Pesticide mixture toxicity to algae in agricultur streams – field and laboratory studies

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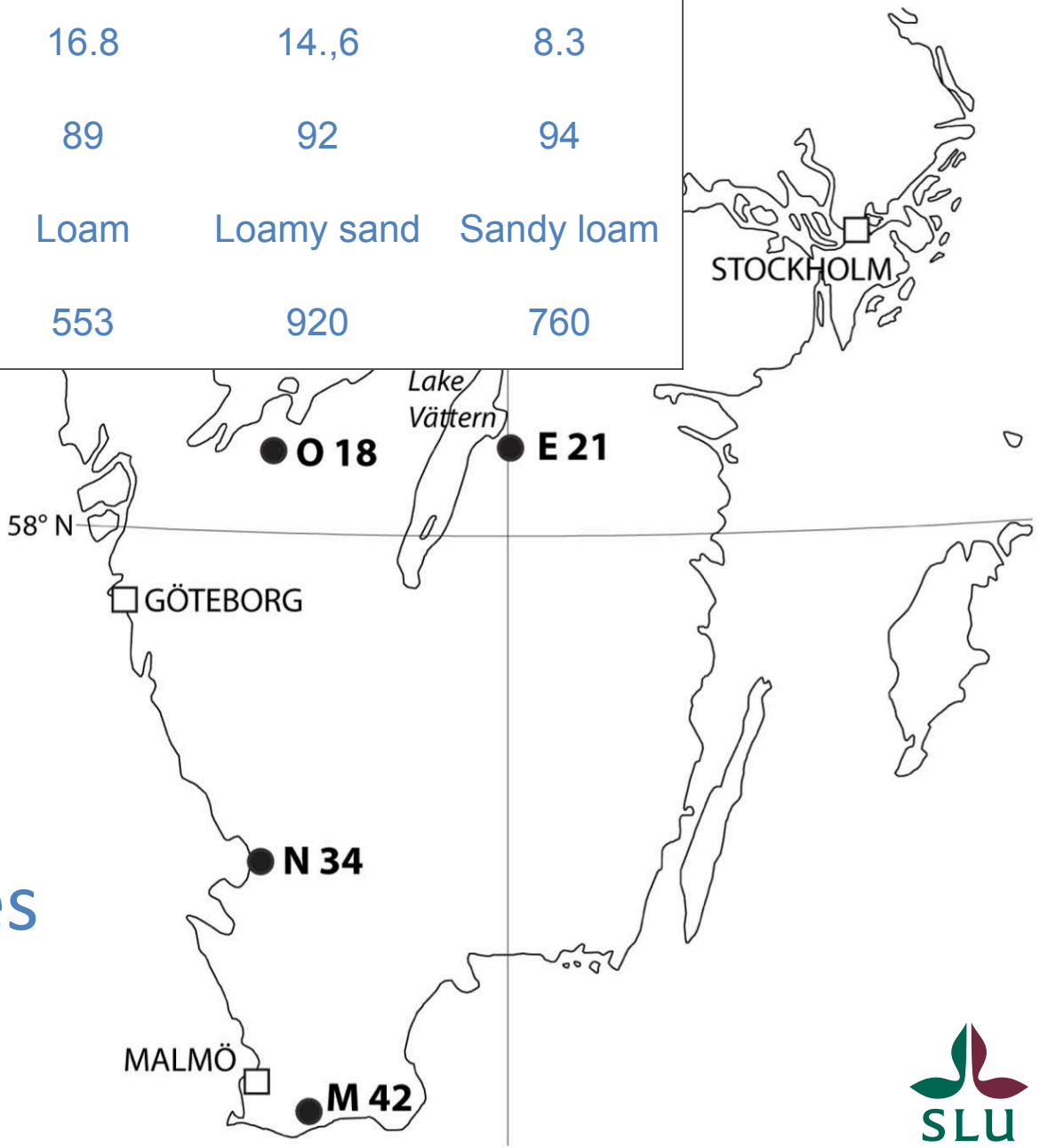
Parameter	O18	E21	N34	M42
Catchment area (km2)	7.8	16.8	14.,6	8.3
Agricultural land use (%)	91	89	92	94
Dominating soil type	Clay loam	Loam	Loamy sand	Sandy loam
Precipitation (mm/year)	607	553	920	760



