$AlCl_3$-treatment of eutrophic Lake Littoistenjärvi: Background and interim results

Heikkilä J. & Vepsäläinen M.

SYKE SEDIMENTTISEMINAARI -Lake restoration using aluminium salts: recent advances, results, and potential hurdles, Helsinki, 5.6.2017, updated 18.8., 13.9., 29.10., 1.11.2017; 8.2.2018

Lake Littoistenjärvi N 60° 27,289' E 22° 23,105' (~WGS84)

- 1,5 km^2, 3 Mm^3, 1,7…1,8 years of residence time
- (3)…4,5 km^2 drainage basin
- Regular collection of data for research (and practice)
  - Earliest 18th century records: special, good quality water for frieze manufacturing (est. 1738, later Barker-Littoinen Oy)
  - 1908-1913 First known scientific records
  - 1971-1998 Water quality measurement by waterworks
  - 1983-2013 University of Turku follow-up
  - 1998-present regular follow-up of water quality, zoobentos, phytoplankton, zooplankton
- Canned food factory, laundry, air base, ice track racing, recreational center for swimming, ballroom, beaches, skating, skiing, fishing, wind gliding, bird watching…

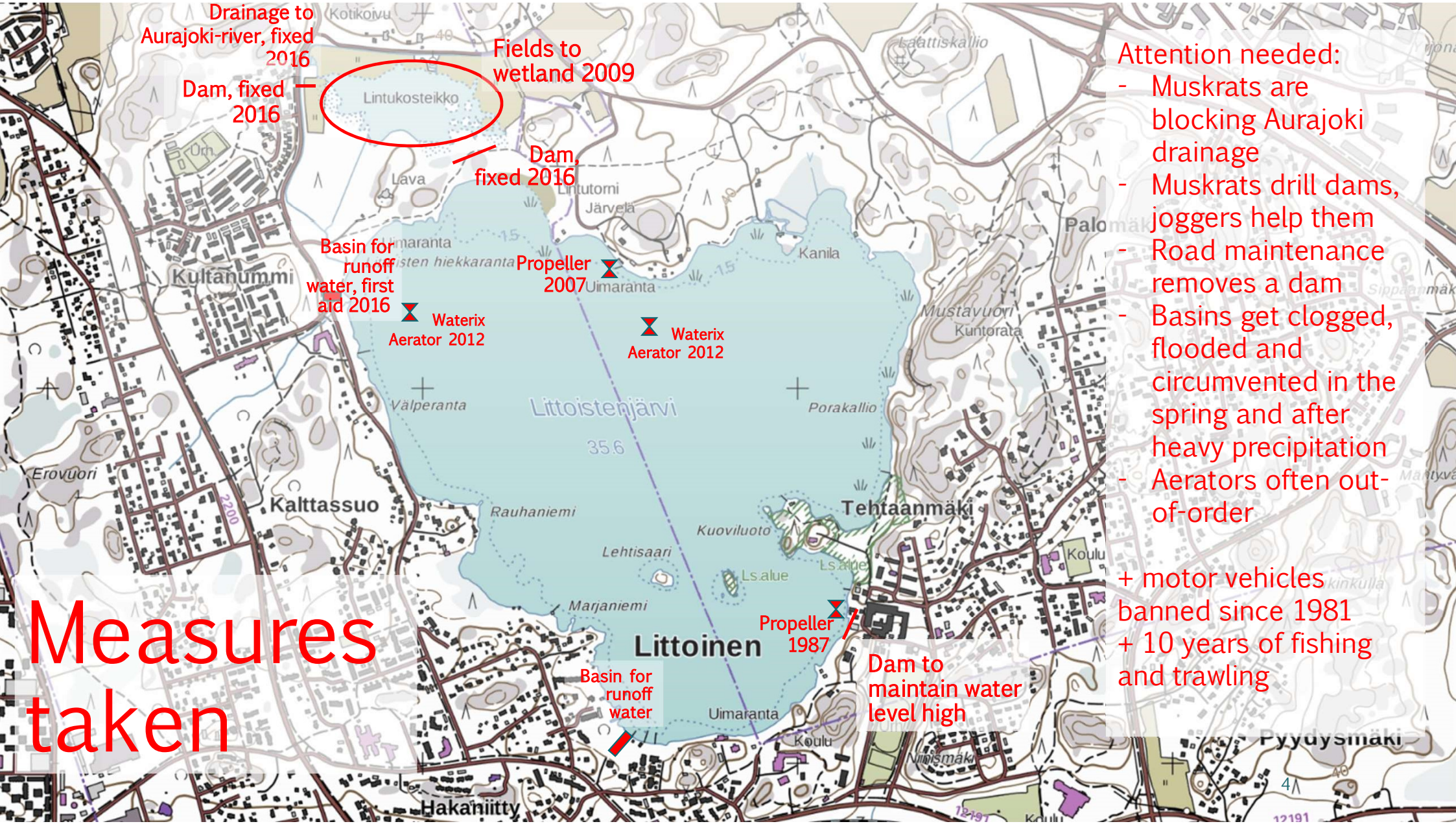
- T_0 eutrophic -> oligotrophic - 1900 (?)
- 1986- eutrophic/oligotrophic severe alternating *elodea canadensis* and *ceratophyllum* overgrowth, pH 5,5…11
- 1998-1999 hypoxia, thereafter diminishing *elodea,* strong phytoplancton growth and internal phosphorus-cycles
- ~2010 toxic cyanobacteria appears, zooplankton diminishes, pH 6,5…10
- 2016 worst year ever in terms of water quality; and against Water Framework Directive (2000/60/EC; 1299/2004 Laki vesien ja merenhoidon järjestämisestä)

Lake Littoistenjärvi

- The other natural lake in Turku region (pop. 300.000)
- 200+ owners, the major shares by Kaarina and Lieto municipalities
  - 1968 Littoistenjärven säännöstely-yhtiö, official
    - water level & drainage flow control
  - 1971-1998 Lieto & Kaarina joint waterworks, and Turku fresh water reserve since then, official
  - 1992-2006 Littoistenjärvi workgroup, which became in 2006 Littoistenjärven neuvottelukunta
    - all stakeholders; water & ashore
  - 2008 Littoistenjärven hoitokunta, official
    - lake owners
  - 2014-2017 hoitokunta applied environmental permit for $AlCl_3$
  - 2016 hoitokunta secured funding from major owners and the government

Korkeustaso (N60+m)	Tilavuus (Mm3)
36.25	3.92
36.00	3.55
35.75	3.17
35.50	2.80
35.25	2.44
35.00	2.09
34.75	1.75
34.50	1.42
34.25	1.11
34.00	0.82
33.75	0.54
33.50	0.30
33.25	0.11
33.00	0.01
32.75	0.00
32.50	0.00

Kuva 2. Littoistenjärven tilavuuskäyrä.


