

Biomanipulation in Lake Ülemiste, Estonia

Lea Tuvikene

Estonian University of Life Sciences



About the lake

- Natural hardwater eutrophic lake
- Water residence time approximately 1 year
- Surface area 9.75 km²
- Mean depth 3.4 m
- Maximum depth 5.2 m
- Tallinn Airport nearby



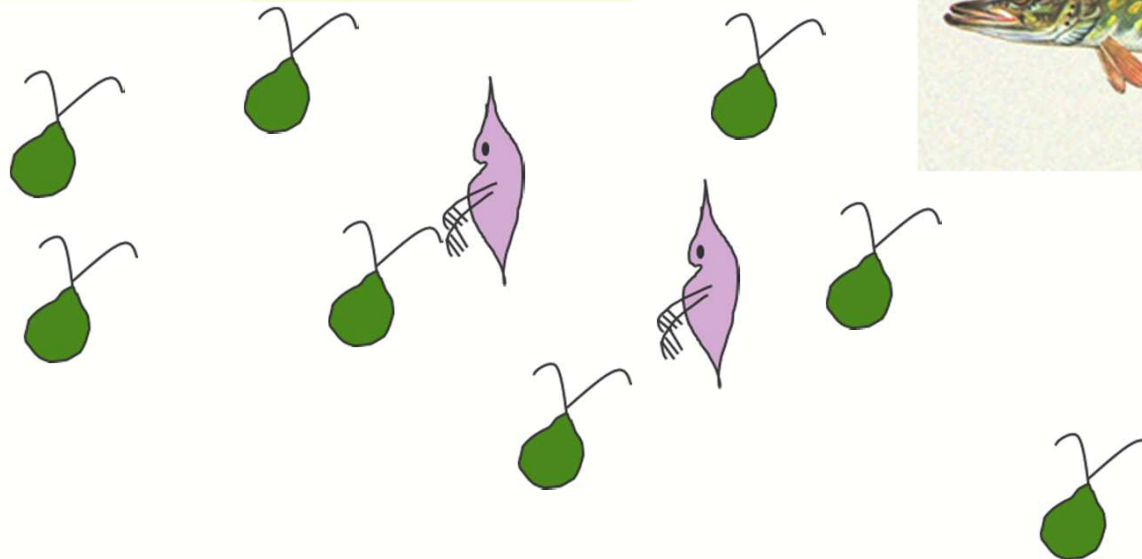
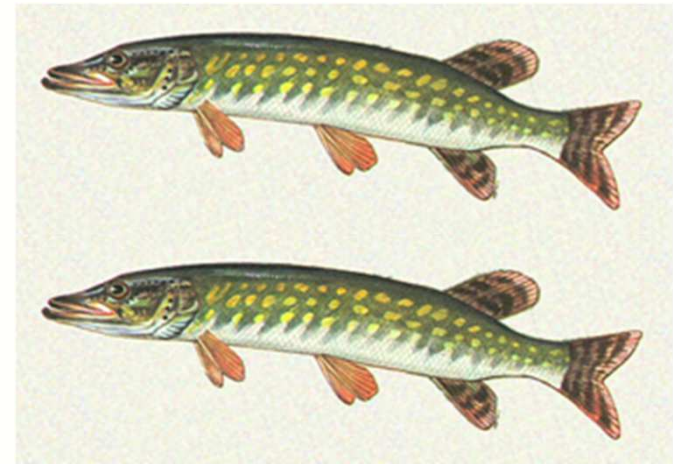
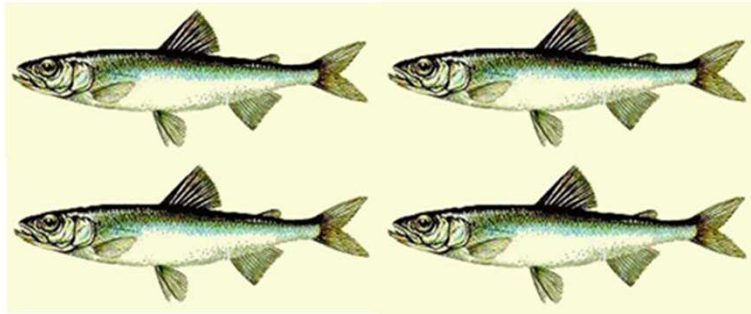
About the lake