4 long-term monitoring sites


M42


N34

E21


O18

Methods

Weekly time-integrated water samples

1-y samples

GC/HPLC

N,P additions

1

Algal growth inhibition tests (OECD 2006)

Data base

Analyse long-term data (10 y)

Identify peak $\sum Tu_{algae}$ events

Reconstitute mixtures

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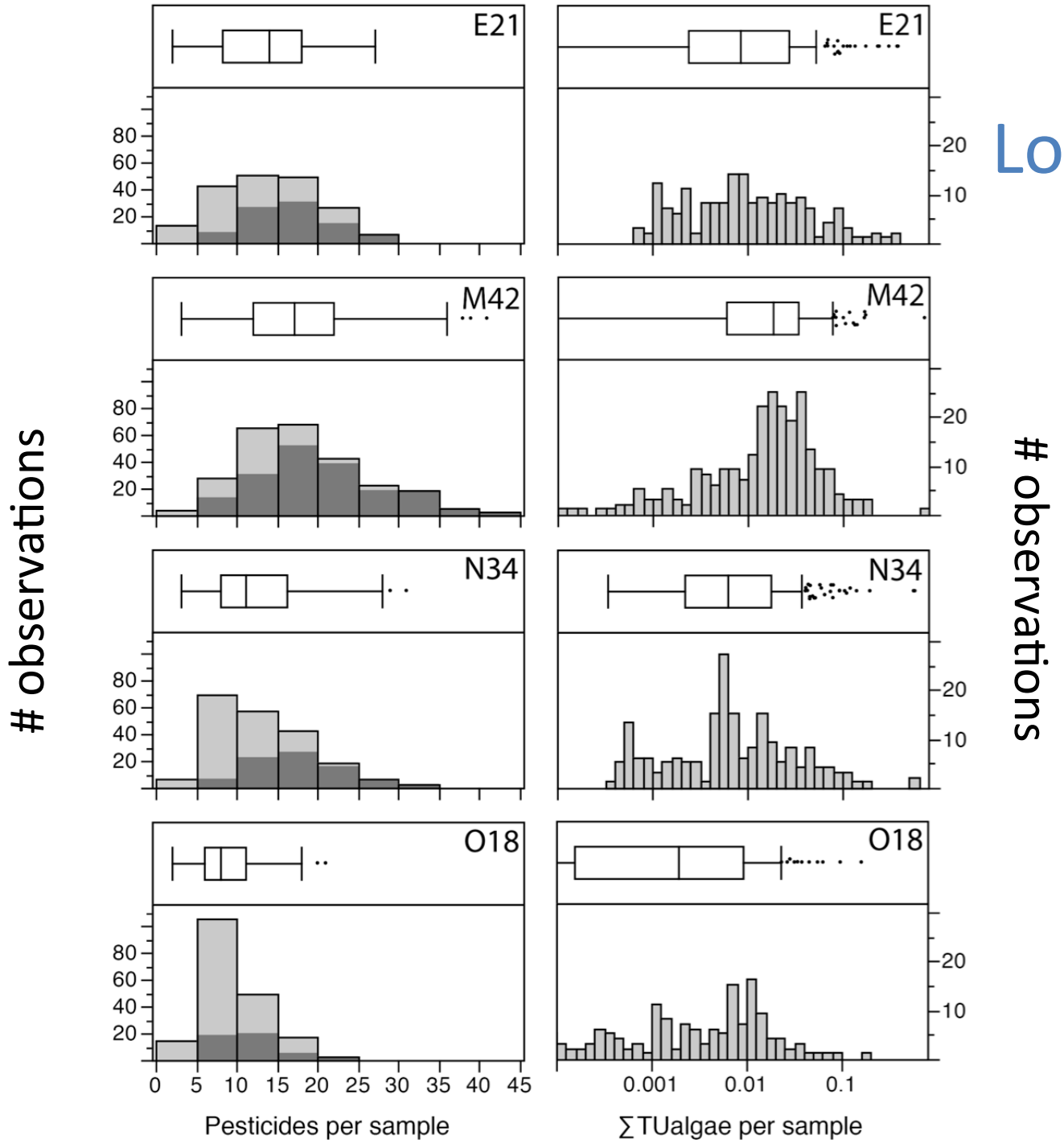
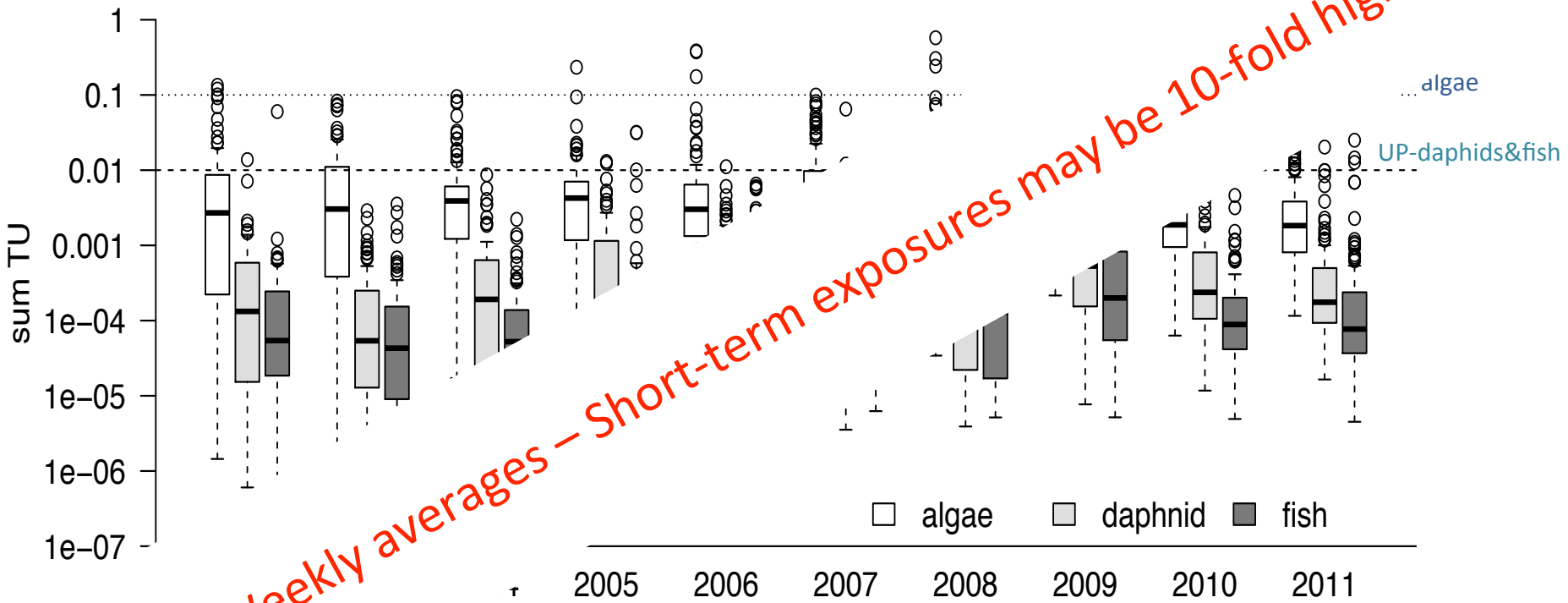
Long-term data



Long-term ∑TU



NB! Weekly averages – Short-term exposures may be 10-fold higher!

See Bundschuh, Goedkoop, Kreuger 2014, Science of the Total Environment 484: 84–91.