Drainage to Aurajoki-river, fixed 2016
Dam, fixed 2016
Fields to wetland 2009
Dam, fixed 2016
Basin for runoff water, first aid 2016
Waterix Aerator 2012
Propeller 2007
Waterix Aerator 2012
Propeller 1987
Dam to maintain water level high
Basin for runoff water
Measures taken
Attention needed:
- Muskrats are blocking Aurajoki drainage
- Muskrats drill dams, joggers help them
- Road maintenance removes a dam
- Basins get clogged, flooded and circumvented in the spring and after heavy precipitation
- Aerators often out-of-order
+ motor vehicles banned since 1981
+ 10 years of fishing and trawling
Littoistenjärvi
Littoinen
Kultanummi
Kalttassuo
Tehtaanmäki
Hakaniitty
Lintukosteikko
Uimaranta
Rauhaniemi
Lehtisaari
Marjaniemi
Kuoviluoto
Porakallio
Kanila
Välperanta
Erovuori
Mustavuori
Kuntorata
Koulu
Ls.alue

KEMIRA PAX XL-100, i.e., 30-40 % polyaluminiumchloride

(Sheet: Kauko Anttila, Kemira Oyj)

Planned in 2016:
- 40 mg/l, 200-280 t

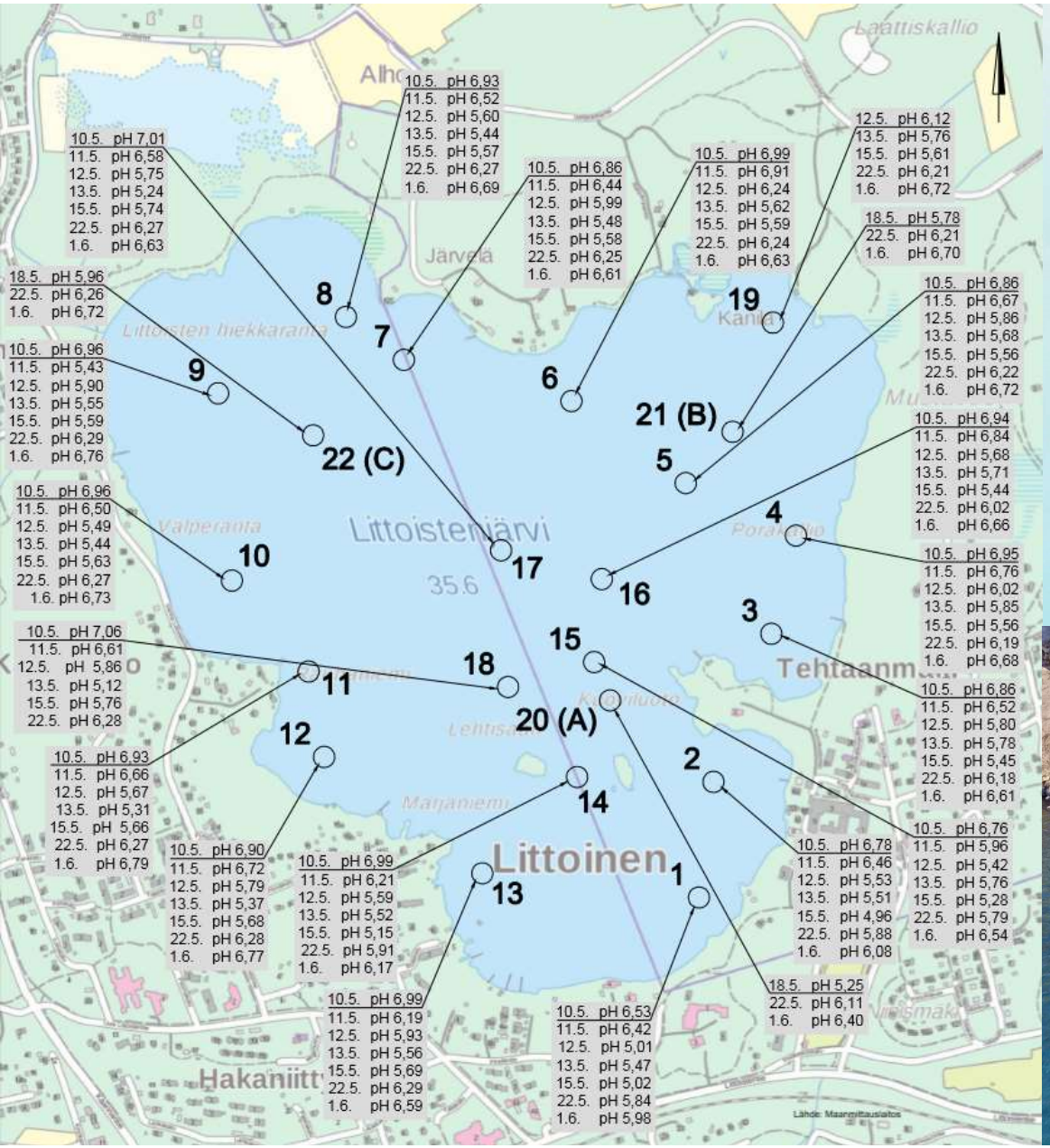
- Early recommendation in 2017:
  - 50-60 mg/l, 200-260 t
- Water volume estimate:
  - 3,65 MM^3
- Completed:
  - 44 mg/l, 160 t *(20%...40% reduction)*
- pH
  - Before ~7
  - Target 6,0...6,3
  - +3d 5,5 (± 0,5)

LITTOISTEN SAOSTUSKOKEET 04.5.2017
KEMIRA OYJ / K. ANTTILA

Näyte	Kemikaali	Annostus ml/l	Annostus mg/l	pH1	pH2	Sameus
0	PAX-XL100	0	0	7,1	7,1	samea ja väriä
1	"	29	40	6	6,2	kirkkain
2	"	43	60	5,5	5,6	kirkas
3	"	58	80	5	5	kirkas ja vähän väriä

SEKOITUS 15 SEK
HÄMMENNYS 10 MIN
LASKEUTUS 20 MIN

HUOM! pH1 mitattu Hyvinkään Veden laboratorion mittarilla ja
ja pH2 mitattu Kemira Oyj:n kannettavalla mittarilla



pH details (Figure: Vahanen Environment Oy; Photo: Janne Jaska Heino)

Short spreading time (36 hrs) and gathering daily winds (4 m/s; 8-10 m/s in gusts) mean that solution spreads out unevenly, close follow-up needed.

