Brno Reservoir Restoration Project

Phosphorus – Actual problems and sollutions
14.-15. 5. 2019, Brno

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Brno Reservoir

- *In service since: 1940*
- *Live storage: 13,020 mil. m³ 229,08 m a.s.l.*
- *Max. reservoir area: 259 ha*
- *Dam: concrete gravity dam*
- *Top of dam width: 3,0 m*
- *Top of dam lenght: 120,0 m*
- *Top of dam height: 23,5 m*
- *Max. depth: 16 m*

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Brno Reservoir

- *Catchment area: 1586 km²*
- *Three regions (JMK 36 %, KV 54 % PK 10 %)*
- *Population: 102 000*
- *200 towns and villages*

Zdroj: Aquatis, a.s.

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Brno Reservoir

- ***Reservoir problems:***

  –*mass occurrence of phytoplankton*

  – *sport fishing, difficult to control fish stock*

- ***Problems in the catchment area :***

  – *high amount of villages without sewage water treatment*

  – *low cleaning efficiency of STPs, rare phosphorus precipitation*

  – *combined sewers, frequent sewage overflows*

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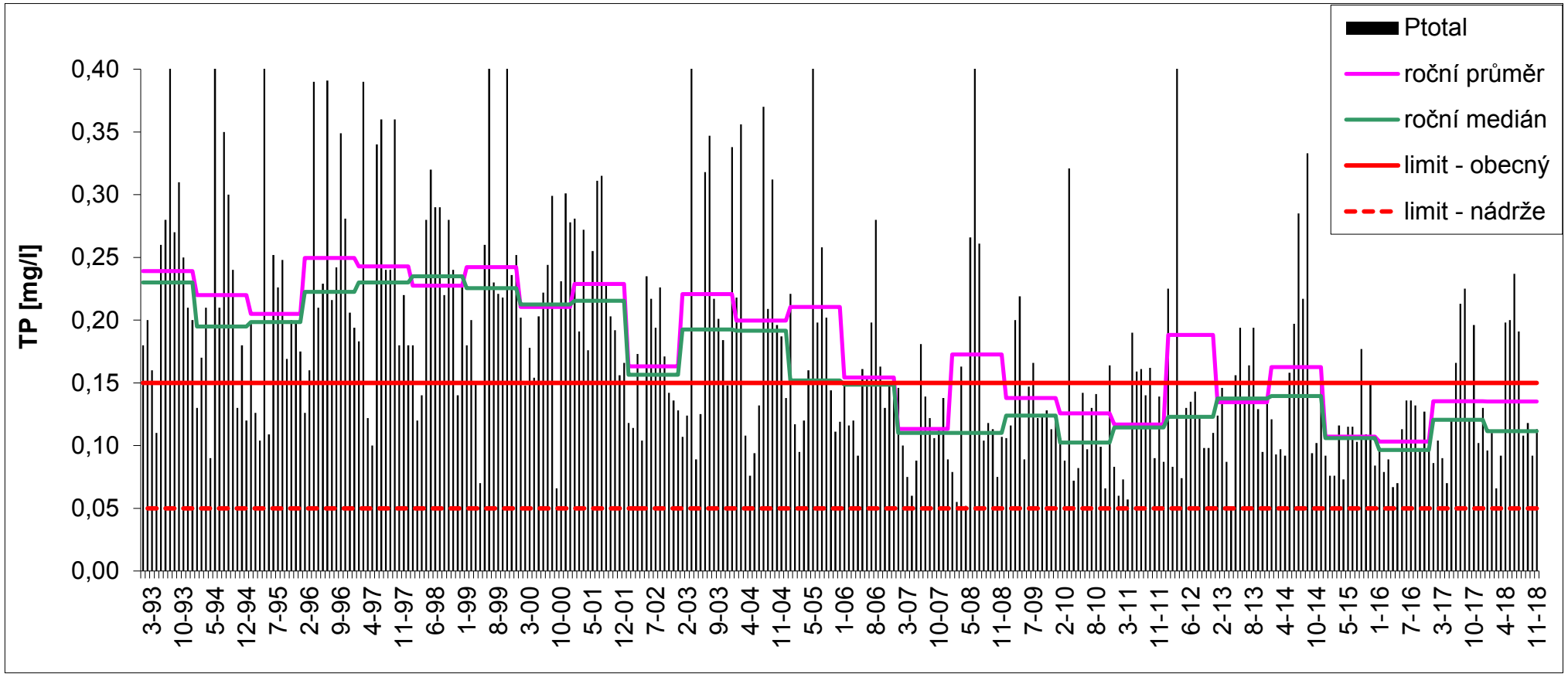
Brno Reservoir

- *Main inlet – Svratka in Veverská Bítýška*
  Phosphorus – key nutrient



Brno Reservoir – projects and studies

- ***2007***
  Feasibility Study on the Implementation of Measures at the Brno Reservoir
- ***2007 – 2009***
  Air application of lime hydrate to the bare bottom of the reservoir, November 2007, February and November 2008 and April 2009
- ***2009***
  Water level lowering for 10 m –for freezing and drying of sediments
- ***2009 June–September***
  Aerating and collecting blue-green algae biomass

