

Disrupting aquatic communities from bottom-up – a long-term assessment of herbicides

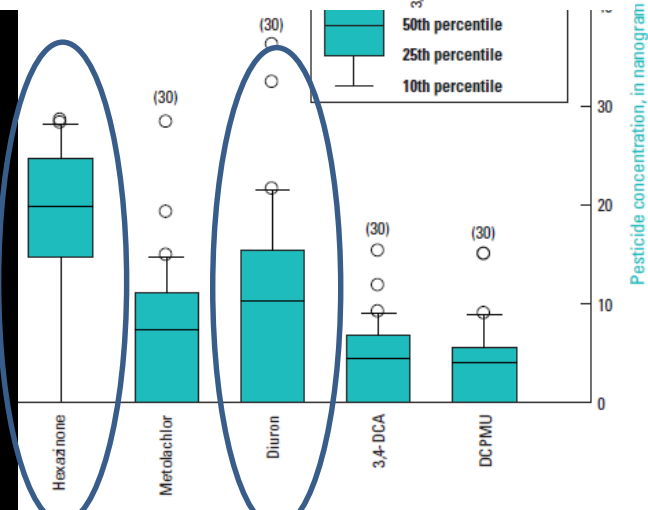
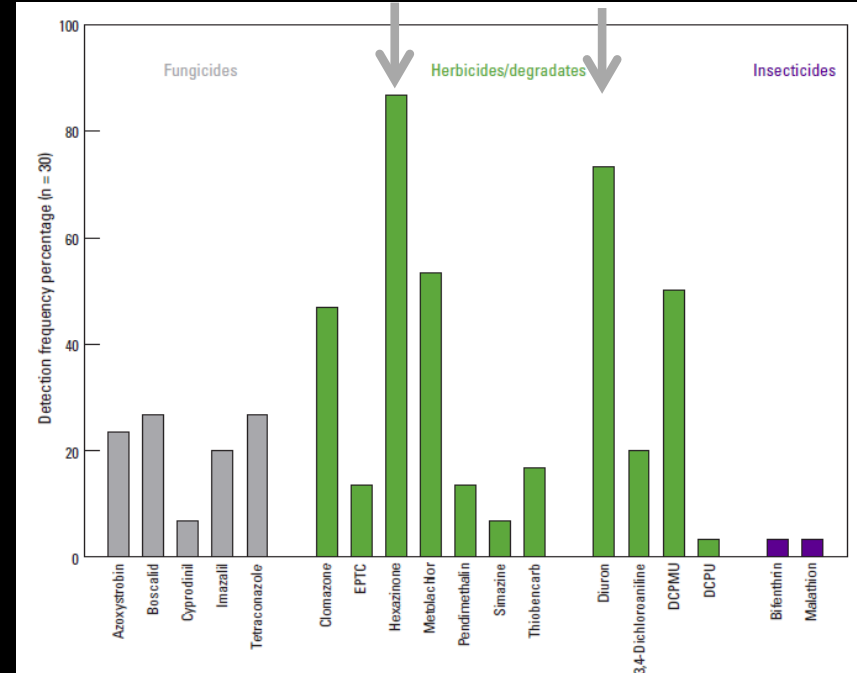
Simone Hasenbein^a, Sharon P. Lawler^b, Richard E. Connon^a

^aSchool of Veterinary Medicine, Department of Anatomy, Physiology and Cell Biology, UC Davis