- On 6.6.2017: pH 6,8…7,0

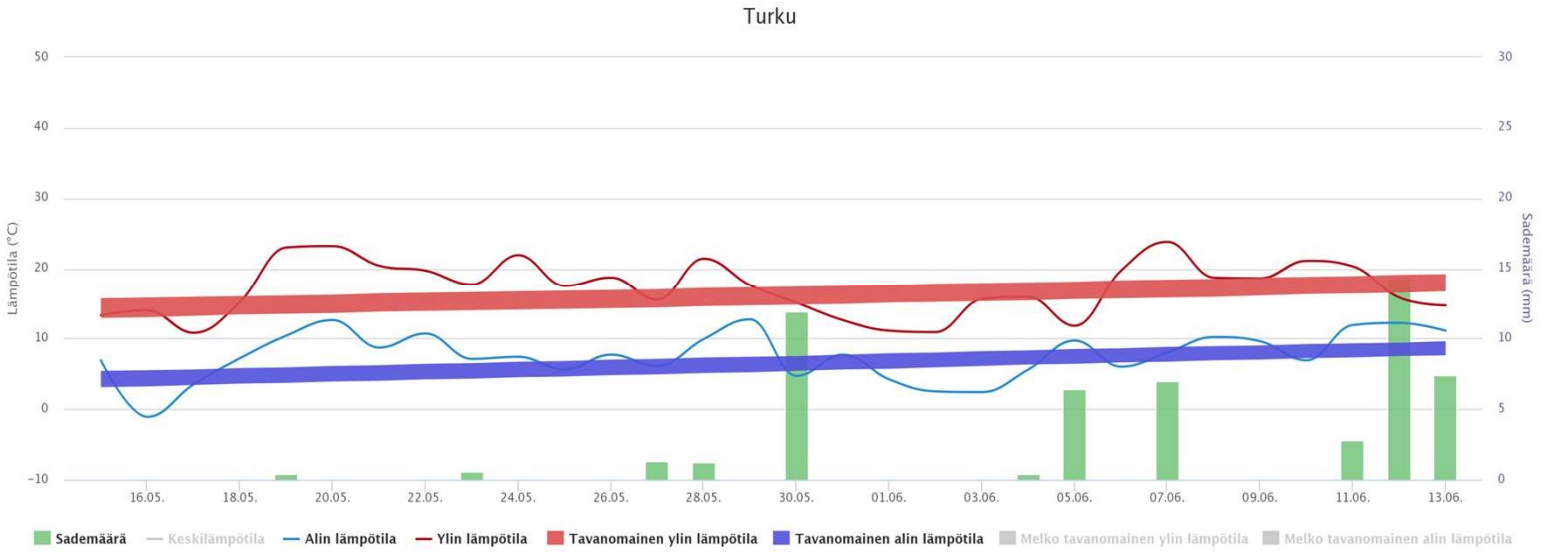
Weather Artukainen during treatment

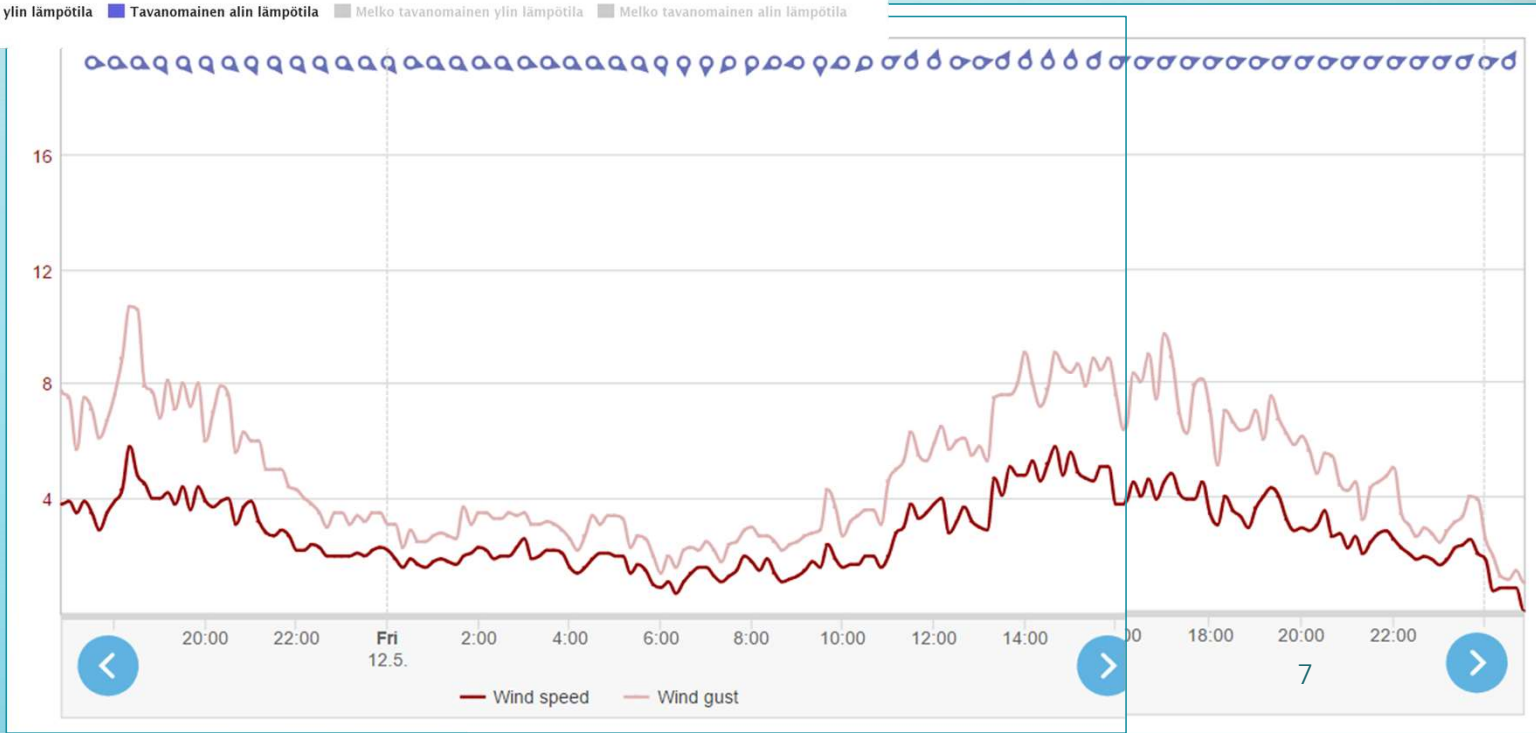
(Figures: Finnish Meterological Institute)

1010-1017 hPa

-3,0...+10 °C

Varying winds 0...10 m/s





Four months after:
Average of three samples
(Figure: adapted from Jouko Sarvala, 2016

Phosphorus is gone

- Last ten years: 40…160 µg/l
- 5 µg/l (total 15.5.2017) -> 10 µg/l (total 6.6)…
- < 3 .. 8 µg/l (soluble5.5 & 6.6.)
- < 3 µg/l (phosphate 6.6)

