, R.E. Evans, J.M. Lazorchak and R.W. Flick (2007). Collapse of a fish population after exposure to a synthetic estrogen, *PNAS*, 104(21):8897-8901.

MP modelling in an ecotoxicological context (Clouzot *et al.*)

ELA: EE2 distribution



Benthic
invertebrates



ELA: Biomass



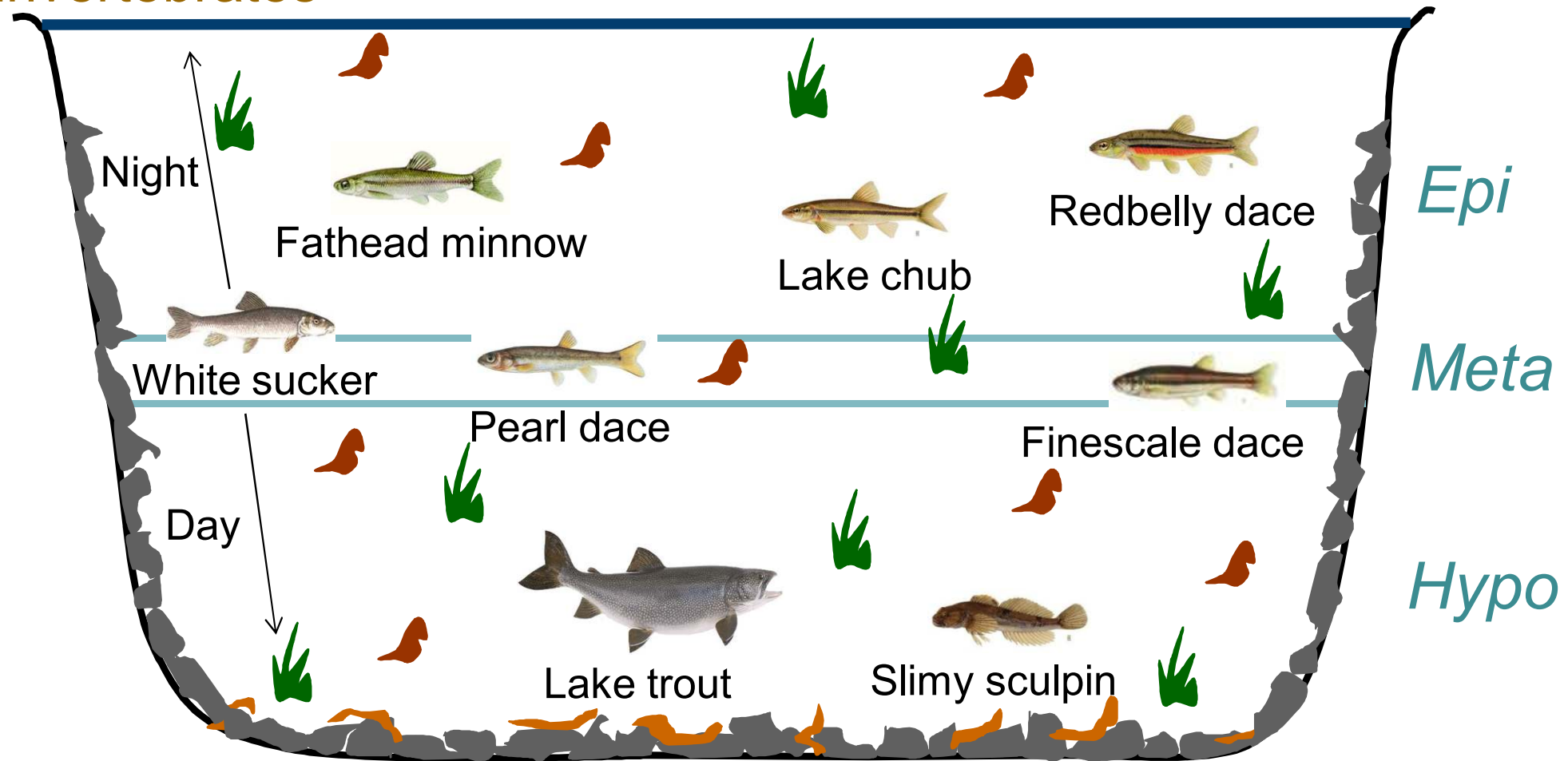
Benthic