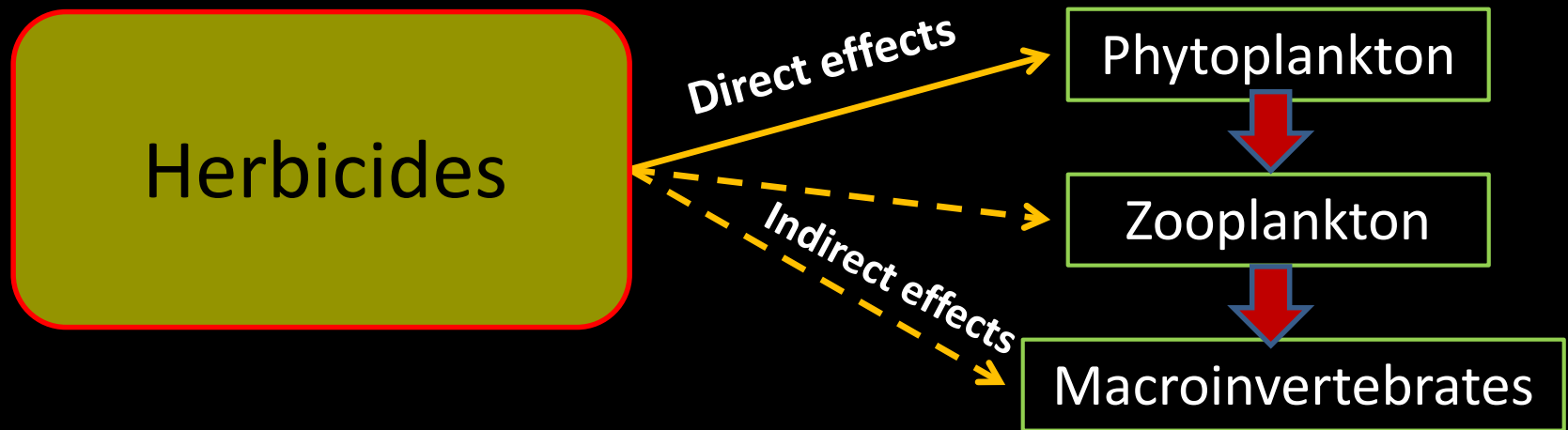
^bDepartment of Entomology and Nematology, UC Davis

Hexazinone and Diuron

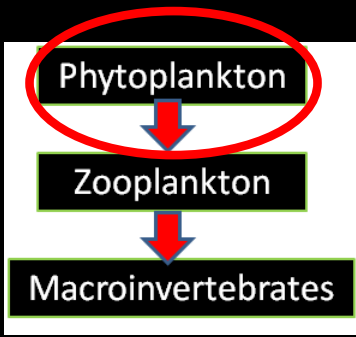
- Among the most frequently detected and with highest conc. (Fig. from Orlando et al. 2014, SSJ Delta)
- Combined application
- PS inhibitors → nonselective broad-spectrum herbicides
→ potential ecotoxicological risks to non-target plants and insects