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Brno Reservoir – projects and studies

- ***2010–2012: Restoration project***

– *A subsidized project focused on nutrients removal and changing conditions in the reservoir*

– *Phosphorus precipitation by ferric sulfate in the main inlet*

– *Aeration and destratification of the water column*

– *Fish stock change*


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Brno Reservoir – projects and studies

- ***2013–2017: period of project sustainability***
  Continuation of main measures (precipitation, aeration / destratification)
- ***2017: Evaluation study***
  Study of measures effectiveness, update of nutrient balance study
- ***2018–2022***
  Continuation of the project

Brno Reservoir – reasons for the measures

- ***Iron application in main inlet***

  Reason: excess phosphorus in inflowing water, predominance of dissolved reactive phosphorus (readily available for cyanobacteria) Phosphorus is the key nutrient (as opposed to nitrogen)

- ***Aeration/destratification***

  Reason: The stratified, calm reservoirs are suitable for Planktonic species of cyanobacteria. Some genera (Microcystis) "hibernate" in sediments without oxygen and have better starting conditions in spring.

- ***Fish stock change***

  Reason: biomanipulation attempt: more predators - less white fish - more zooplankton - less phytoplankton. In addition, the white fish engraves in the bottom and reactivates the deposited phosphorus

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Brno Reservoir – details

- ***Iron application in main inlet***

  Iron Sulfate (PIX 113, Prefloc) dosage in a dose of about 2 mg Fe / 1 liter of water, from April/May to September, excluding high flow rates

- ***Aeration/destratification***

  5 aeration towers (stream of fine bubbles from bottom), 15 turbine towers (suction from level to bottom)

- ***Fish stock change***

  Planting predatory fish (sander, pike), catching whitefish (mainly common bream)

Mixing and oxygenating – results

- *Difference between water level and bottom is very low, thermocline is weak or absent*
- *There is significantly more oxygen at the bottom of the water column, bottom anoxia is not so strong, anoxia periods are transient and just above the bottom in the deepest part of the dam*
- *Destratification - is the reservoir really mixed, or is the hypolimnion just warmer? Will it restrict planktonic cyanobacteria?*
- *Effect only on the main lake (the deepest part), unspecified reach of the effect*