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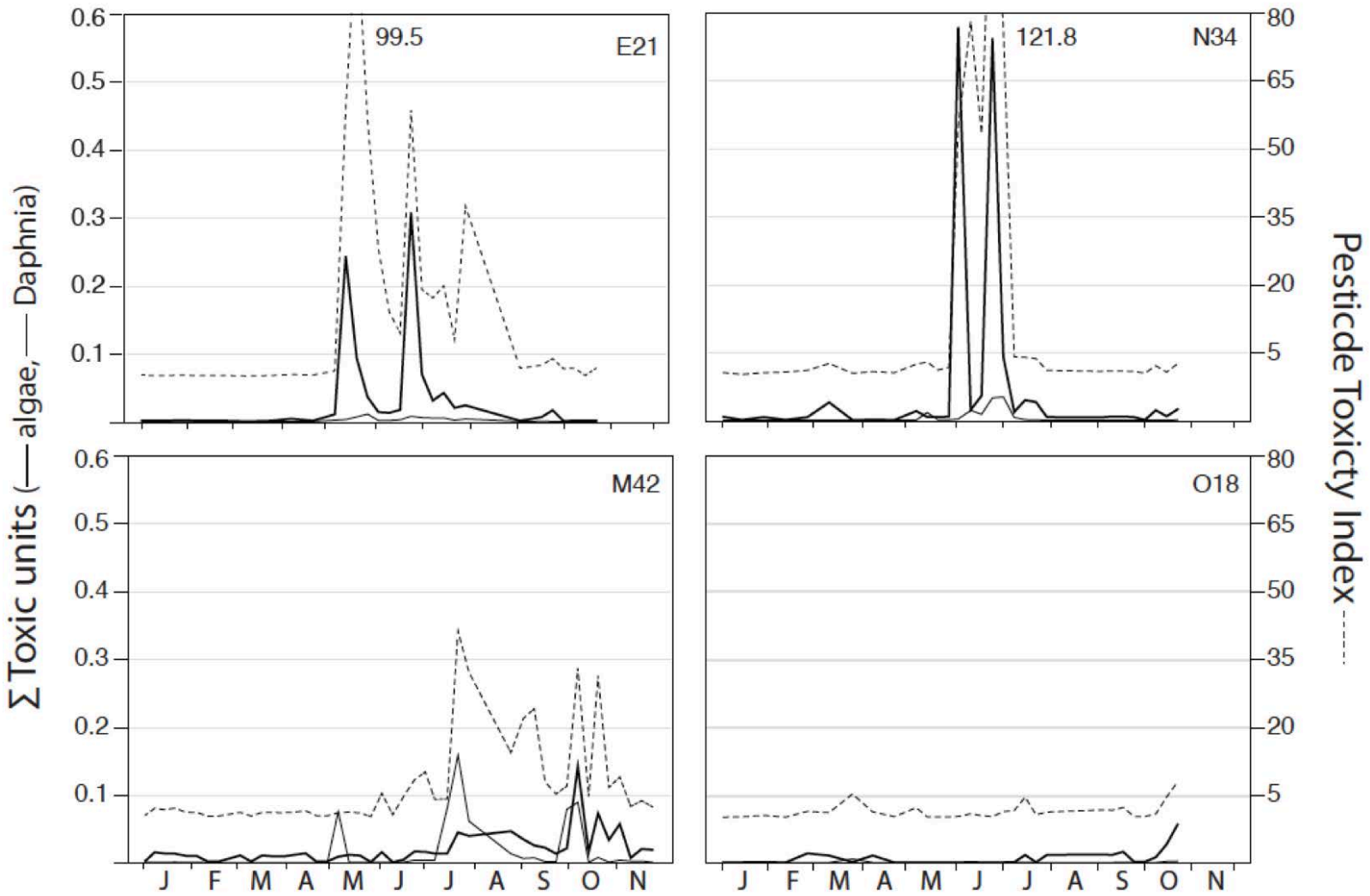
1