- Drinking water supply for Tallinn
- Drinking water cleaning since 1927
- Water treatment plant supplies 90% of the water to the city
- Not open for public use
- Fishing prohibited since 1990s
- Nowadays natural catchment area of the lake forms only 4% of the Tallinn ground water reach

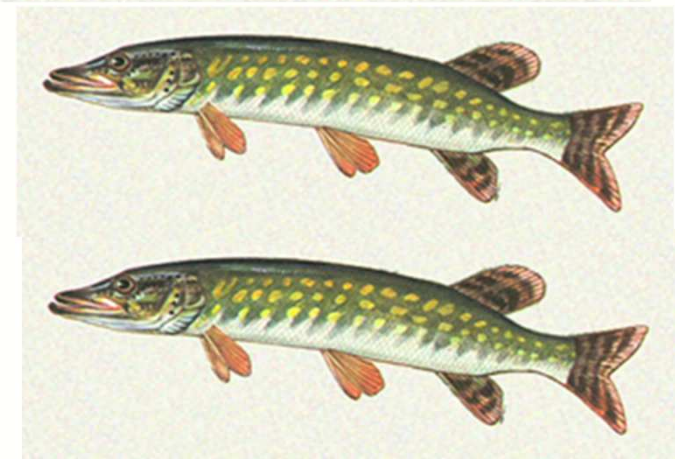
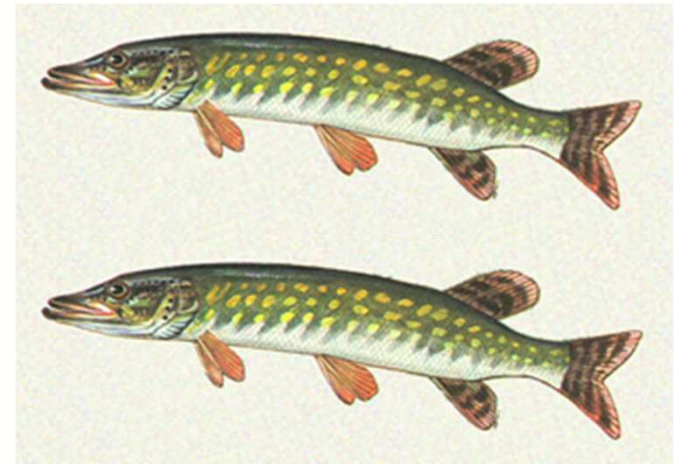
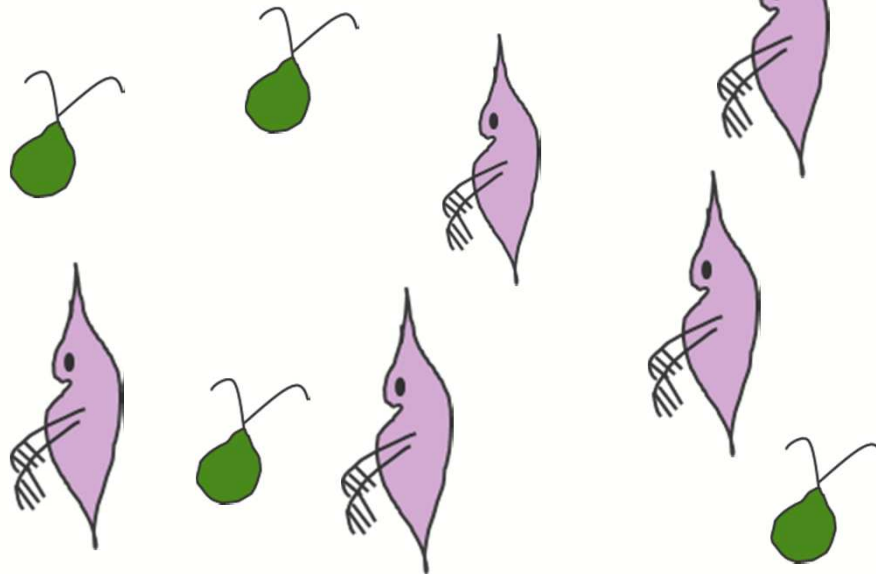
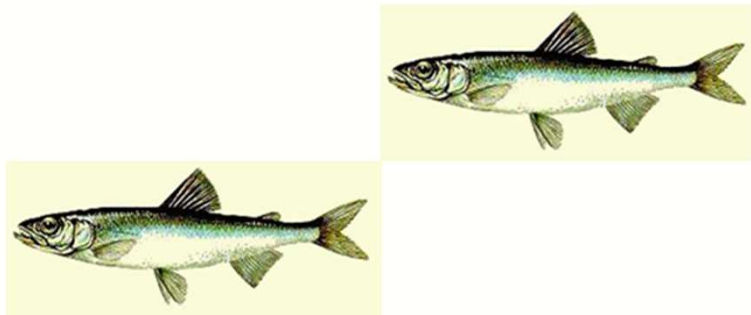
Ecological status of Lake Ülemiste