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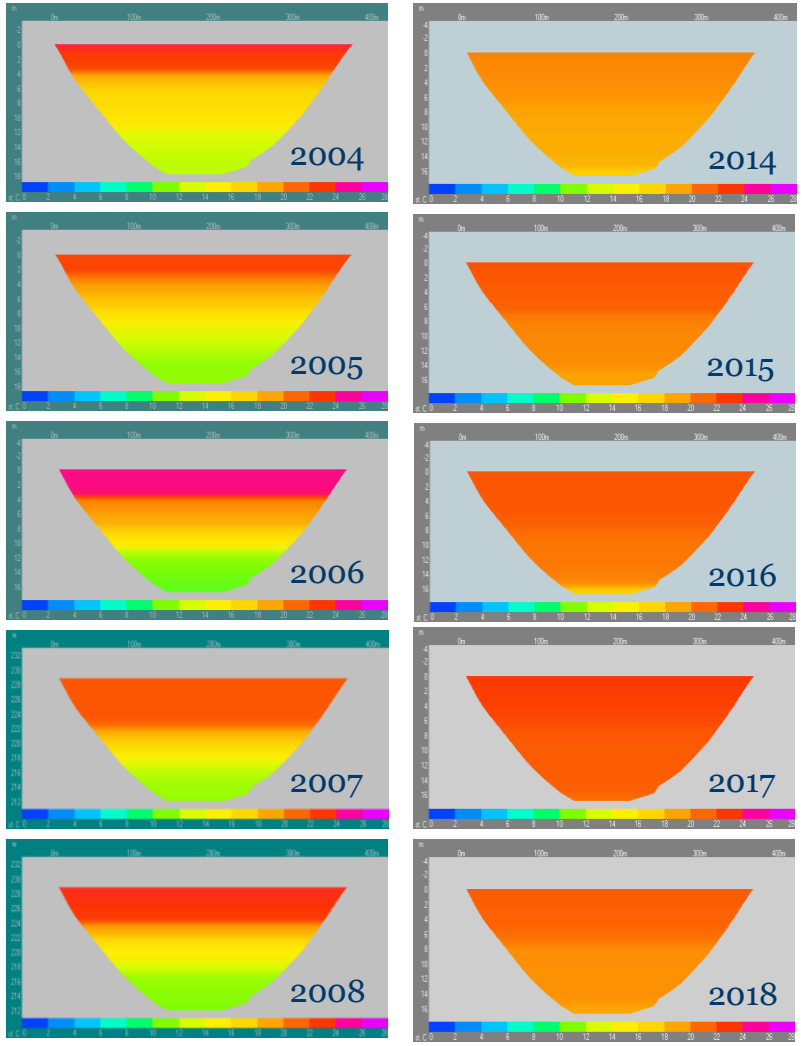
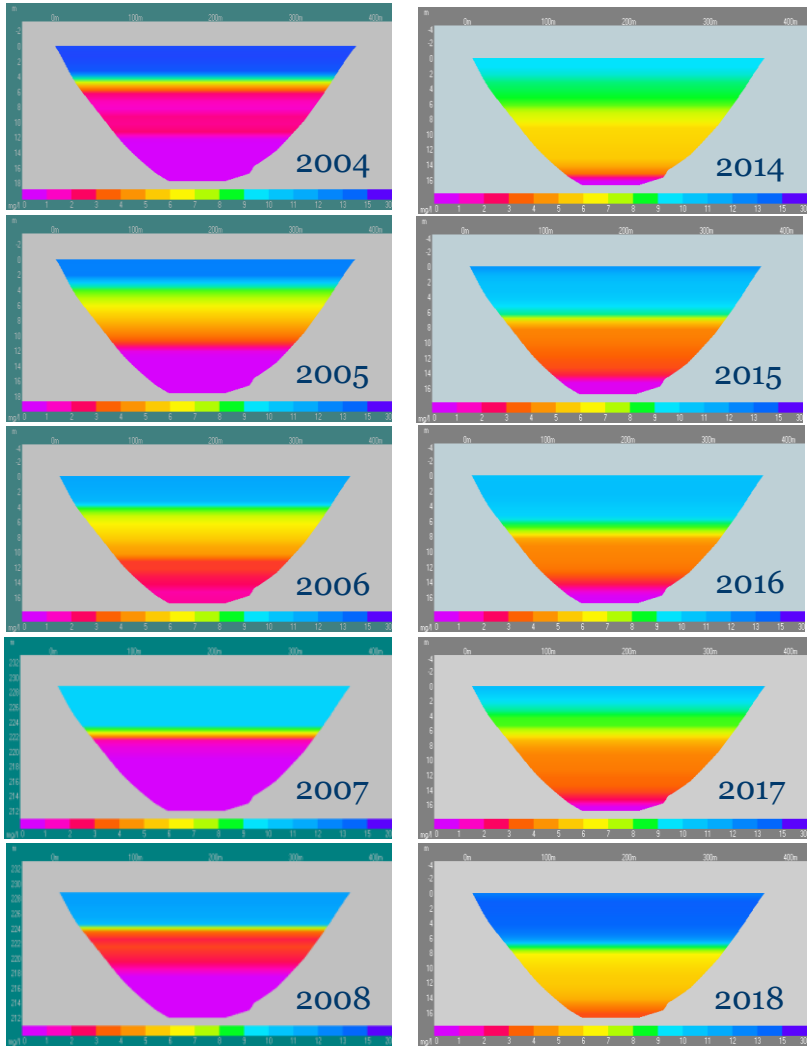
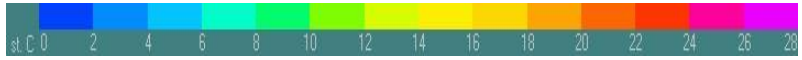
• *Stratifikace u hráze*

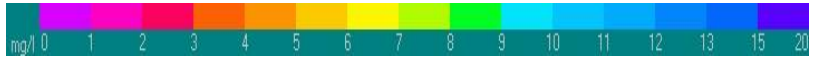
teplota v červenci



rozp. kyslík v červenci







Application of ferric sulfate – precipitation of dissolved phosphorus – reasons

- *Too high concentration of phosphorus in inlet*
- *Large ratio of dissolved phosphorus and orthophosphate*
- *Insufficient phosphorus removal at point sources (precipitation)*
- *Large amount of untreated villages (septic tanks, cesspools, direct discharge)*

Application of ferric sulfate

- ***Problems of precipitation***
- *Lacks during floods, operation only spring to autumn*
- *Large amount of chemicals (600–1200 tons/year)*
- *Insufficiently known effect on biota (roe, fry, zooplankton, …)*
- *Large financial costs (millions of CZK per year) – long-term unsustainability*
- *Dangerous psychological impact ("somebody solves it for us"), contradiction with the principles of Czech water law (pollution should be eliminated at the place of origin, polluter is responsible for it, polluter pays principle)*