Seasonal study – *in situ* water



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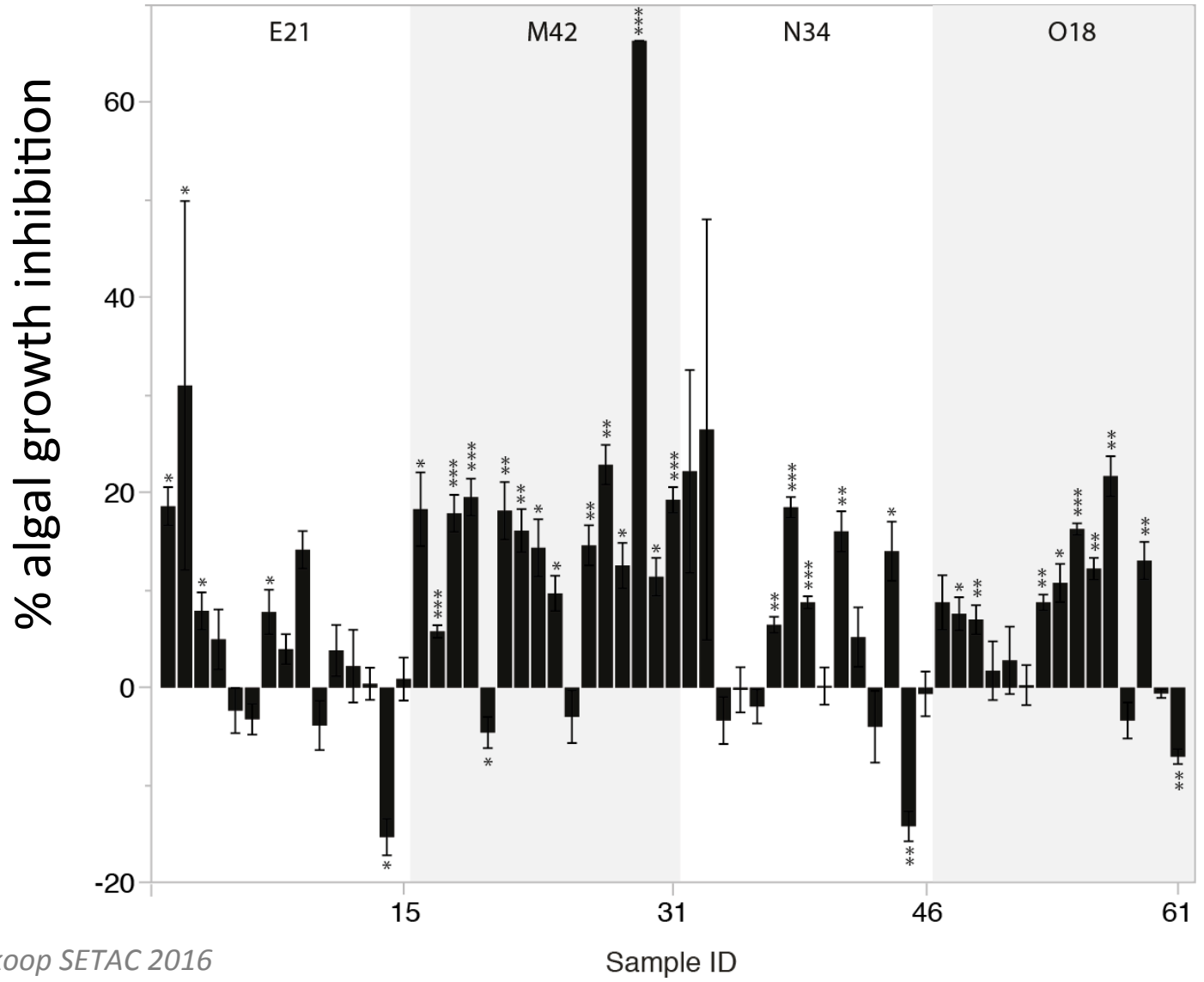
Seasonal study – *in situ* water



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Peak ∑TU mixtures in long-term data