Risk to Non-target Organisms



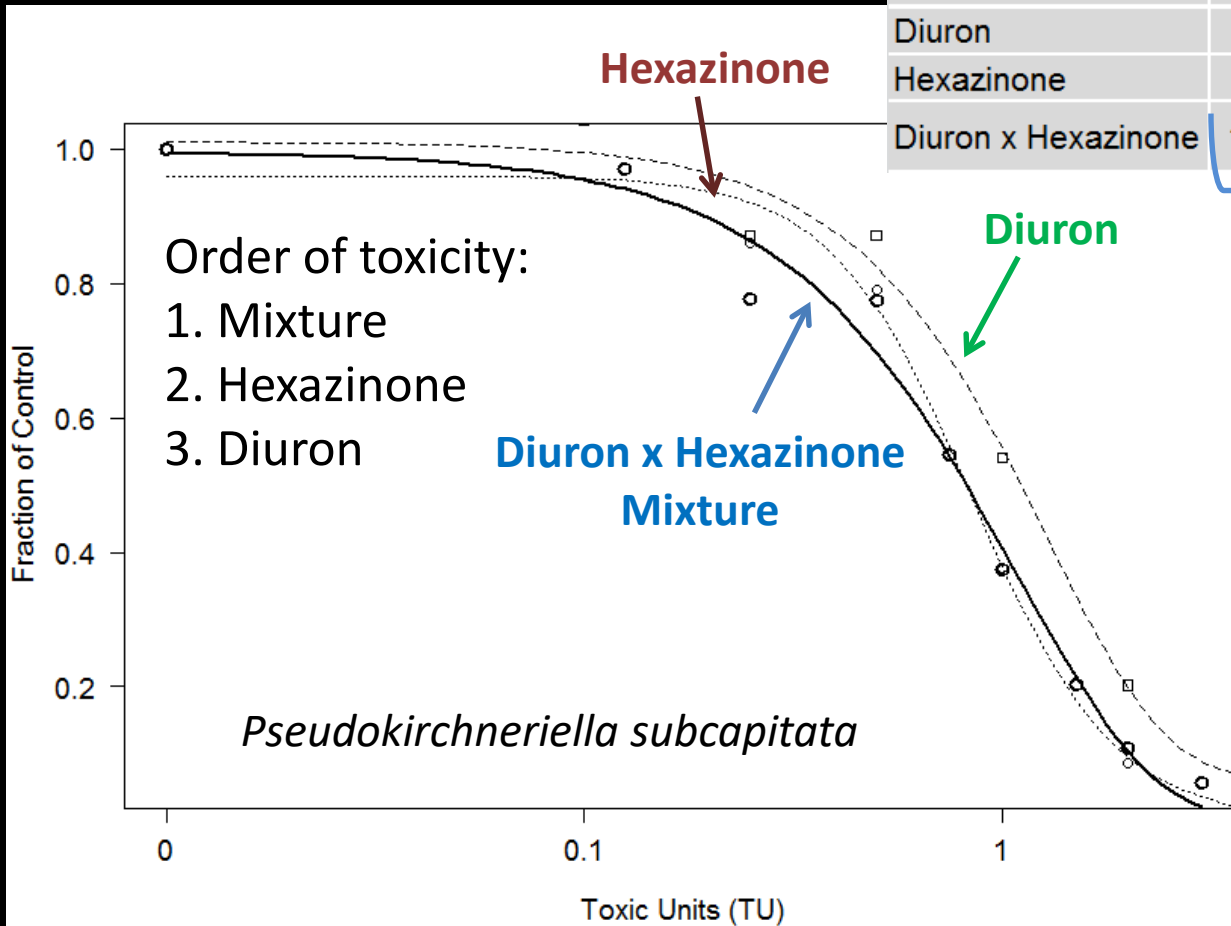
Direct applications may result in direct toxicity to non-target plants and animals or indirect effects due to the death and decomposition of plants.



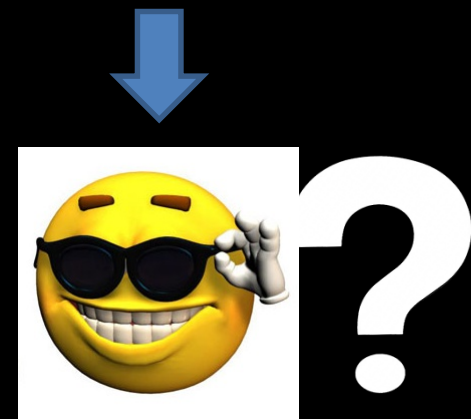
96h Phytoplankton Growth Inhibition



Concentration (µg/L)	EC10	EC50	EC90
Diuron	1.64	5.46	18.2
Hexazinone	0.74	1.81	4.45
Diuron x Hexazinone	1.09 x 0.55	2.99 x 1.16	4.89 x 1.67