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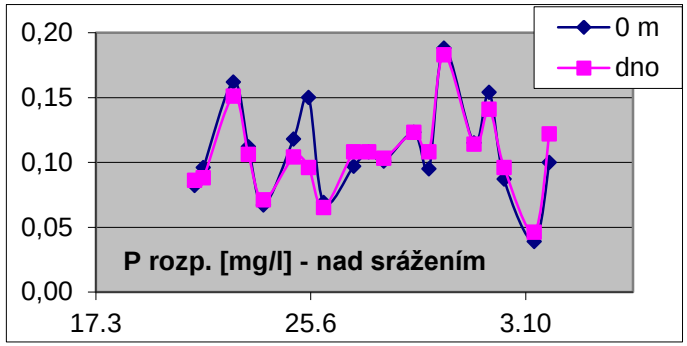
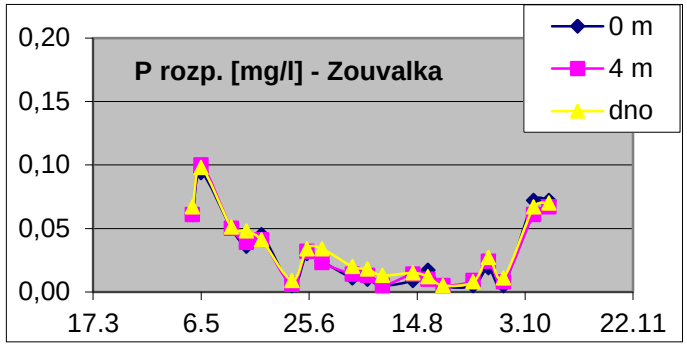
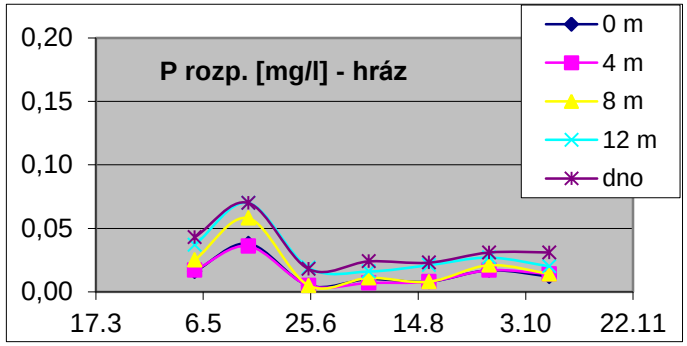
• *Srážení fosforu síranem železitým*