Mixture	*C (µg/L)*	*TU*	*TU(%)*	*Mixture*	*C (ug/L)*	*TU*	*TU(%)*
Mixture 1 M42 02-Feb-04:				*Mixture 5 E21 12-May-08:*			
Diflufenican	0.32	7.1E-1	98.2	Aclonifen	0.017*	5.9E-4	0.24
Isoproturon	0.80	1.1E-2	1.54	Cyanazine	4.4	2.2E-1	90.6
Metazachlor	0.035*	1.3E-3	0.18	Imidacloprid[1]	3.0	3.0E-4	0.12
Total	*1.2*	*0.72*		Iodosulfuronmethyl-sodium	0.10	1.4E-3	0.59
				Metazachlor	0.027*	1.0E-3	0.41
Mixture 2 E21 06-Jun-05:				Metribuzin	0.13	1.9E-2	7.64
Aclonifen	0.025*	8.6E-4	0.37	Tribenuron methyl	0.061	7.6E-4	0.31
Cyanazine	2.2	1.1E-1	47.0	*Total*	*7.7*	*0.24*	
Isoproturon	0.017*	2.4E-4	0.10				
Iodosulfuronmethyl-sodium	0.045*	6.4E-4	0.27	*Mixture 6 N34 01-Jun-08:*			
Metazachlor	0.028*	1.0E-4	0.44	Fenpropimorph[2]	0.53	3.1E-3	0.54
Metribuzin	0.84	1.2E-1	51.3	Metribuzin	4.0	5.7E-1	98.9
Metsulfuron-methyl	0.050	1.1E-3	0.47	Thifensulfuron-methyl	0.040	2.5E-3	0.44
Tribenuron methyl	0.023*	2.9E-4	0.12	*Total*	*4.6*	*0.58*	
Total	*3.2*	*0.23*					

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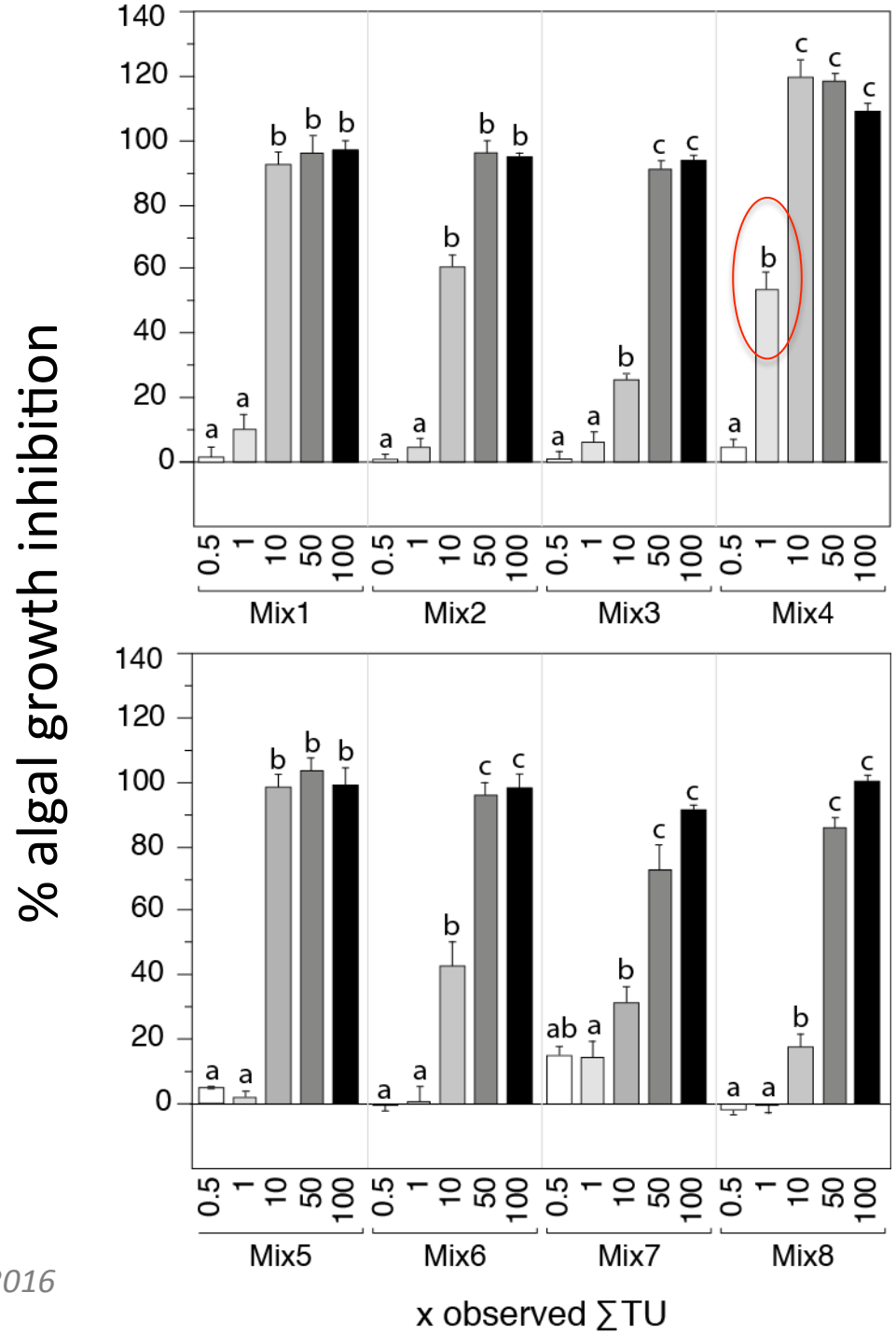
2