invertebrates

Phyto

Zoo

Planktivore fish

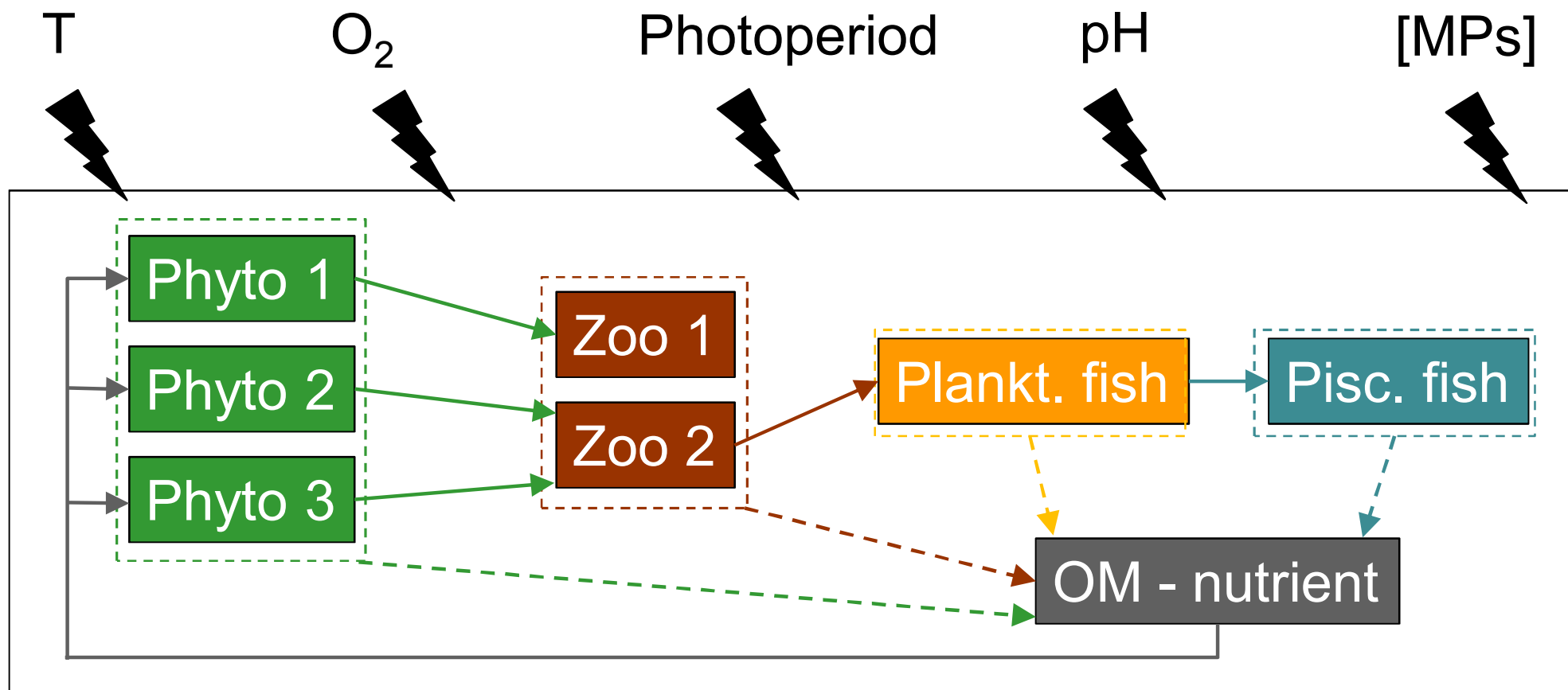
Piscivore fish



Ecological model: Object-oriented

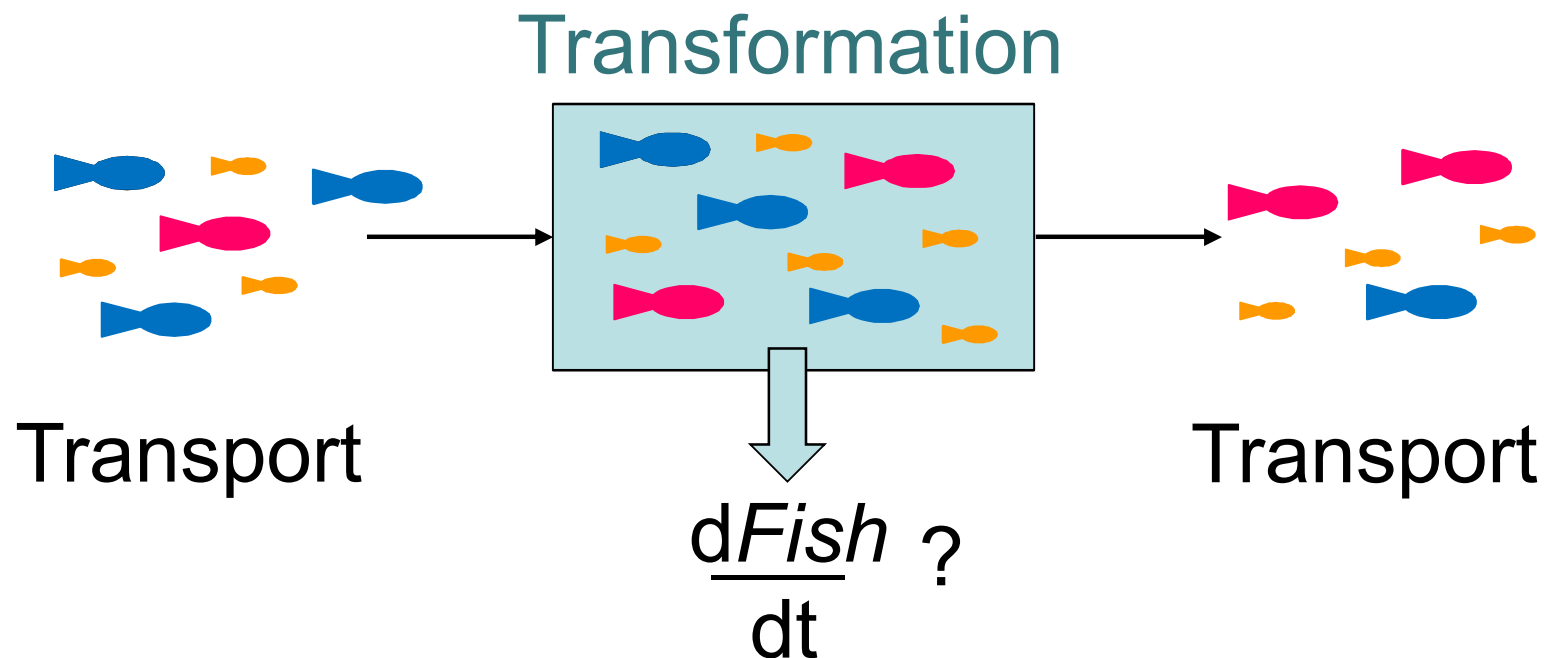


AQUATOX-WEST



Ecological model: Equations

Mass balance

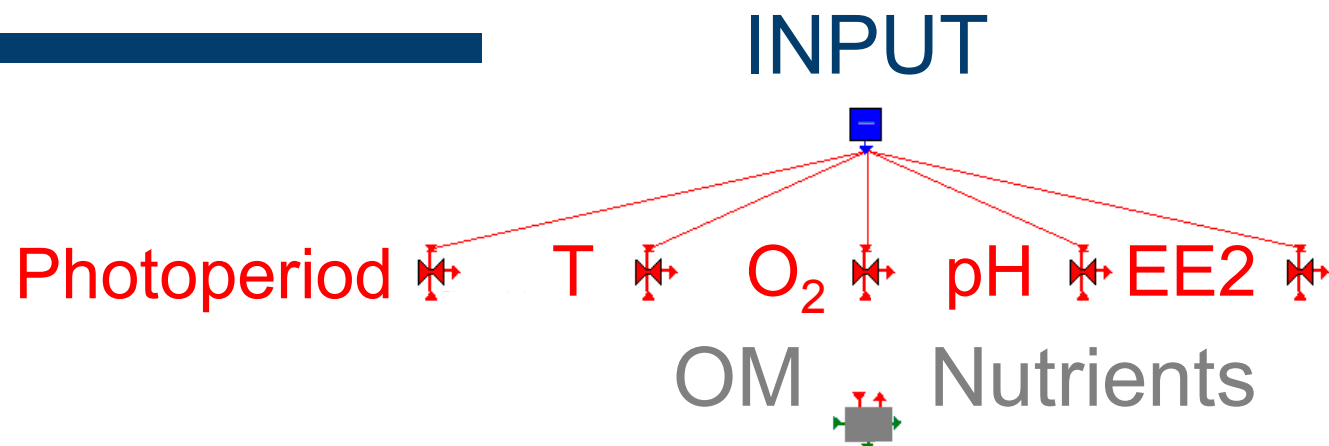


$$\frac{dFish}{dt} = \text{Transformation} + \text{Transport}$$

Ecological model: Equations

	Transformation	Transport
$\frac{dFish}{dt}$	=	
■ Simplified model ■ Endocrine disruptions	+ Consumption - Defecation - Respiration - Excretion - Mortality - Predation + Recruitment - Promotion - Gamete Loss	+ Loading - Washout + Washin ± Diffusion_{seg} ± Migration - Entrainment + Fishing