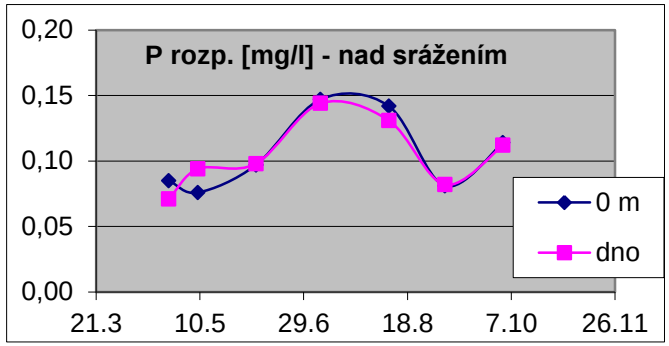
2013 – rozp. fosfor

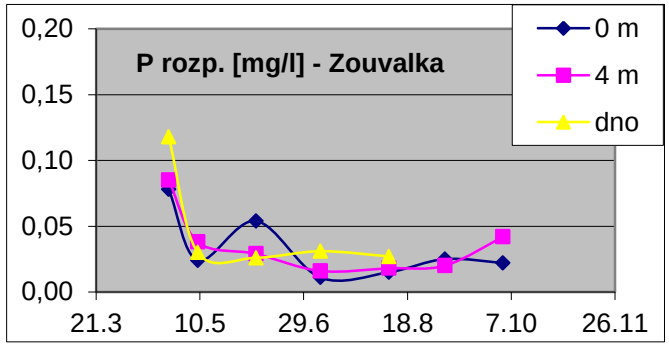


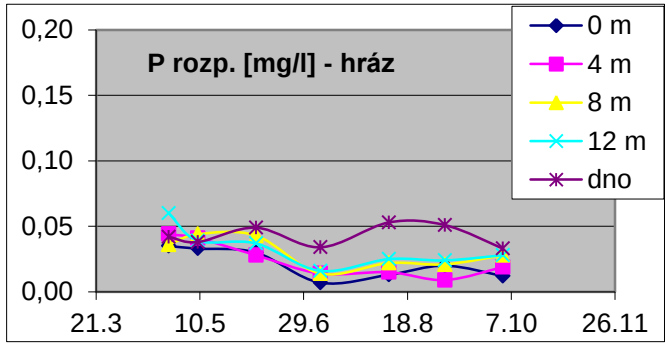




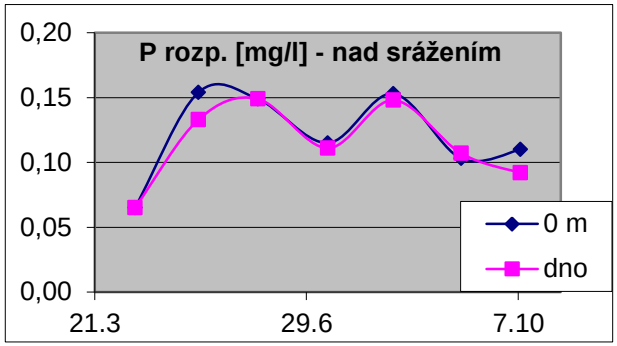
2016 – rozp. fosfor

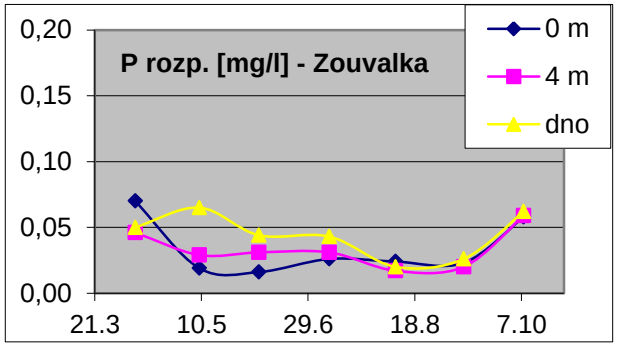


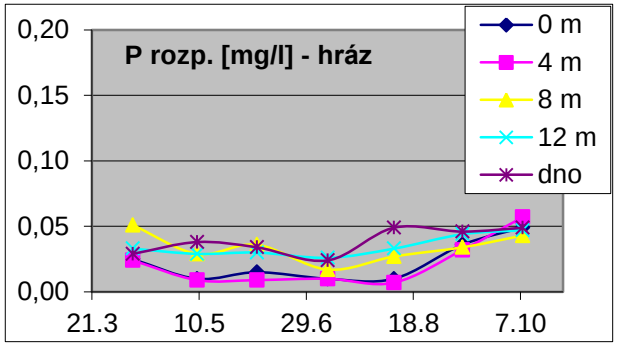




2018 – rozp. fosfor







Fish stock development

- *The fish stock change was a part of the revitalization project*
- *Catch of white fish (80–85% common bream, the rest was white bream) 2008: 3890 kg, 2009: 1200 kg, 2010: without catch, 2011: 3150 kg, 2012: 1220 kg, 2013 and 2014: without catch*
  A total of about 14,000 kg of whitefish
- *Planting of predatory fish*
  2010–2012: yearly 1000 kg of pike (0.3–1 kg) 1000 kg of sander (0.3–1 kg). In total 4500 pcs of pike, 12500 pcs of sander

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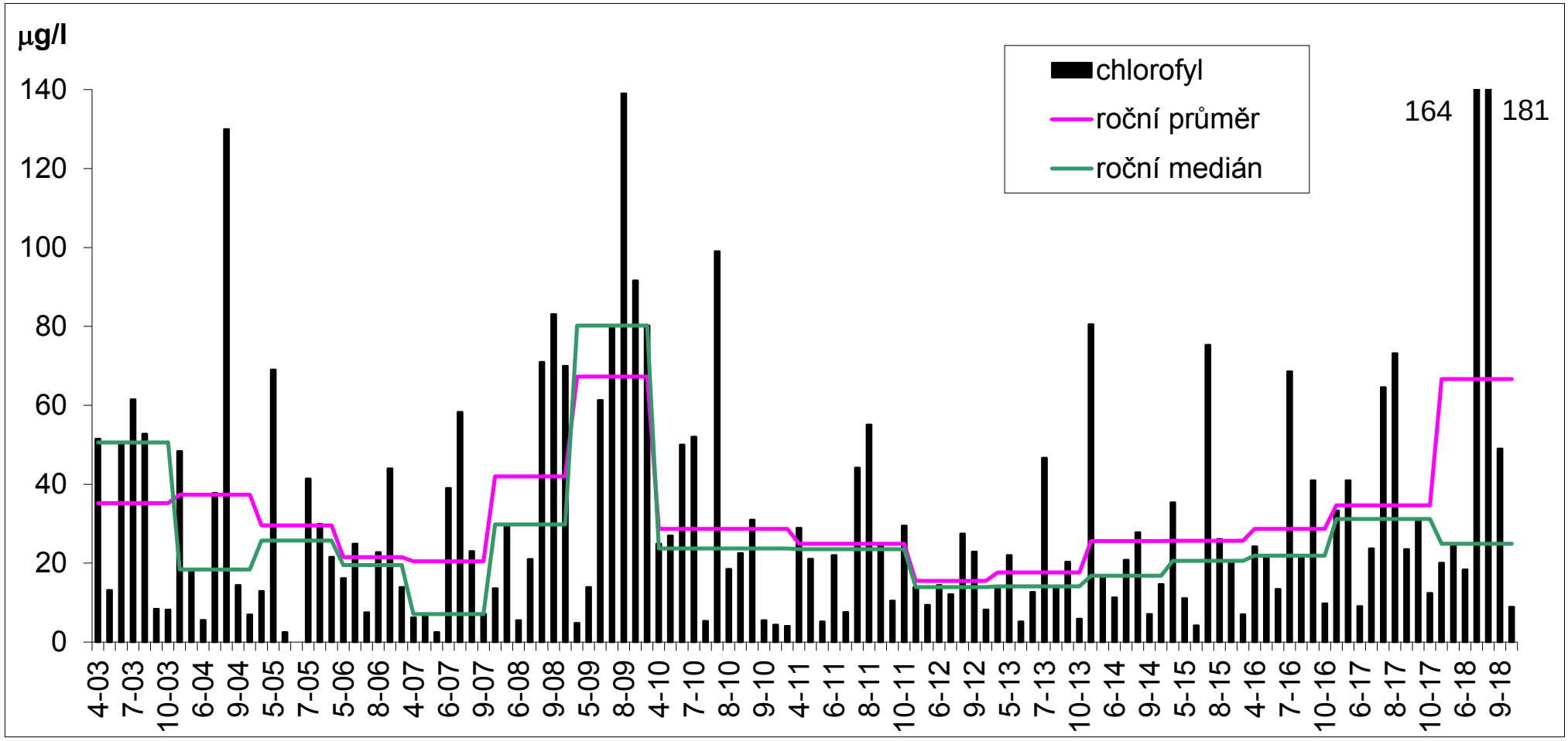
Fish stock development