- Eutrophied already at the end of 19th century
- During the last century, share of macrophytes decreased remarkably
- Water transparency 0.5 m
 - abundant phytoplankton
 - sediment resuspension due to waves
- Too few (5%) predatory fish – the classical food chain does not function

Before biomanipulation



Aim of biomanipulation



Major indicator of successful biomanipulation is significant improvement of water transparency

Top-down control



Reducing planktivorous fish

Bottom-up control



Reducing benthivorous fish

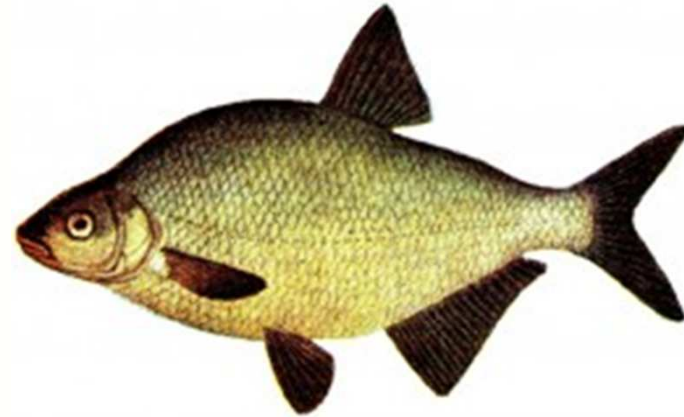
- Pre-investigations 2000-2004
 - Biomanipulation 2004-2007
 - Co-operation with SYKE
 - Reviews in scientific papers
-
- Pedusaar, T.; Sammalkorpi, I.; Hautala, A.; Salujõe, J.; Järvalt, A.; Pihlak, M. (2010). Shifts in water quality in a drinking water reservoir during and after the removal of cyprinids. *Hydrobiologia*, 649(1), 95 - 106.

Investigations before biomanipulation

- Once a week from May to October:
 - TP and TN since February 2001
 - Secchi transparency since June 2003
 - Chl *a* since July 2003
 - Zooplankton since September 2003
- Mass-balance calculations of TP
- Test fishing

Results of test fishing

- High proportion of bream (*Abramis brama* (L.))
- High density of YOY percids:
perch (*Perca fluviatilis* (L.))

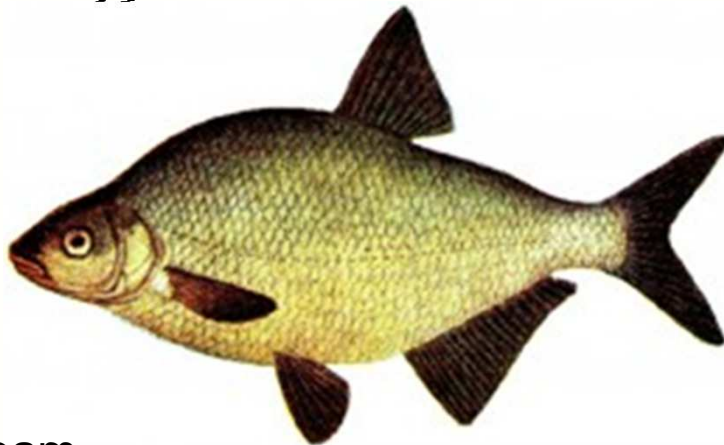


and
Pike-perch (*Sander lucioperca* (L.))