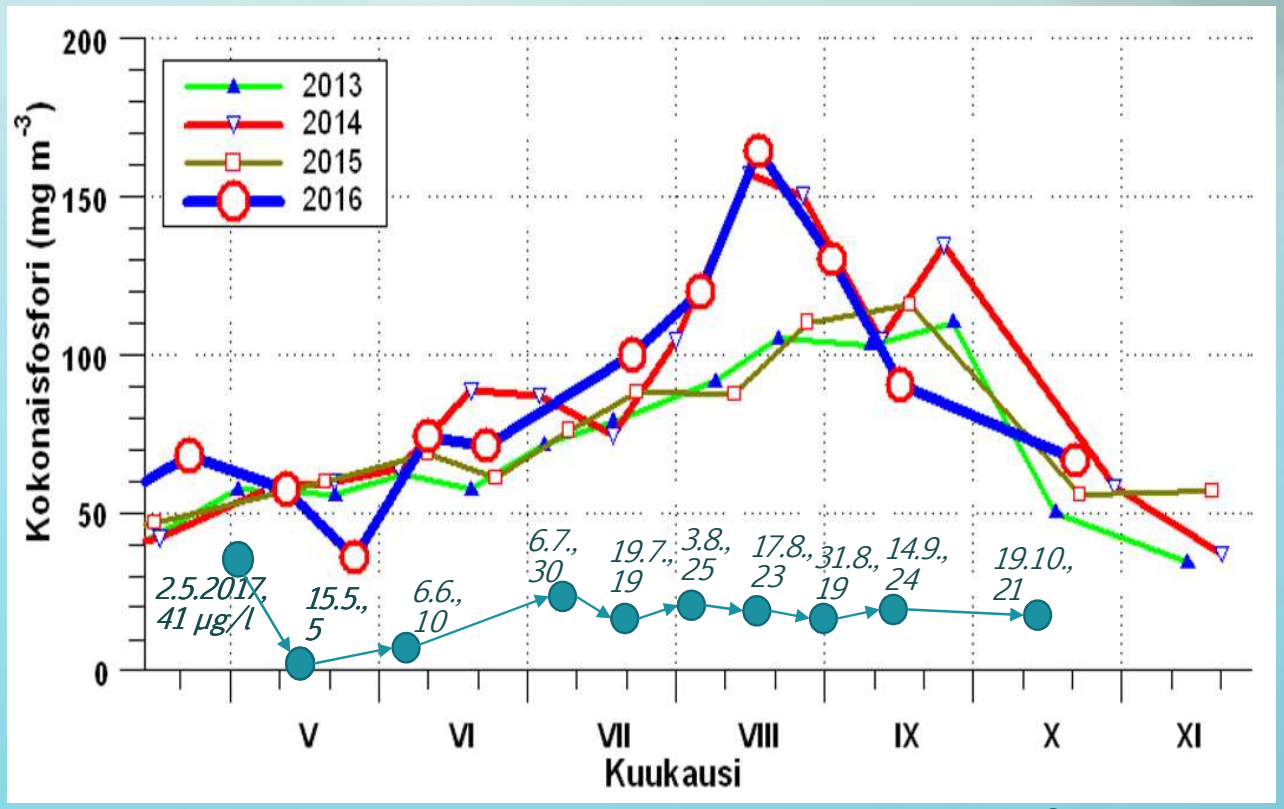
Aluminium

- Last ten years: 100 µg/l
- 630 µg/$l_{15.5.}$ -> 45 µg/$l_{6.6.}$
  - 3x drinking water guidance value; below the levels of Finnish acidified lakes, now lowest ever measured.

Alkalinity very low

- Last ten years: 0,4…0,6 mmol/l
- < 0,04 mmol/$l_{15.5.}$ -> 0,13 mmol/$l_{6.6.}$

For research and open data: Please follow http://www.littoistenjarvi.fi/tutkimustyo/



Four months after:

Average of three samples

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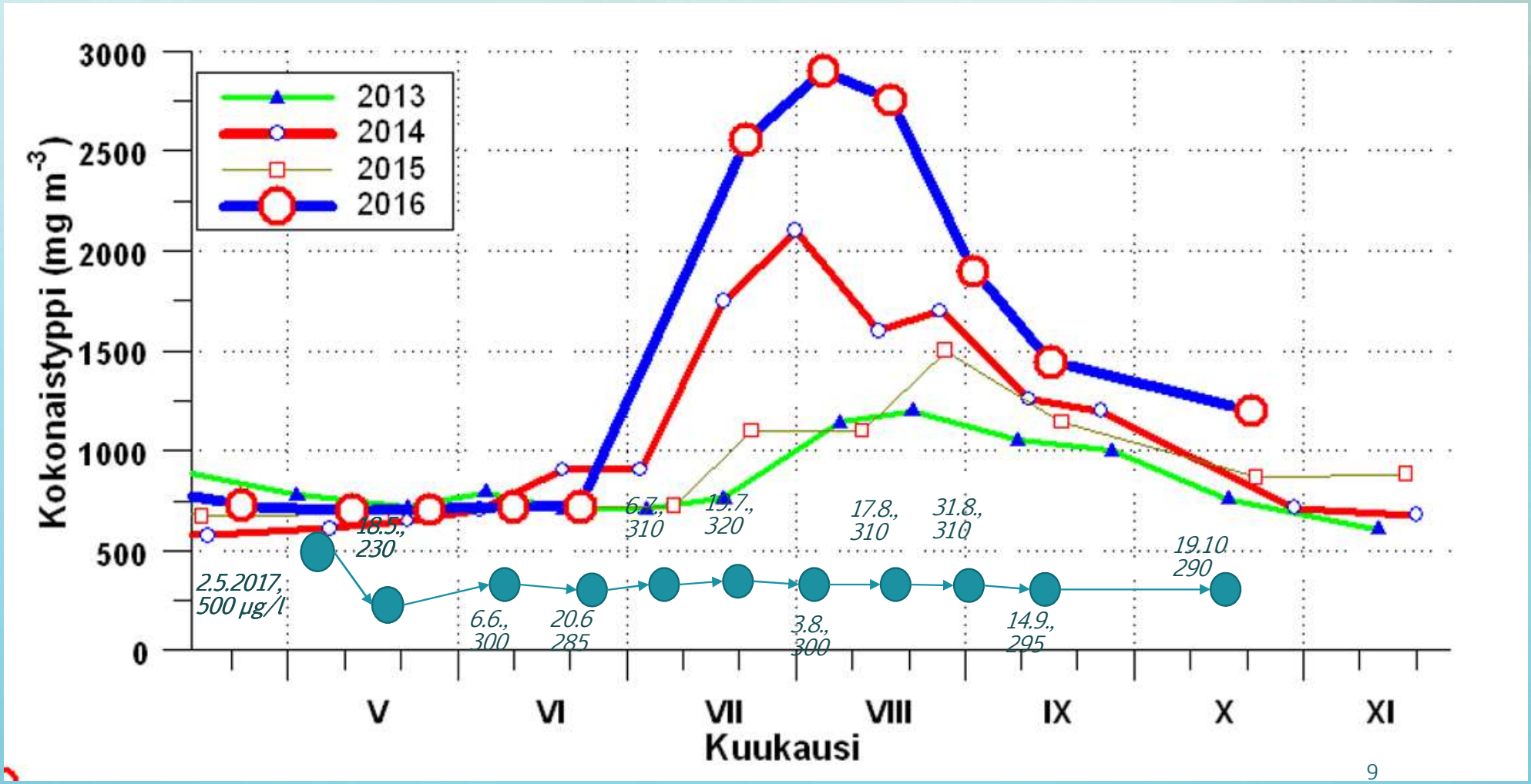

Four months after:

Average of three samples

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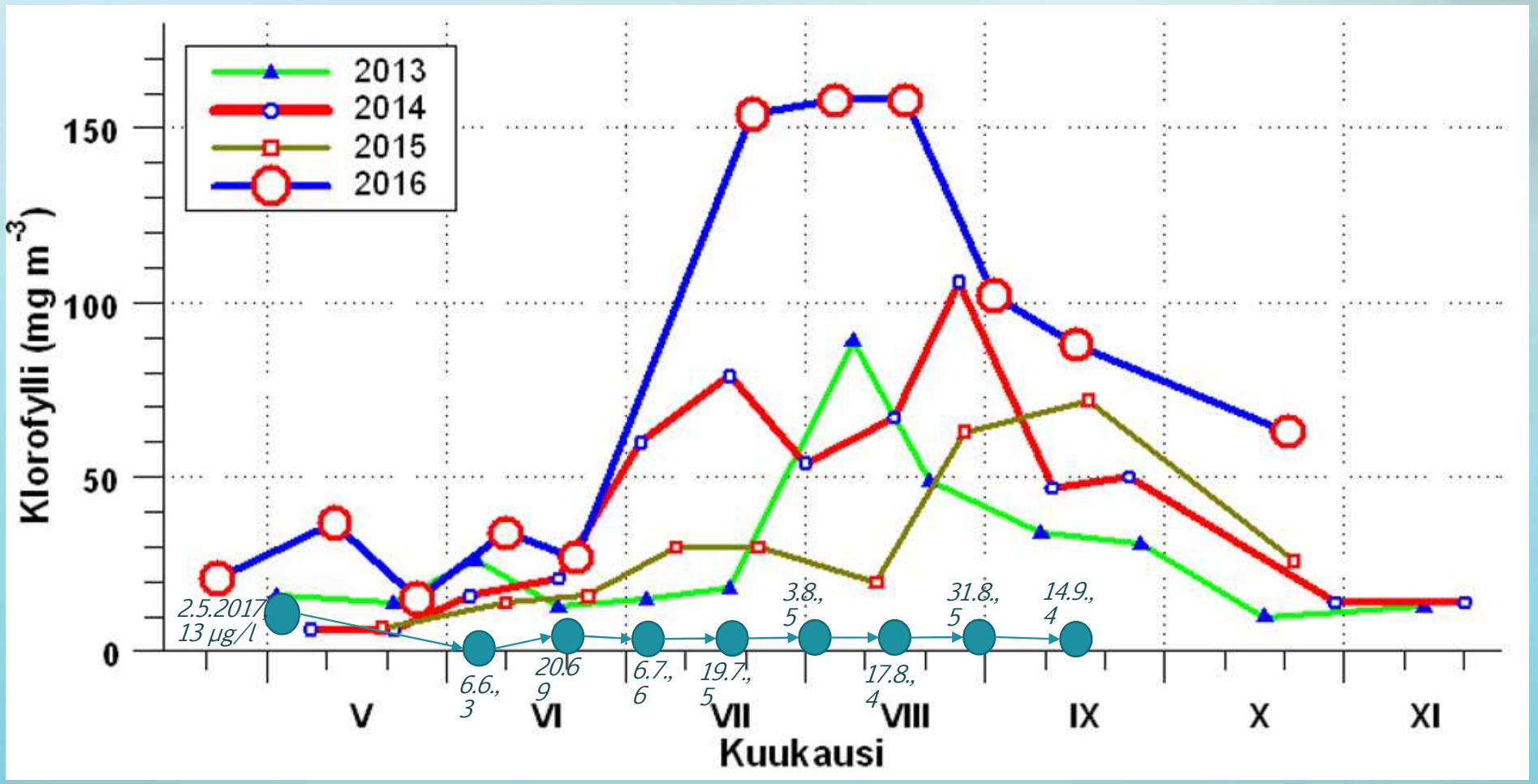
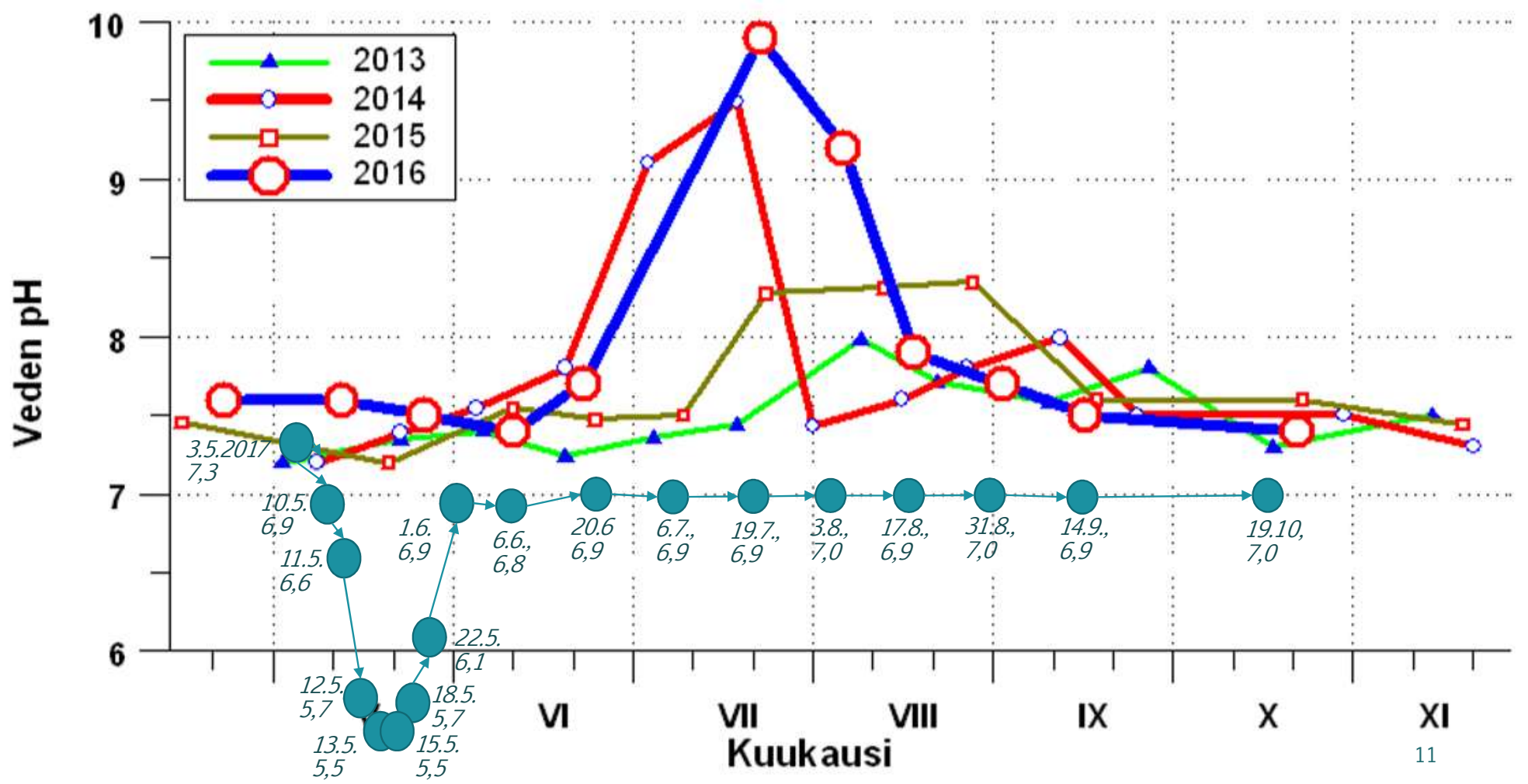


Four months after:

Average of available samples

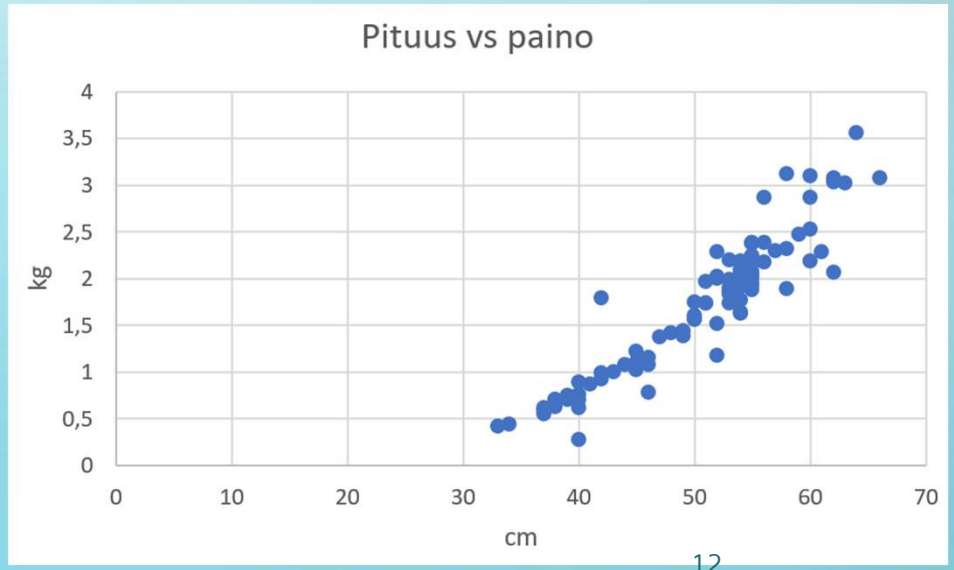
(Figure: adapted from Jouko Sarvala, 2016



Changes of animalia

(Photos: Jukka Heikkilä)

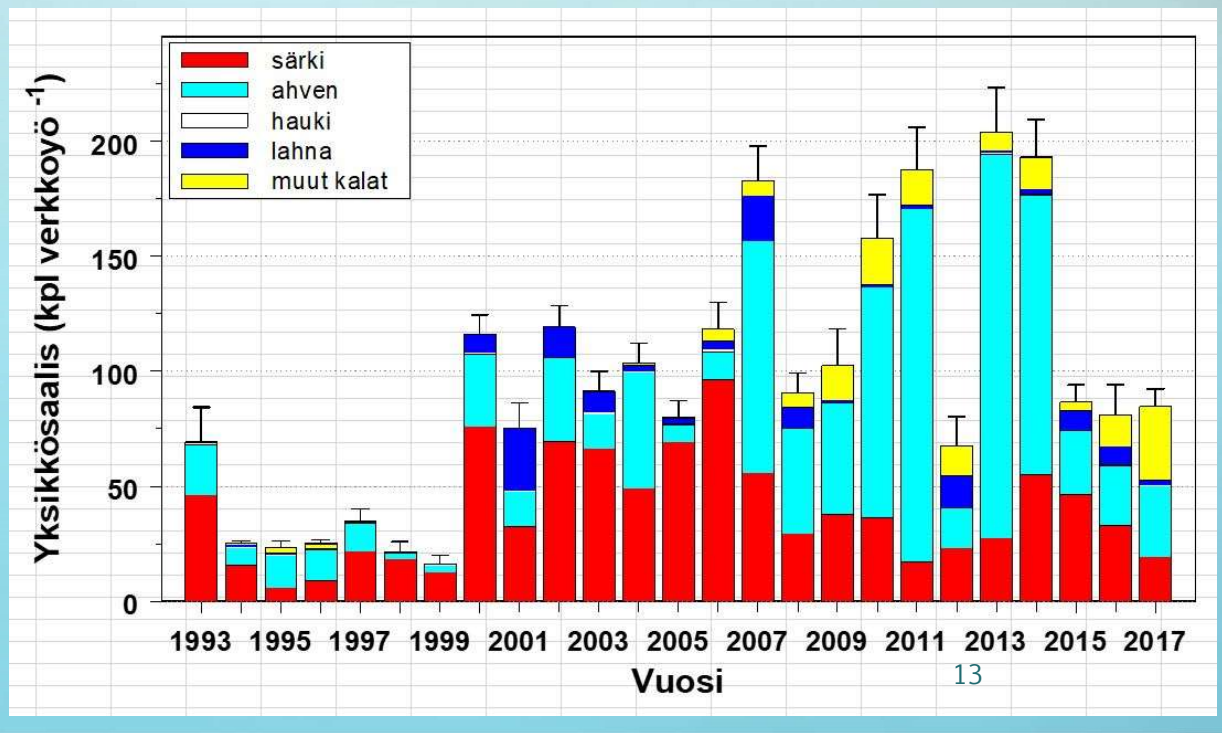
- Fish collected
  - Bream *(Abramis brama),* 97 % of collected fish consists of big breams (8-18 years), 5 tons removed (weighed)
    - Harpoon fishing on Sat 20, 19 participants. Focus on large breams, about 230 dead and 100 alive caught (stats on the right)
  - Pike *(Esox lucius),* a few big ones, 20-30 altogether (max 14kg)
  - Roach *(Rutilus rutilus),* many of all ages
  - Perch *(Perca fluviatilis),* some
  - Eurasian ruffe *(Gymnocephalus cernua),* some
  - Crucian carp *(Carassius carassius),* 10 (max 2kg)
- Insects (casual observations)
  - Mayflies *(ephemeroptera)*, reduced hatches (not confirmed)
  - Midges *(nematocera, chironomidae),* hatching
  - Caddisflies *(trichoptera),* hatching
- Mussels
  - Duck mussel *(Anodonta piscinalis),* studied in 24.-25.5.2017. Obviously no significant harm, but the population has shrunk to 1/5th of the 1980's population.



Effect on fish population = next to none (figure: Jouko Sarvala; photo Raimo Gratschew)

- 'New' species, belica, allikkosalakka (*Leucaspius delineatus)* in test fishing of 21 net nights (30.-1.9. & 14.-15.9.2018)
- Still plenty of big breams
  - harpooning by diving
  - torchfishing with trident
  - trammel-netting
- No further water mould (fungus) cases on pikes, but on some individual breams and bleaks.