Ecological model: WEST



1 icon = 1 model

- OM - nutrients
- Sediments
- Benthic invertebrates
- Phyto / Zooplankton
- Fish

External terms

- Temperature
- O₂
- Photoperiod
- pH
- [EE2]

Sediments

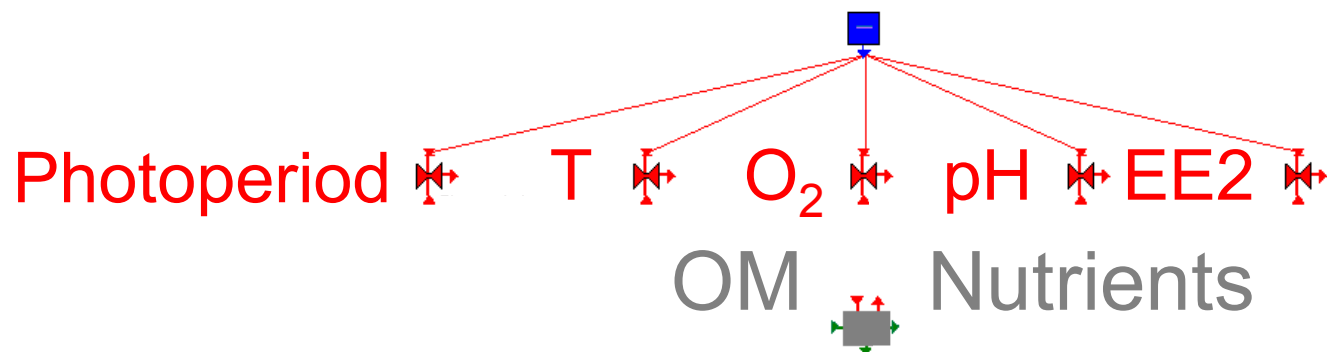


Benthic invertebrates



Ecological model: WEST

INPUT



Phyto



Chryso/Crypto



Diatoms



Chloro/Dino

Cyano

$$\frac{dBiomass_{phyto}}{dt} = Photosynthesis - Respiration - Excretion - Mortality - Consumption_{zoo} - Sinking$$