Hypothesis

Fish removal will primarily reduce nutrient concentrations (availability of sediment phosphorus) and enhance also zooplankton grazing

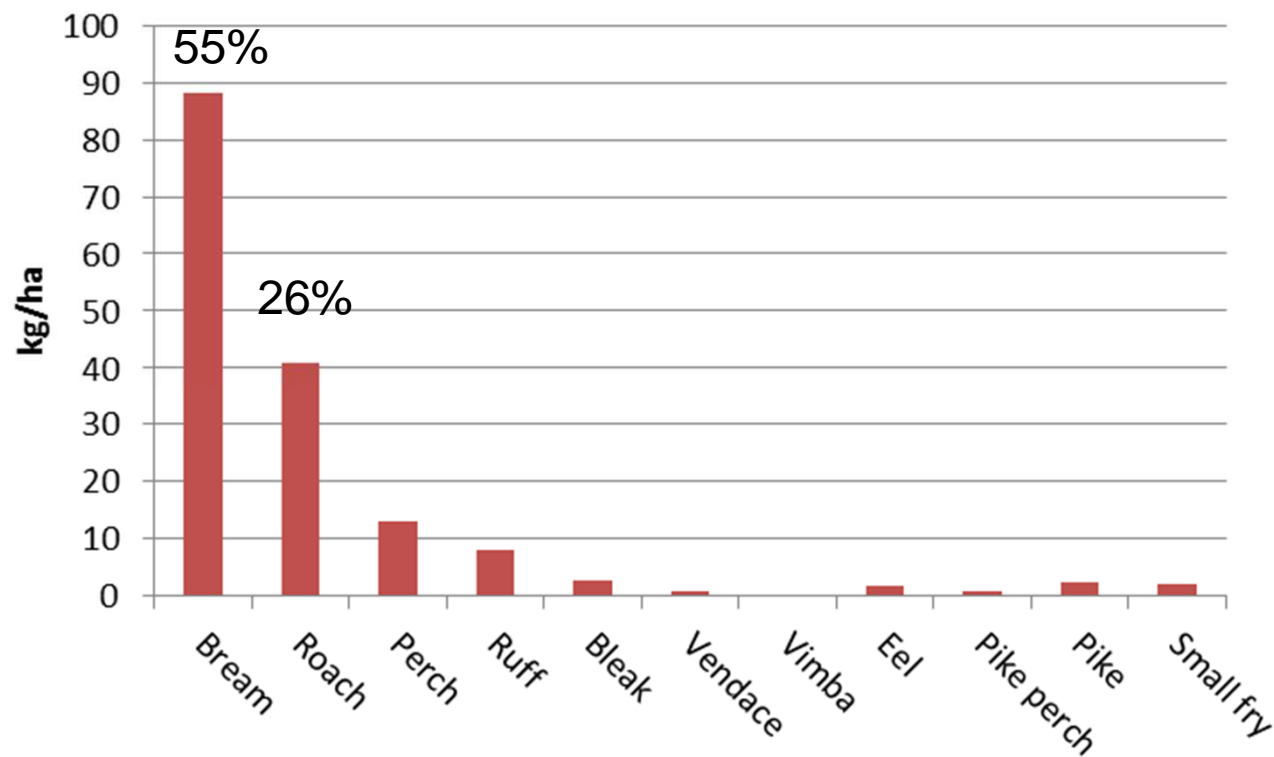


Bream



Roach,
(*Rutilus rutilus* (L.))