Env. Rel. Conc.:
 $< 1 \mu\text{g/L}$



Mesocosm

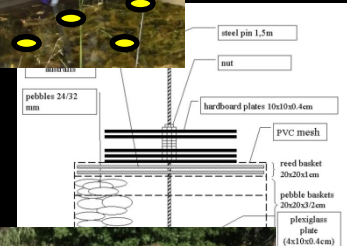
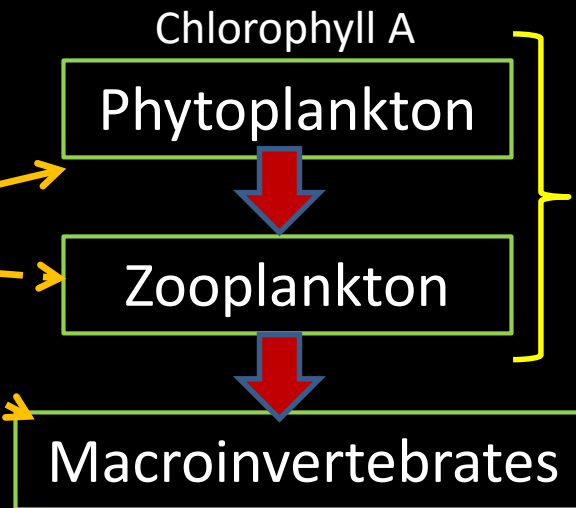


ENVIRONMENT:

Treatments (ng/L)	Control	Low	High
Diuron	0	10	1090
x Hexazinone	0	40	550

=EC10 Lab Test

Application
Days: 0, 2, 7,
14, 28

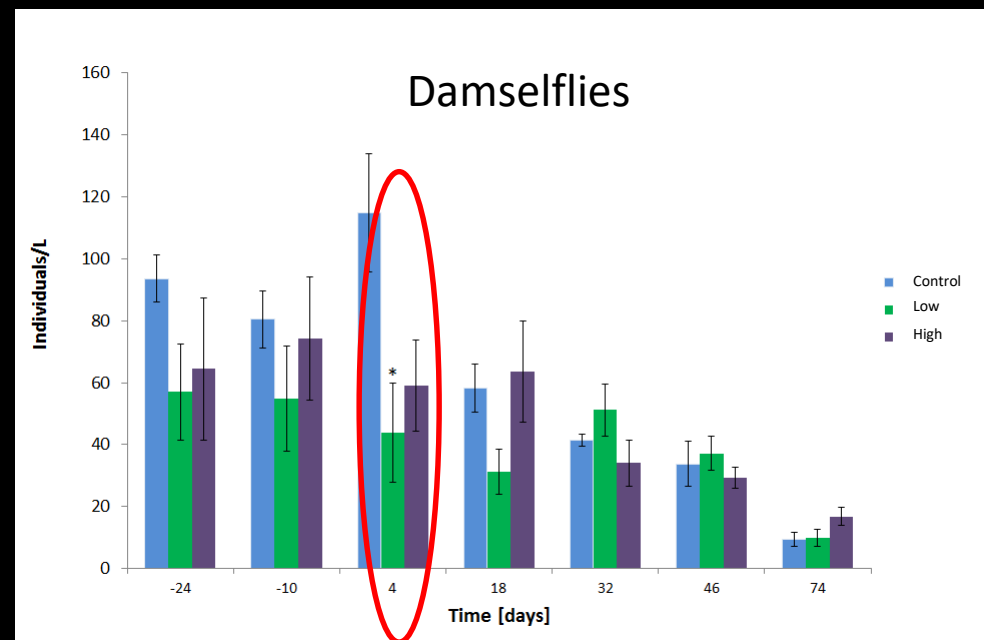
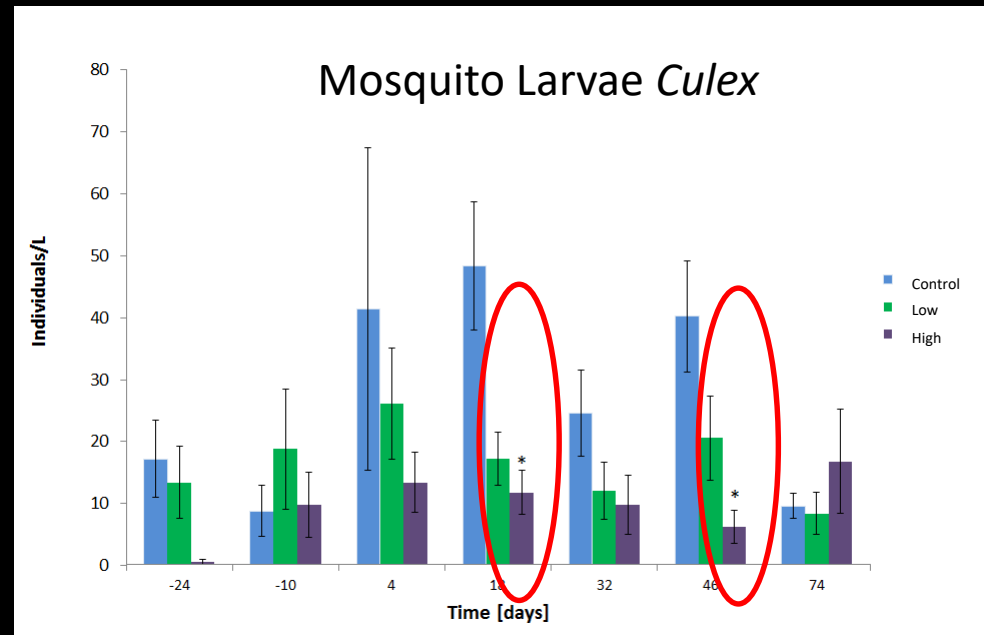