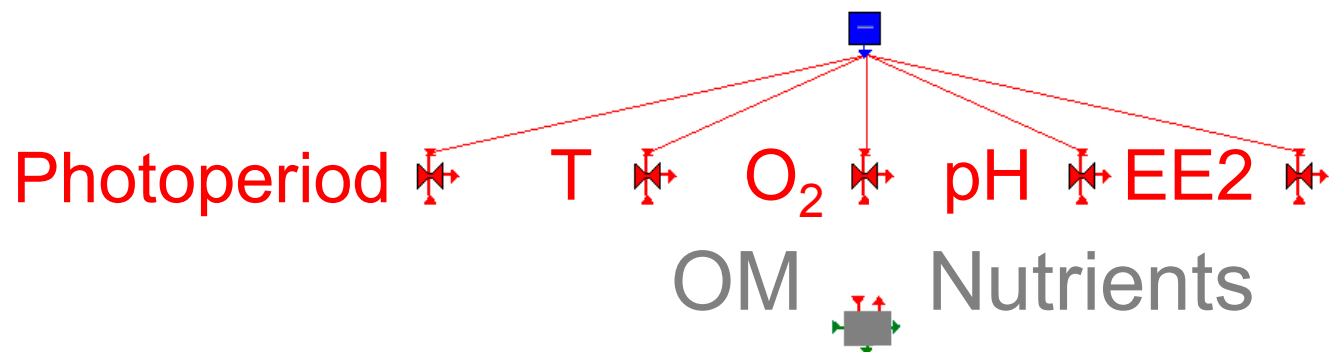
Sediments



Benthic invertebrates

Ecological model: WEST

INPUT



Phyto

Zoo

 Chryso/Crypto  Rotifers

 Diatoms  Clado

 Chloro/Dino  Copepods
Cyano

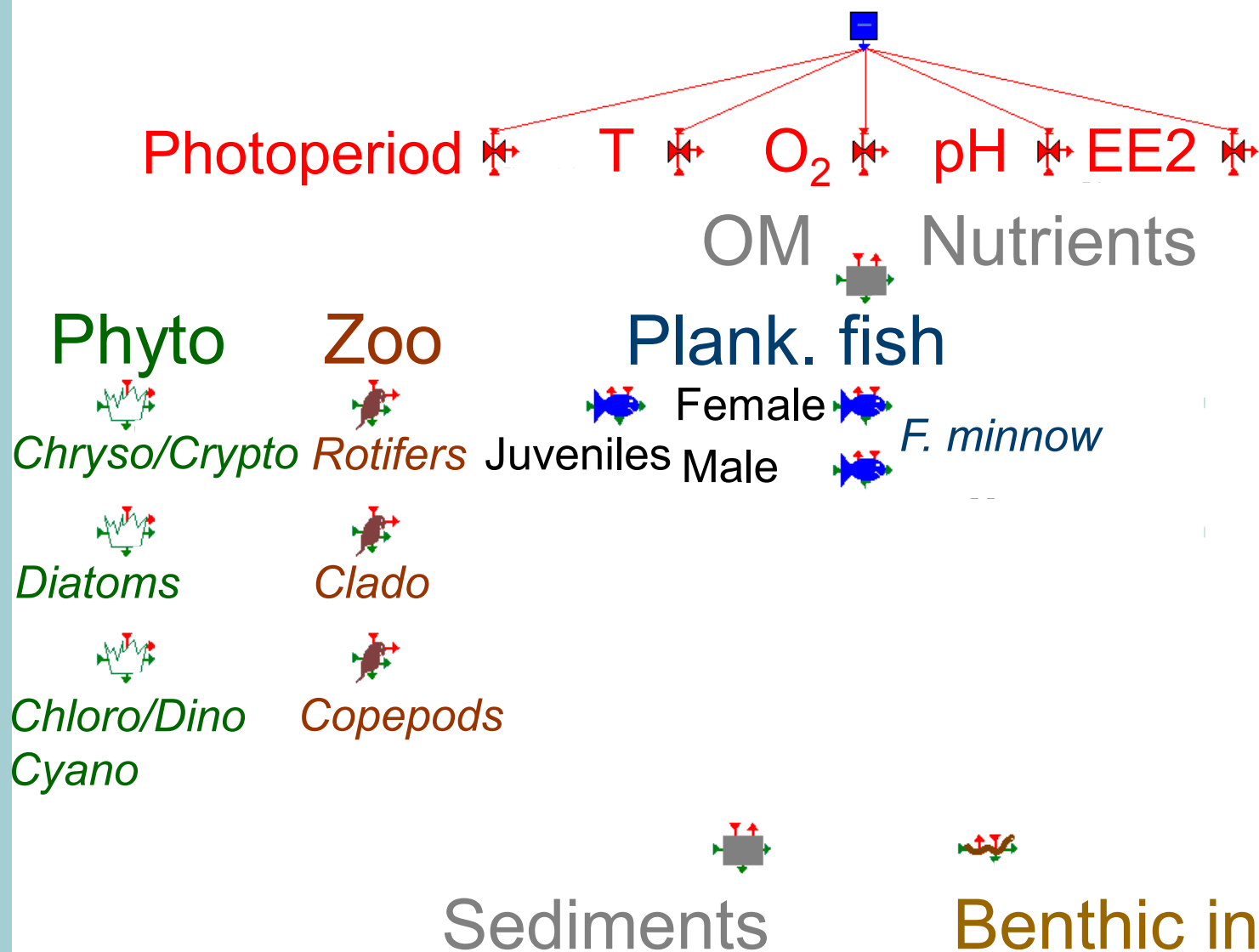
$$\frac{dBiomass_{animals}}{dt} = Consumption - Defecation - Respiration - Excretion - Mortality - Predation$$

 Sediments

 Benthic invertebrates

Ecological model: WEST

INPUT



Benchmarking of WWTPs: Ecological criteria?

Index of diversity (D) (Simpson 1949)

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

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

D_{fish}, D_{zoo}, D_{phyto}

Benchmarking of WWTPs: Ecological criteria?

Index of diversity

- D_{fish} , D_{zoo} , D_{phyto}

Fish population

- Extinction?

Phyto: primary producer (N & P cycles)

- Production with min and max thresholds

Conclusion

Numerous MPs with different effects

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

Transfer the outputs of fate models into an ecotoxicological framework

Conclusion

Ecological benchmarking of WWTPs

- **STRUCTURE** = A typical ecosystem
- **INPUT** = The **OUTPUT** of fate models
- **OUTPUT** = Ecosystem changes next to the exposure to MPs