- Selective seine- and basket trap fishing
- 156 tonnes (160 kg/ha) of fish was removed in 2004-2006



1.2 tonnes of fish-bound phosphorus was removed 2004-2007

Table 1 Mass balance of TP of Lake Ülemiste in 2001–2007

Year	TP _{in}		TP _{out}		TP _{sed}
	kg y ⁻¹	g m ⁻² y ⁻¹	kg y ⁻¹	g m ⁻² y ⁻¹	
2001 ^a	1,500	0.16	948	0.10	+659
2002	2,310	0.24	1,440	0.15	–105
2003	3,830	0.40	1,419	0.15	+2,610
2004	2,500	0.26	1,100	0.15	+2,306
			(+298 ^b)		
2005	2,000	0.21	1,172	0.20	–1,513
			(+685 ^b)		
2006	1,300	0.14	636 (+257 ^b)	0.10	+1,243
2007	1,260	0.13	622	0.10	+1,246

TP_{in}—external load; TP_{out}—outflow loss; TP_{sed}—net internal budget

^a Mass balance without January and February

^b Fish-bound phosphorus

(Pedusaar et al., 2010)

Data on vegetation period:

Parameter	Pre-manipulation period	Biomanipulation period			Goal
	2000–2004	2005	2006	2007	
Total phosphorus ($\mu\text{g l}^{-1}$)	48	54	31	36	<50
Total nitrogen ($\mu\text{g l}^{-1}$)	1494	1309	1082	1214	
Chl <i>a</i> ($\mu\text{g l}^{-1}$)	30	23	20	21	<25
Phytoplankton biomass (mg l^{-1})	15	9	8	6	5
Cladocerans biomass (mg l^{-1})	0,570	0,287	0,165	0,189	bigger
Rotifers abundance (mln is. m^{-3})	0,486	0,286	0,218	0,122	less
Secchi disc, May (cm)	81	132	114	123	

(Pedusaar et al., 2010)