- *Significant change in 2009, reduction of perch fry, stock is still low*
- *Minimal breeding of predators – unsuitable conditions*
- *Significant reduction of bream due to catches, stock is still low*
- *The abundance of predators does not increase significantly, the measures had minimal effect – high pressure from fishing, wrong rules, asp and catfish would be more effective*
- *Low possibility of fish stock control (except of bream) – fish stock and fishing rules are managed by a different organisation*

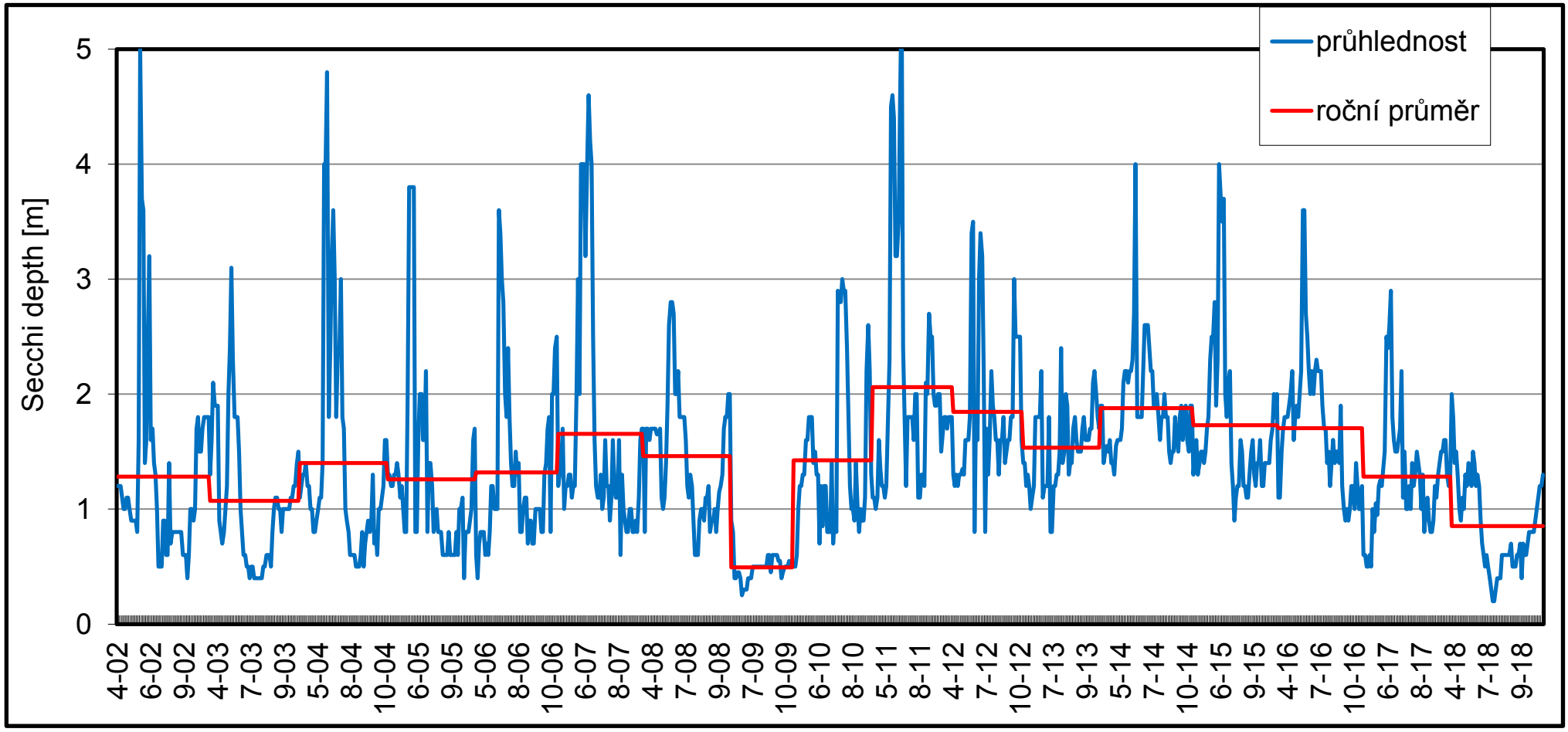
Results

- *Chlorophyll A – 4meter integrated sample – dam*



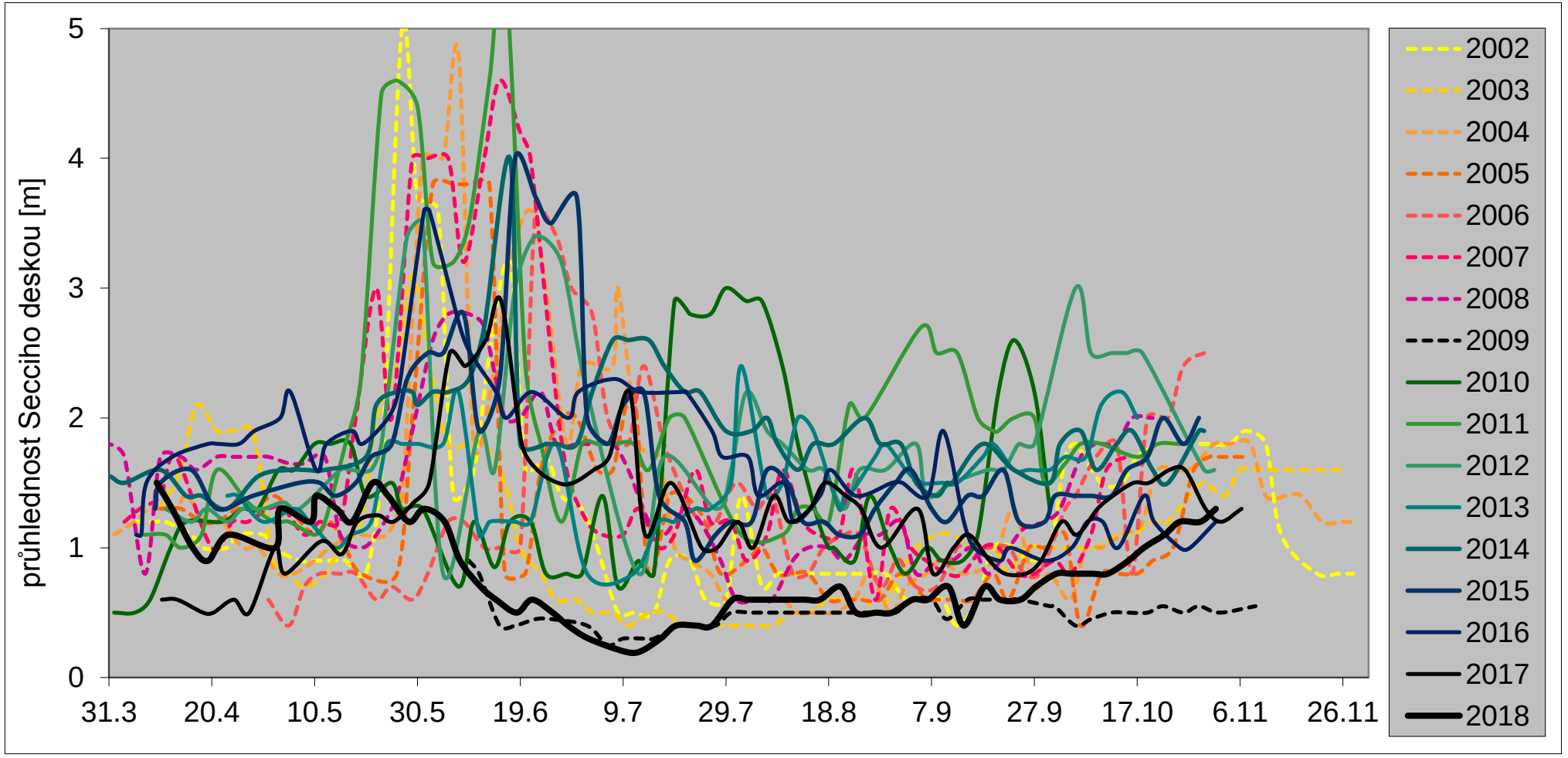
Results

- *Water transparency – dam*



Results

- *Water transparency – dam*



Results

- *data of public health protection authority*

2005	1	1	1	3	1	3		3	5	5	5	5	5	5	1
2006	1	3	3	3	4	5	3		4		4	4	5		
2007	1	1	1	1	3	3	3	5	3	3	3	4			
2008	1	1	1	5	5	5	5	5	5	5	5	5	1		
2009	1	2	3	odpuštění nádrže											
2010		1	2	1	3	3	1	1	3						
2011	1		1	1	3	3	1	2	2						
2012	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
2013	1	1	1	1	1	3	1	2	2	2	2	1	1	1	2
2014	1	1	1	1	1	3	1	1	1	1	1	2	1	1	
2015	1	1	1	1	1	1	3	1	1	2	2	1	1		
2016	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1
2017	1	1	1	1	1	1	1	1	1	1	1	2			
2018	1	1	1	2	2	2	3	3	5	5	4	4	4	4	3