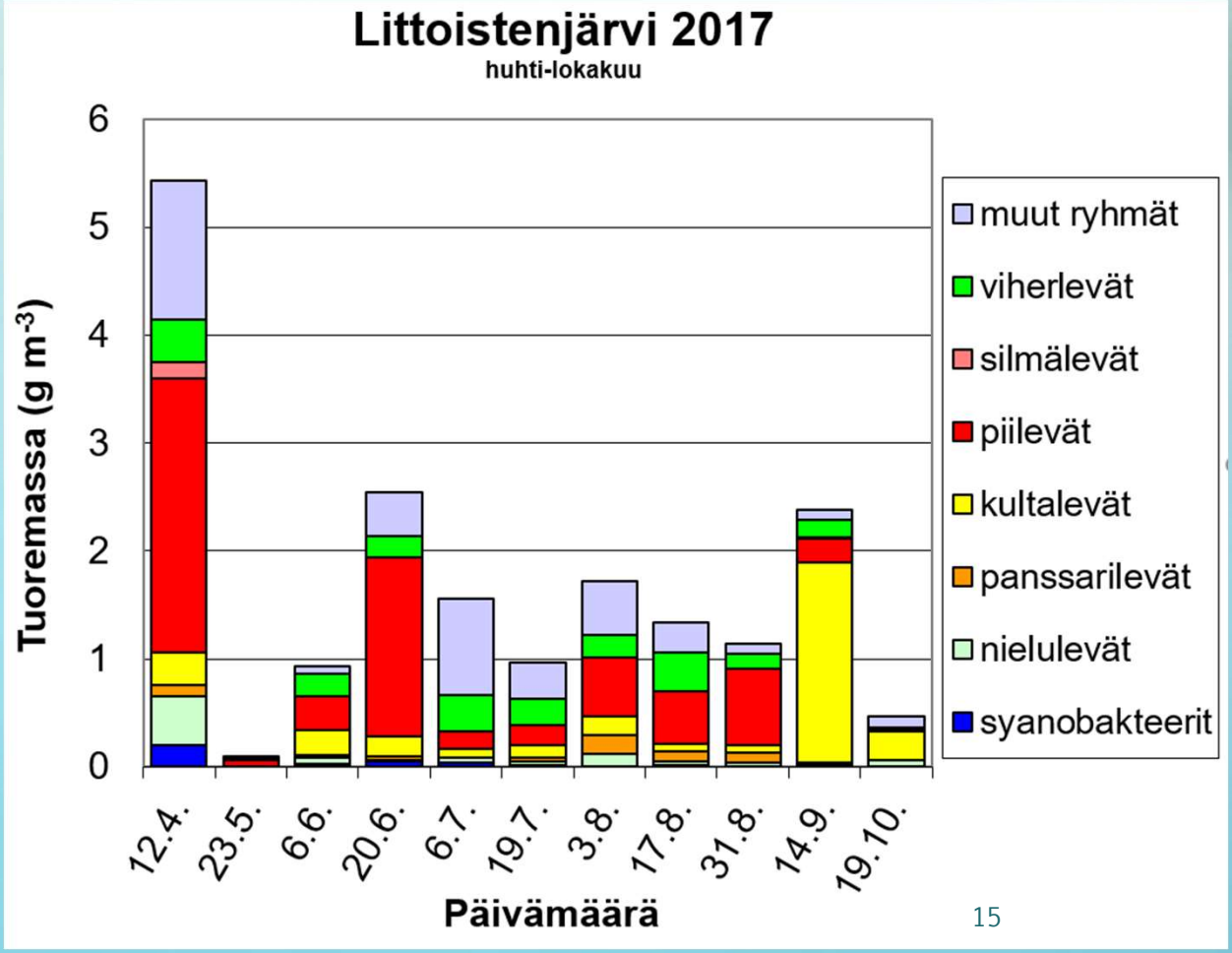
- Crayfish (both *pacifastacus leniusculus* and *astacus astacus*) observed in 2018, first time in eight years.



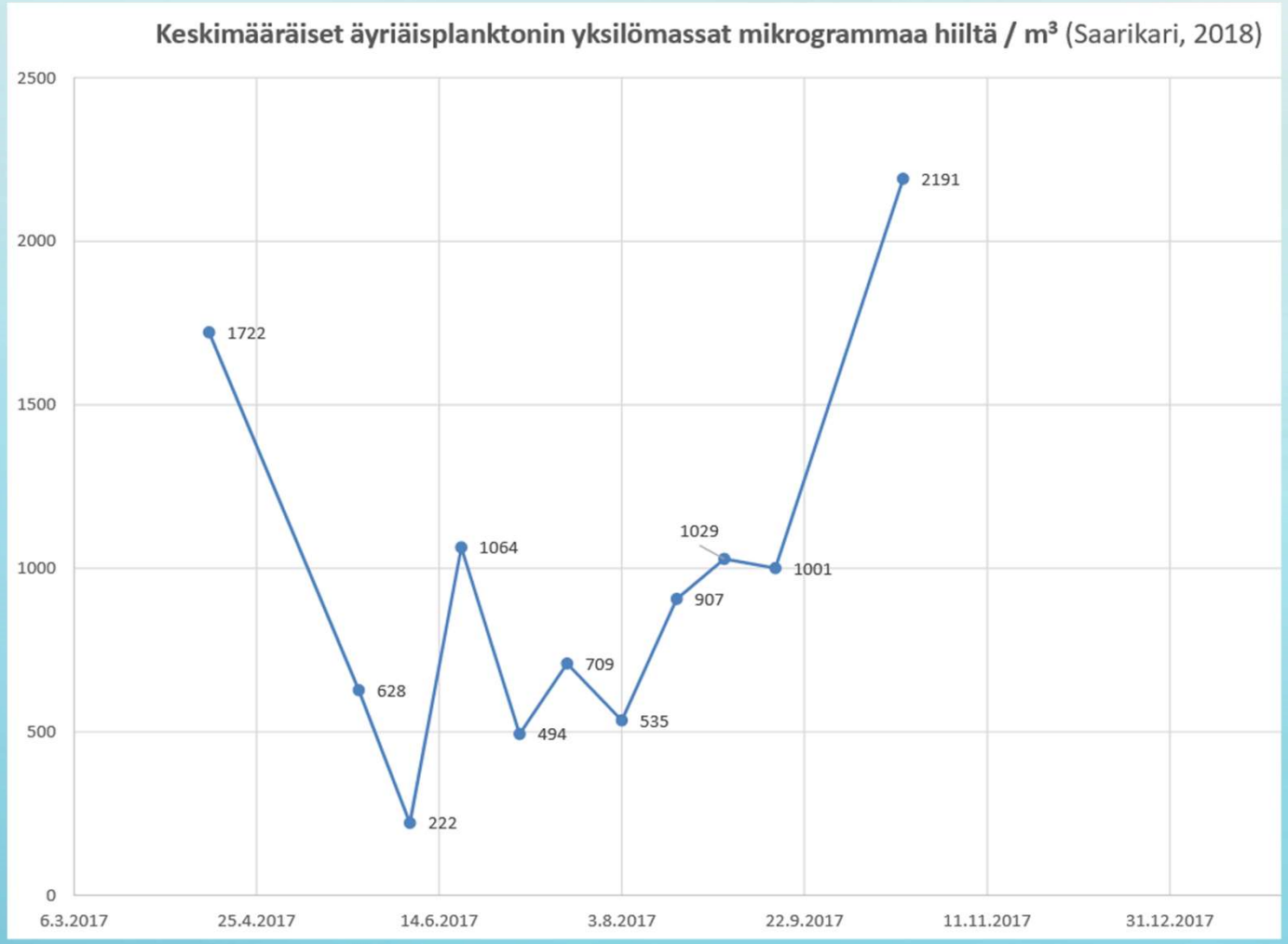
Effect on zoobenthos – results pending (photos: Jukka Heikkilä)

Phytoplankton recovery in 4-6 weeks

- No syanobacteria blossoming at all
  - In Fall of 2018, no observable syanobacteria (under acceptable drinking water limits)
- Turn of the species towards oligotrophic lake ecosystem