Decrease of
external load



Selective fish
removal

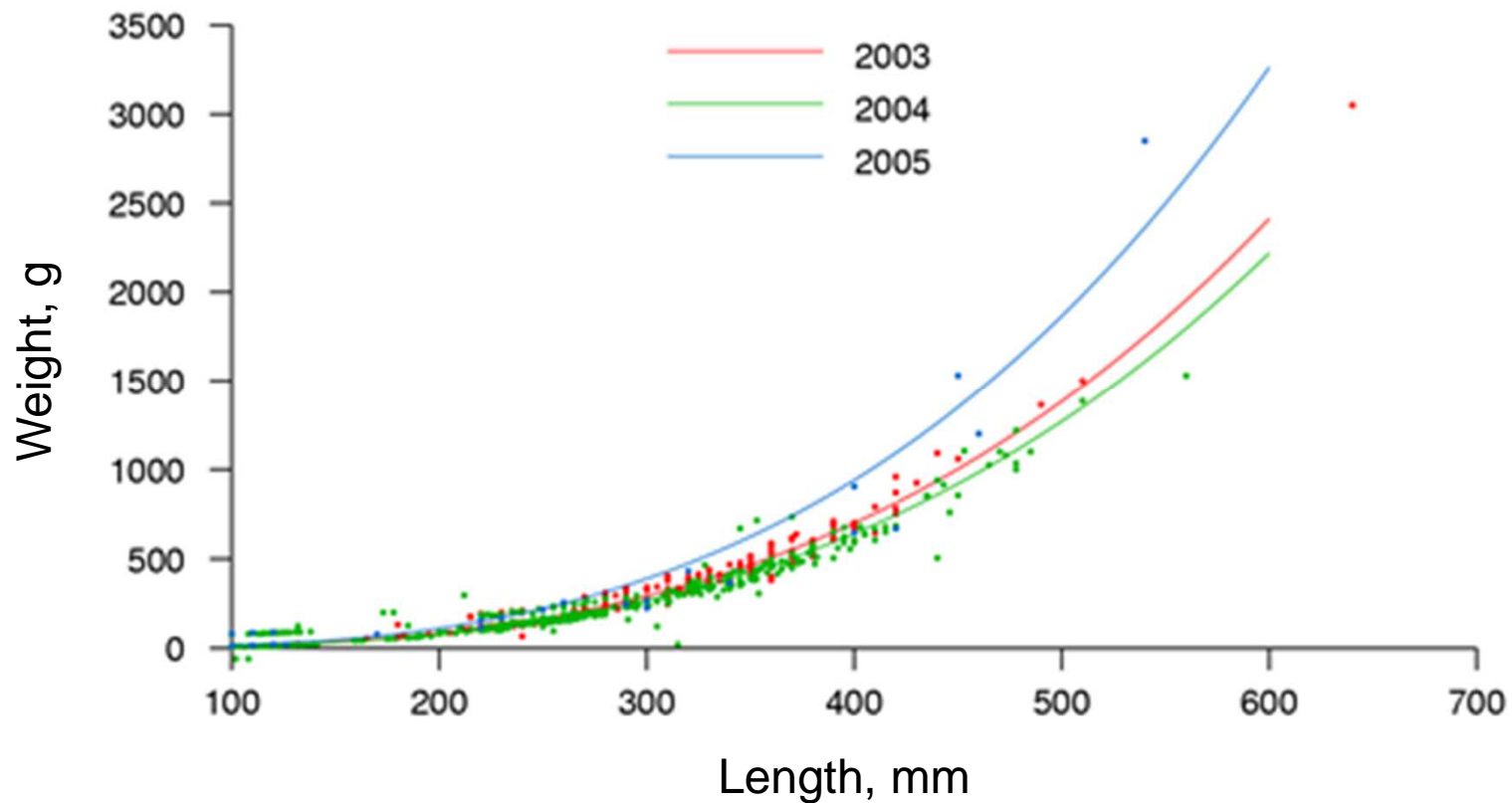


decreased TP in lake



Food web was influenced by down-up
control

Decreased fish biomass improved nutritional condition of bream



Selective removal of cyprinids



High densities of YOY percids were not affected



Daphnids were still under pressure



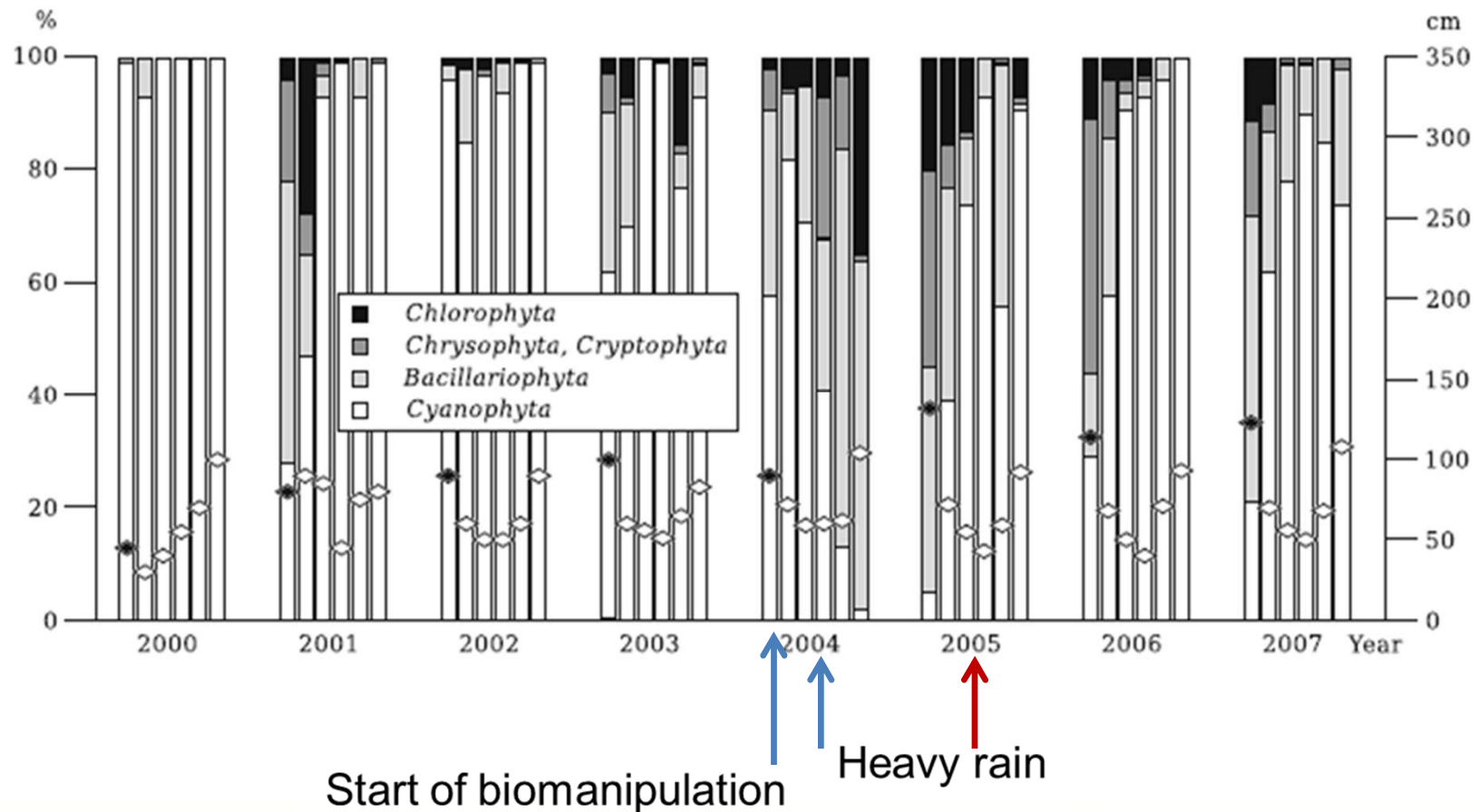
Top-down control was not achieved

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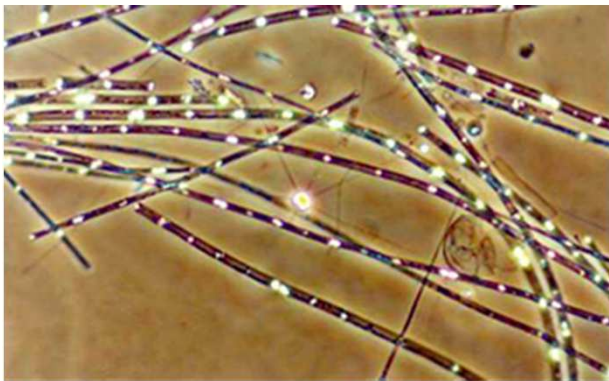
(Pedusaar et al., 2010)

Phytoplankton composition during May-October changed during biomanipulation in Lake Ülemiste 2000-2007



(Pedusaar et al., 2010)

A shift from the dominance of filamentous cyanobacteria to co-dominance with colonies and a decline in the biomass of the dominant species *L. redekei*, were evident in May–October 2004–2007