Phytoplankton

Zooplankton

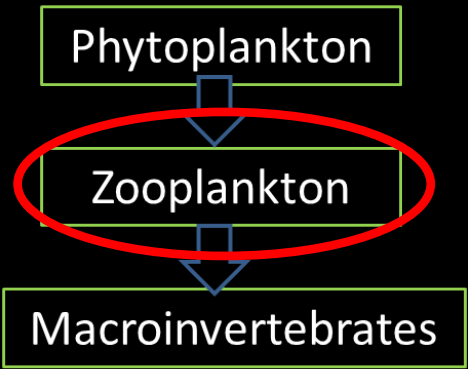
Macroinvertebrates

Application
Days: 0, 2, 7,
14, 28



Treatments (ng/L)	Control	Low	High
Diuron	0	10	1090
x			
Hexazinone	0	40	550

* = One-way ANOVA, Dunnett's test ($P < 0.05$)



Copepods



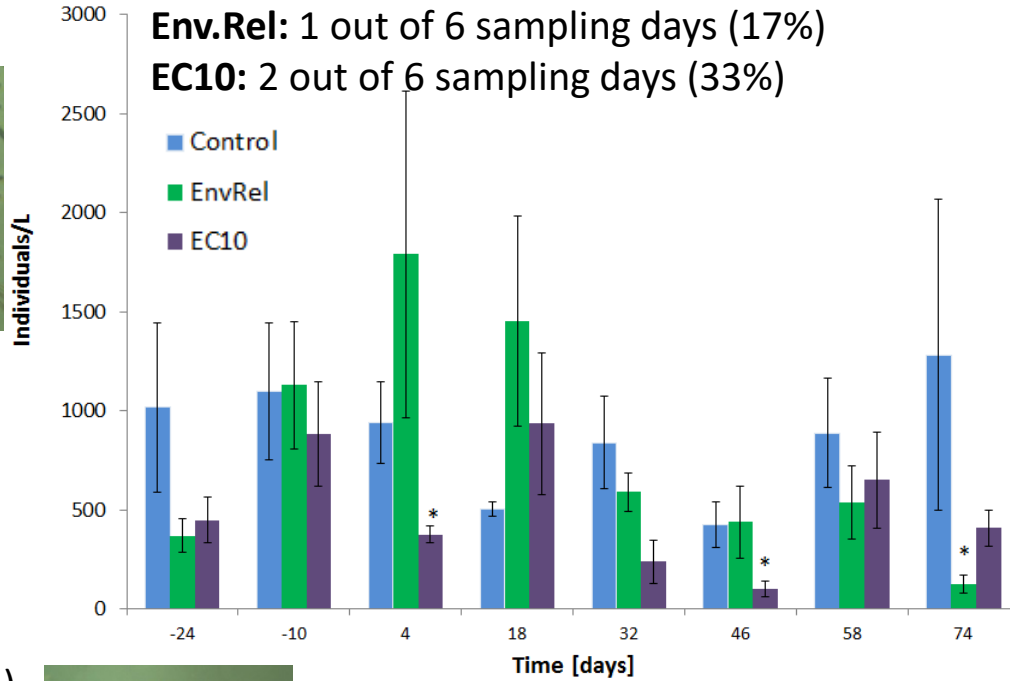
Application
Days: 0, 2, 7,
14, 28

Daphnia magna

Significant effects:

Env.Rel: 1 out of 6 sampling days (17%)