% algal growth inhibition
x observed ∑TU
Mix1
Mix2
Mix3
Mix4
Mix5
Mix6
Mix7
Mix8
0.5
1
10
50
100

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Conclusions (1)

- Mixture toxicity of pesticides is a common feature in Swedish agricultural streams
- Mixture toxicity is commonly set by only a few compounds
- Algae most at risk as $\sum TU_{algae}$ repeatedly exceed UP
- *In situ* water tests shows high frequency of growth inhibition, but hard to link to exposure
- Tests with reconstituted mixtures confirm inhibition occurs at 1–10 $\sum TU_{algae}$

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Seasonal field study

Monthly sampling

Taxonomic analysis

Index calculation

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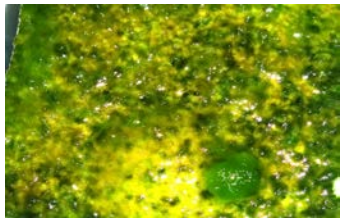

Community response	Variables	VIP	Coeff.	
Diversity	Ca	1.89	-0.14	
R^2=0.62, p=0.016	Cond.	1.66	-0.12	
	Al	1.51	0.11	
	$\Sigma TUmax_{algae}$	1.51	-0.11	← !
	PTImax	1.32	-0.10	← !
	pH	1.24	-0.09	
	Pb	1.16	0.09	
	$Flow_{max}$	1.08	0.08	
	Si	1.03	0.08	
Pollution Index (IPS)	Ca	2.06	0.03	
R^2=0.90, p<0.001	Cond.	1.58	0.15	
	Al	1.53	-0.15	
	$\Sigma TUmax_{algae}$	1.52	0.21	← ?
	Pb	1.26	-0.08	
	PTImax	1.15	0.13	← ?
	Si	1.02	-0.13	
	pH	1.02	-0.005	
Pollution tolerance (%)	Ca	1.67	-0.13	
R^2=0.62, p=0.015	PTImax	1.52	-0.12	← ?
	Cond.	1.52	-0.12	
	Si	1.32	0.10	
	$\Sigma TUmax_{algae}$	1.31	-0.10	← ?
	pH	1.27	-0.10	
	$Flow_{max}$	1.05	0.08	
	Al	1.04	0.08	

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Conclusions (2)