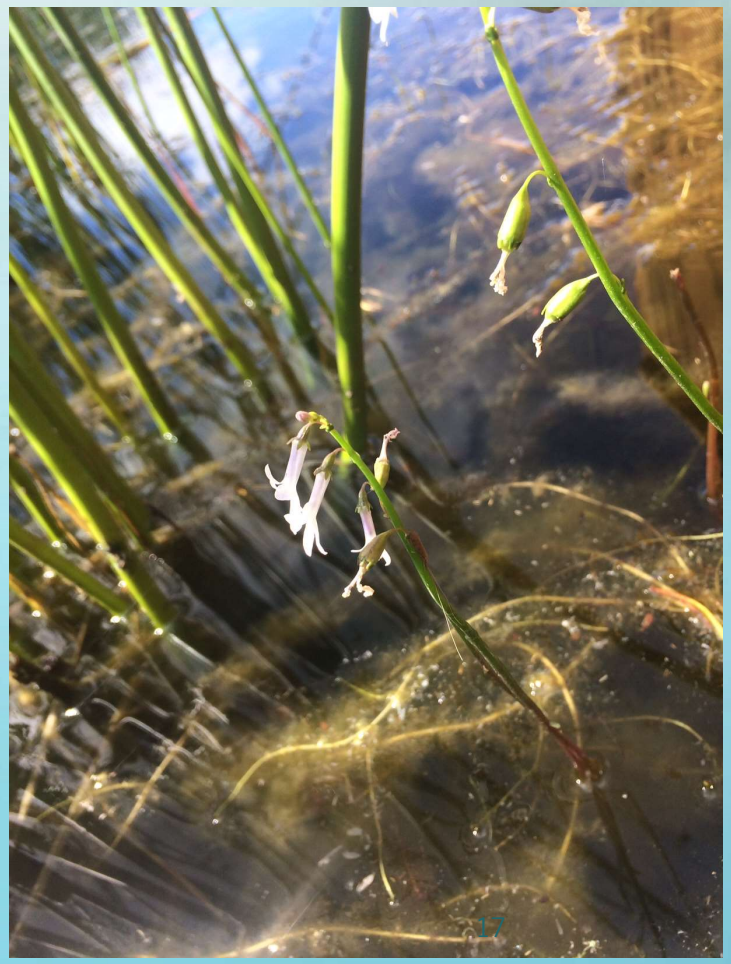
Zooplankton recovery in 4-12 weeks



- Tentative finding:
  - Turn of species towards oligotrophic lake ecosystem

Effect on vegetation = shall see

- The divers could cover the vegetation area
- Some oligotrophic species spreading
- No quick changes, but elodea *(elodea canadensis)* growth potential at normal level
  - we can expect more elodea in forth coming 3-5 years, unless water milfoil *myriophyllum alterniflorum*, and other species cover it.



Algae – no algae

(Photos: Jukka Heikkilä, video Vesa Ritvanen)

Before, in August 2015

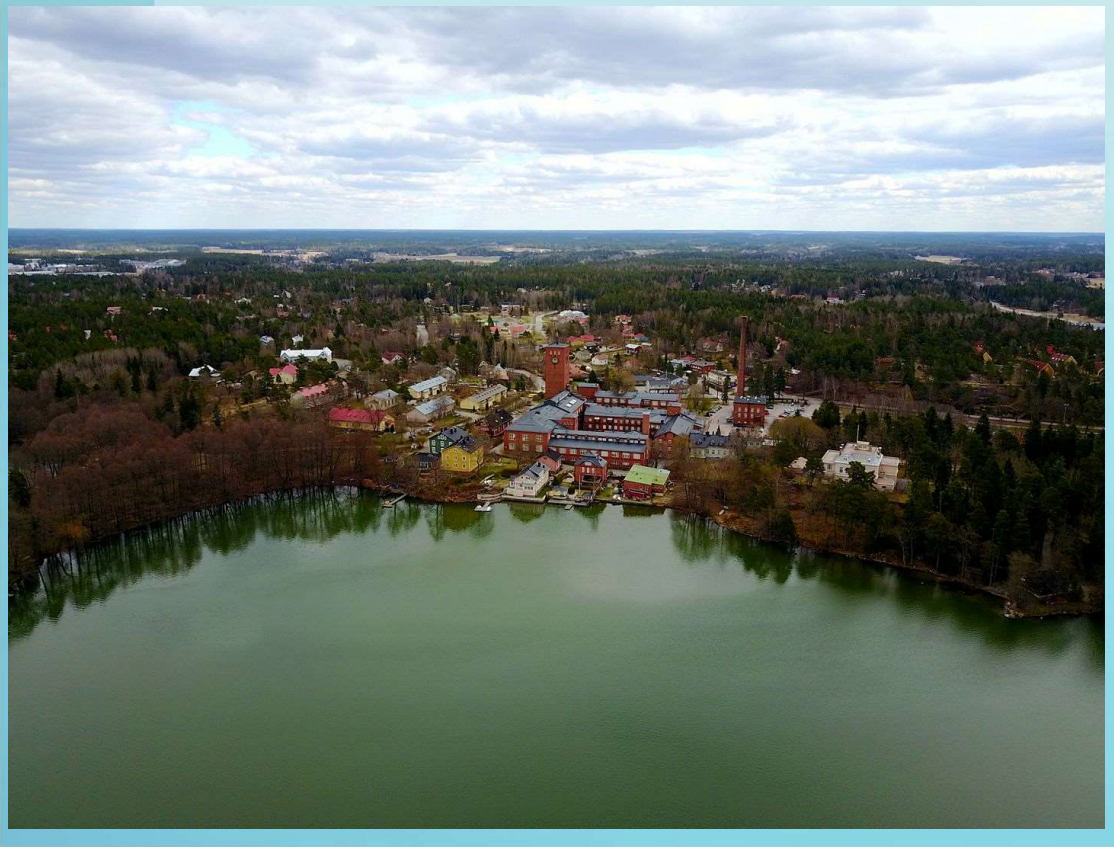
After, in May 2017
(https://youtu.be/ow4ud1S_Hmg)

Algae – no algae

(Photos: Janne Jaska Heino, video Kari Koskinen)

Before, May 2017

- visibility 0,3m
- FNU 4,5…5,1



After, May 2017 (https://youtu.be/KqJzVrBqU8), Early June:

- visibility 1-3m,
- FNU 1,3…2,1

Next steps

- LITSA/PROP project inofficial kick-off on Wed 24.5., starting at 1.7.2017.
  - Measurement of zoobenthos, vegetation, mussels in 2017
  - Intensified measurement of water quality (22 parameters) + phytoplankton and zooplankton in 2017-2018
  - Test fishing in 2017-2019 for deciding about further netting/trawling.
  - Aerial photos & videos
  - Sediment analysis (?)
  - UTU Vehniäinen/Pettersson toxic cyanobacteria/algae follow-up continues.
- Aerators off in 2017-2018
- Contacting with Vesistökunnostusverkosto (water restoration network).

Some extras

- Elevated media interest in and coverage of Lake Littoistenjärvi and Littoinen village
- Huge increase in use:
  - Requires toilets, bins, parking & hygiene checks
- Some observations made possible by clear water:
  - The strong effect of wind in the lake basin
  - Fish are schooling https://youtu.be/3i0PagxdchA
- Further development of surface skimming devices

Most important effects:
- People can change their environment to the better
- People learn about caring the nature
- People understand the nature better
- The above is equivalent to €s, too!

Aerial photo and video as of 11.9.2017 (all photos)

http://www.littoistenjarvi.fi

(Drawings: Pekka Pihlaja, ©Littoistenjärven hoitokunta)

LITTOISTENJÄRVI
Littoistenjärven osakaskunnat

Kaarina VAHANEN CLEAN WATERS LIETO

Ympäristöministeriö
Miljöministeriet
Ministry of the Environment