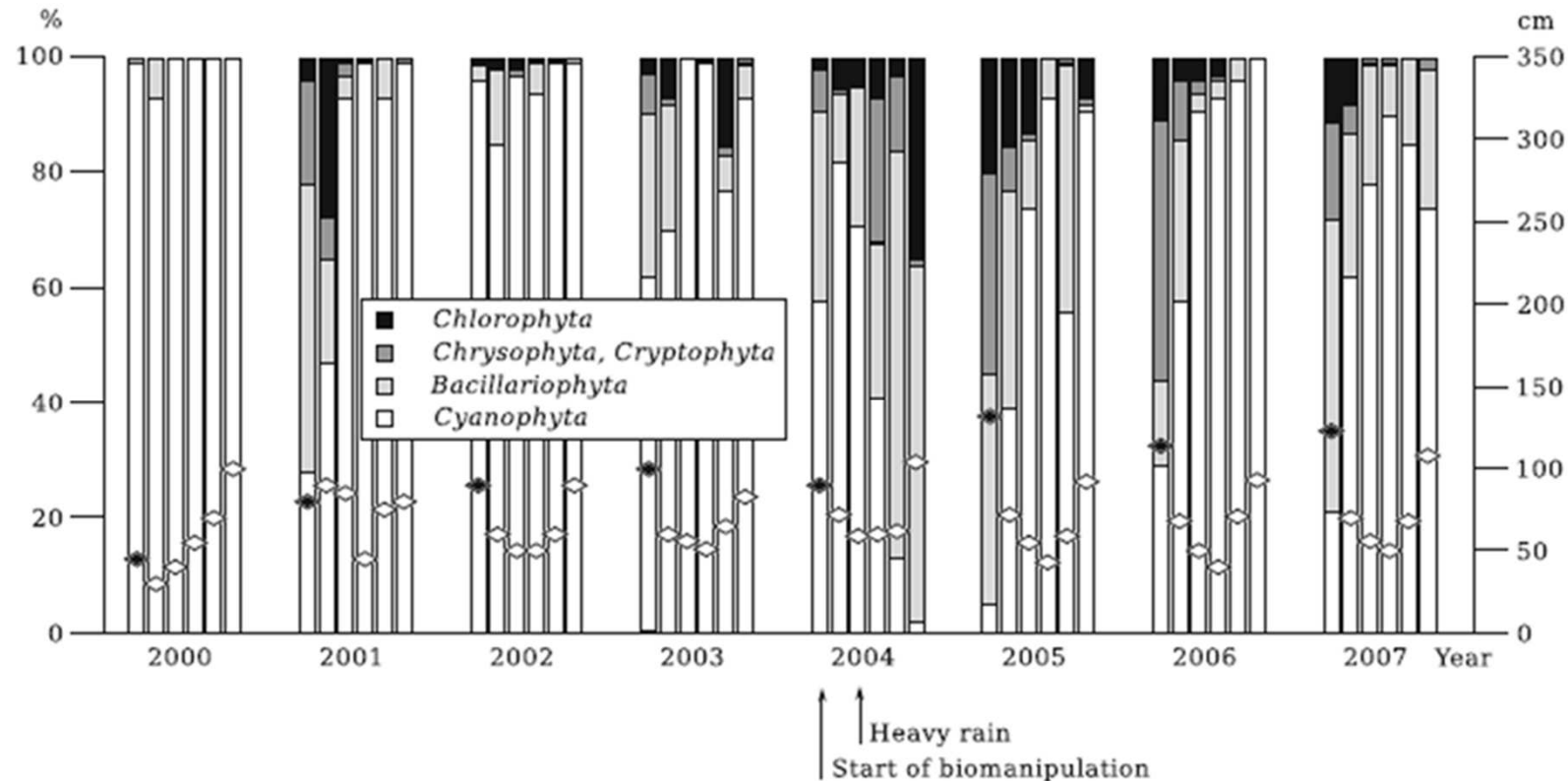
Dominate
filamentous cyanobacteria



Co-dominance:
Filamentous cyanobacteria
Colonial forms

The proportion of phytoplankton species other than cyanobacteria in the total phytoplankton increased remarkably

Secchi disc transparency showed increase only in May, exceeding one meter



Most of variability of Secchi transparency was attributed to Chl *a*

Mean zooplankton abundance and biomass lowered significantly, but dominance of rotifers remained



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Summary

1. Simultaneous effects/processes took place:

- gradual decrease of external loading
- fish removal
- heavy rainfall

The main cause of TP reduction?

Combined effect!

Summary

2.

TP



TN



TN:TP



Algal species other than Cyanobacteria are favoured!

Summary

3. Improved water transparency in May and higher phytoplankton diversity matched expectations

4. Neither abundance or length of cladocerans did grow

– due to predation of planktivorous YOY cyprinids

Summary

5. The main goal – better water transparency for the whole vegetation period – was not achieved

6. Decrease in Phytoplankton was primarily controlled by TP availability



Future management of lake Ülemiste

- No single cause for poor water quality
- No single management solution
- Reducing external load more and more
- Repetitive restoration (biomanipulation or other)
- Sediment studies – internal loading!
- Adequate fish stock to remove is about 70 kg ha⁻¹
- Lowering the density of YOY percids – a challenge

Practical issues appeared during and after the biomanipulation

- High interest of press – good chance for education!
- Good prior knowledge on fish behaviour in the lake are in favour
- Shortcomings in legislation appeared
- No quick or clear results lead to decrease of interest of stakeholders



Thank you!