- Benthic algal communities indicate eutrophic conditions
- Diversity of benthic algae negatively correlated to pesticide toxicity
- Correlations with pollution metric make no sense
- Multiple stressors scenarios!
- But algae show rapid recovery, making effects likely not very long-lasting…

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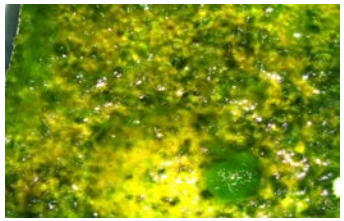
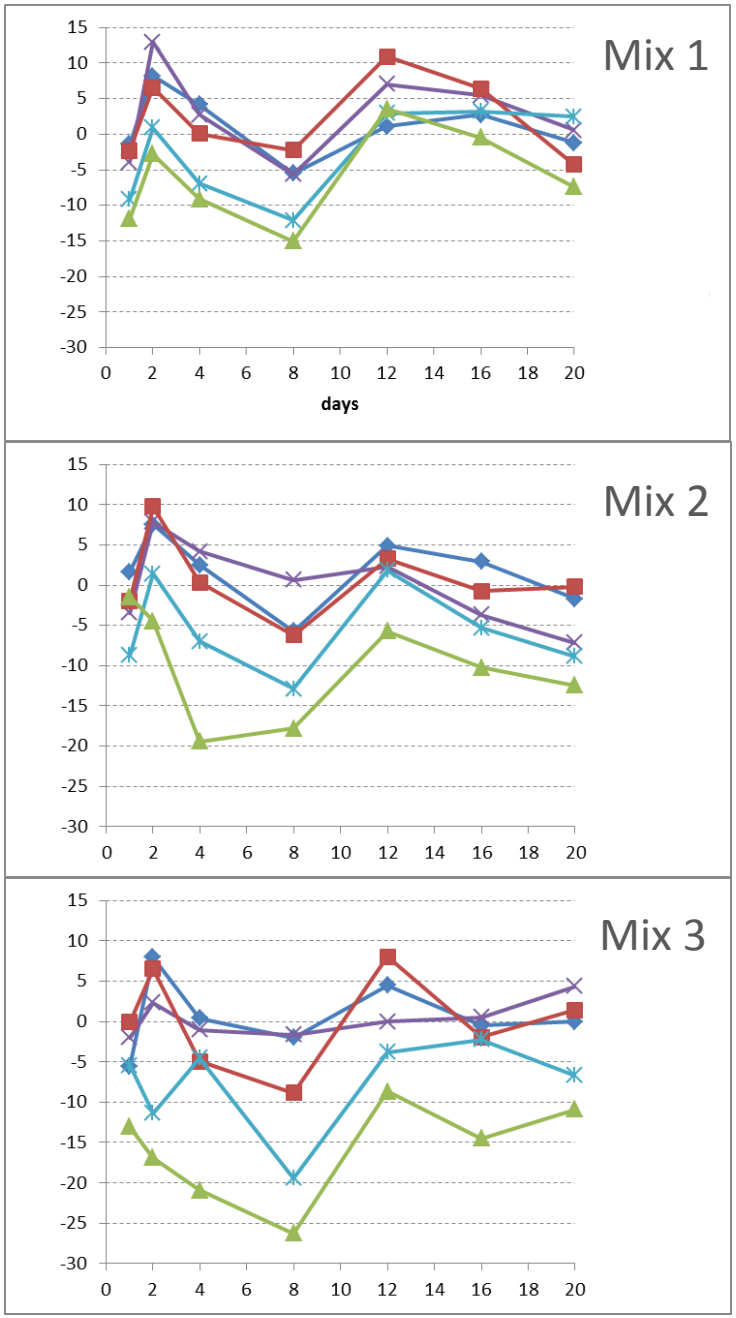


% change in photosynthesis of benthic algae



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Conclusions (3)

- Experimental evidence shows effects on photosynthesis at $\sum TU \geq 10$
- Benthic algae show rapid recovery due to short generation times,
- Therefore functional effects likely not very long-lasting

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