• *Temperature in the longitudinal profile of the reservoir*

2017

9.5.2017						22.5.2017						5.6.2017					
hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov
13,3	12,9	12,7	13,1	12,6	12,3	16,1	16,0	16,0	16,9	17,1	15,3	20,7	20,6	20,8	21,4	22,3	22,2
13,4	12,9	12,7	13,0	12,4	12,2	16,0	16,0	15,9	16,4	16,4	15,1	20,7	20,6	20,3	20,8	20,8	20,4
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12,3	12,0	10,8	10,4			15,6	15,6	15,5	14,2			19,6	19,3	18,8	17,4		
11,3	10,8	10,7	10,4			15,6	15,5	15,3	14,0			18,8	18,2	18,0	17,4		
10,8	10,7	10,6	10,4			15,5	15,5	14,7	13,9			17,8	17,8	17,7	17,3		
10,6	10,6	10,6				14,6	14,3	14,1				17,7	17,6	17,6			
10,6	10,5	10,5				14,2	14,2	13,9				17,6	17,5	17,5			
10,5	10,5	10,4				14,1	14,0	13,8				17,5	17,4	17,3			
10,5	10,4	10,1				14,0	13,9	13,6				17,4	17,3	17,2			
10,3	10,2					13,9	13,5					17,3	17,2				
10,4	10,2					13,8	13,5					17,3	17,1				
10,2						13,6	13,3					17,1					
						13,2						16,9					

2018

9.5.2018						22.5.2018						6.6.2018					
hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov
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18,9	18,7	18,5	17,8	16,3	15,9	19,1	19,1	18,8	18,0	15,6	15,1	21,1	21,4	21,1	20,9	19,1	17,8
18,4	18,4	17,6	16,6	16,3		18,8	18,3	18,7	16,3	15,2		20,9	20,8	20,6	20,1	18,9	
17,9	16,7	16,9	16,6			17,7	17,5	18,0	15,9			20,3	20,3	19,9	19,2		
15,0	15,2	15,9	16,2			16,9	17,1	17,1	15,9			19,7	19,6	19,3	19,1		
12,5	13,5	14,1	15,5			15,9	16,4	16,4	15,9			19,1	19,0	19,1	19,0		
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10,5	11,1	10,8				14,1	14,4	13,7				18,6	18,7	18,8			
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9,7	9,3	9,5				11,9	11,5					18,5	18,6	18,1			
9,4	9,1					11,0	10,2					18,4	18,6				
9,1	9,0					10,2	10,0					18,3					
9,0						10,1						18,0					
8,9						9,7						16,1					

• DO in the longitudinal profile of the reservoir

2017

9.5.2017						22.5.2017						5.6.2017					
hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov
13,1	13,2	13,2	12,1	12,0	11,7	10,0	10,0	10,2	12,7	13,4	9,8	10,6	10,3	10,0	9,6	12,9	12,9
13,7	13,1	13,3	12,1	11,9	11,3	10,1	10,0	10,0	11,9	12,4	9,7	10,8	10,5	9,9	9,3	12,8	13,9
13,8	13,0	13,4	12,0	11,3	11,0	10,0	9,9	9,9	10,3	10,7	9,6	10,8	10,4	9,7	8,9	11,9	13,2
13,7	12,8	13,2	12,1	10,9	10,7	10,0	9,9	9,8	9,8	8,6	9,3	10,5	10,1	9,4	7,8	9,8	11,5
13,4	12,5	12,8	12,2	10,1	10,6	9,9	9,8	9,8	9,6	7,8	9,1	9,9	9,8	8,8	6,5	5,7	9,7
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11,4	11,0	11,5				8,9	8,7	8,5				6,7	6,5	6,2			
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11,1	9,9					8,7	8,3					6,6	6,6				
11,3	11,1					8,7	8,1					6,5	6,7				
11,2						8,1	7,3					6,2					
						7,5						5,9					

2018

9.5.2018						22.5.2018						6.6.2018					
hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov	hráz	střed	Sokolák	Rokle	Zouvalka	Mečkov
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9,1	8,1	8,4	8,0			6,7	5,9	6,5	8,5			4,7	4,4	4,3	4,5		
7,0	7,3	7,6	7,1			5,3	5,9	6,6	8,4			3,9	3,3	3,4	4,2		
6,2	6,6	6,6	5,0			4,6	5,8	5,7	8,2			3,9	3,3	3,4	3,5		
5,9	5,8	6,0				4,1	4,5	4,7				3,8	3,4	3,4			
6,0	5,4	5,7				3,2	3,3	3,1				3,6	3,2	3,5			
6,2	5,3	5,2				3,0	2,3	2,1				3,5	3,2	3,2			
5,6	5,0	4,0				2,8	2,3					3,5	3,2	1,4			
5,1	4,6					2,6	1,9					3,4	3,0				
3,2	4,2					2,0	1,6					3,2					
3,2						2,1						2,4					
2,7						1,5						0,3					

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Conclusions

- *Precipitation of dissolved P is quite effective, works only at steady flows, it‘s expensive, probably permanently unsustainable, only a small part of the year*
- *Aeration / destratification has an observable effect on temperature equalization and oxygenation of the hypolimnion. But mixing ??? Sediment oxygenatin???*
- *Biomanipulation effective for bream reduction, ineffective in enhancing predators, small management possibilities, conflicting purposes*

Conclusions

- *Observable changes in zooplankton (due to changes in fish stock)*
- *Significantly higher transparency (except of 2018), in the main season without Microcystis dominance, significantly higher hygienic quality*
- *High requirement for suppliers and operators experience and know-how, expensive monitoring and evaluation*

Thank you for your attention.

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