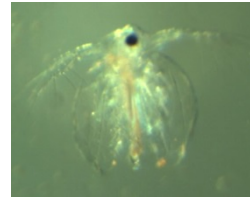
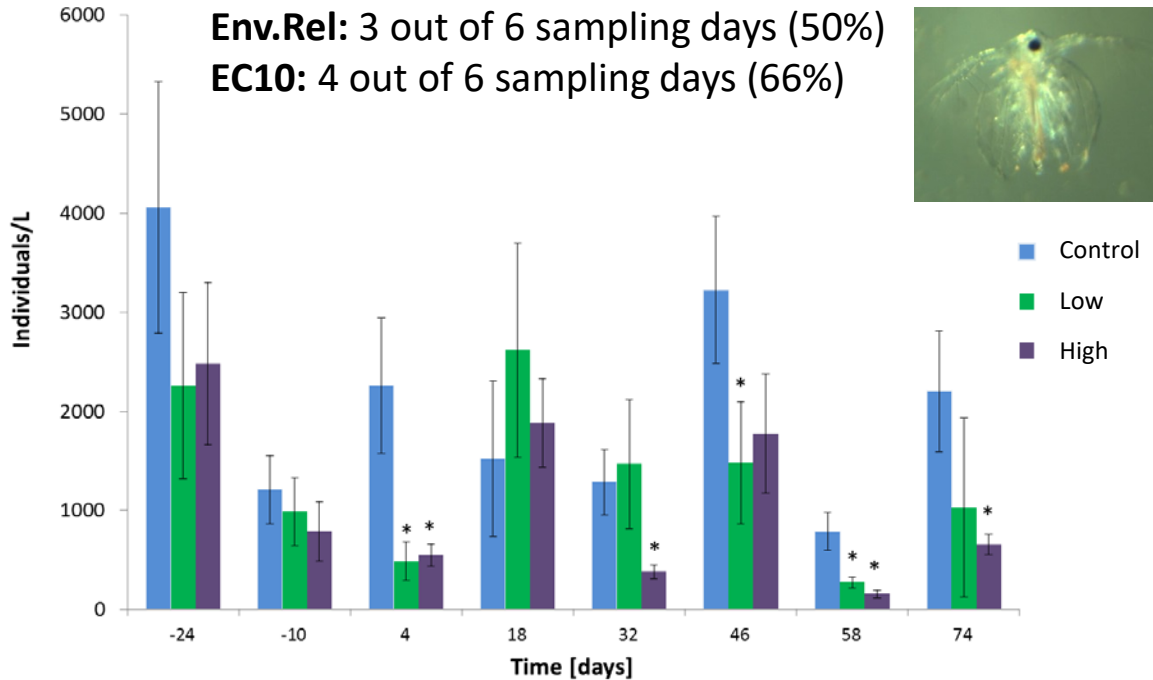
EC10: 2 out of 6 sampling days (33%)



Significant effects:

Env.Rel: 3 out of 6 sampling days (50%)

EC10: 4 out of 6 sampling days (66%)



Treatments (ng/L)	Control	Low	High
Diuron	0	10	1090
x Hexazinone	0	40	550

* = One-way ANOVA, Dunnett's test (P < 0.05)

Phytoplankton

Zooplankton

Macroinvertebrates

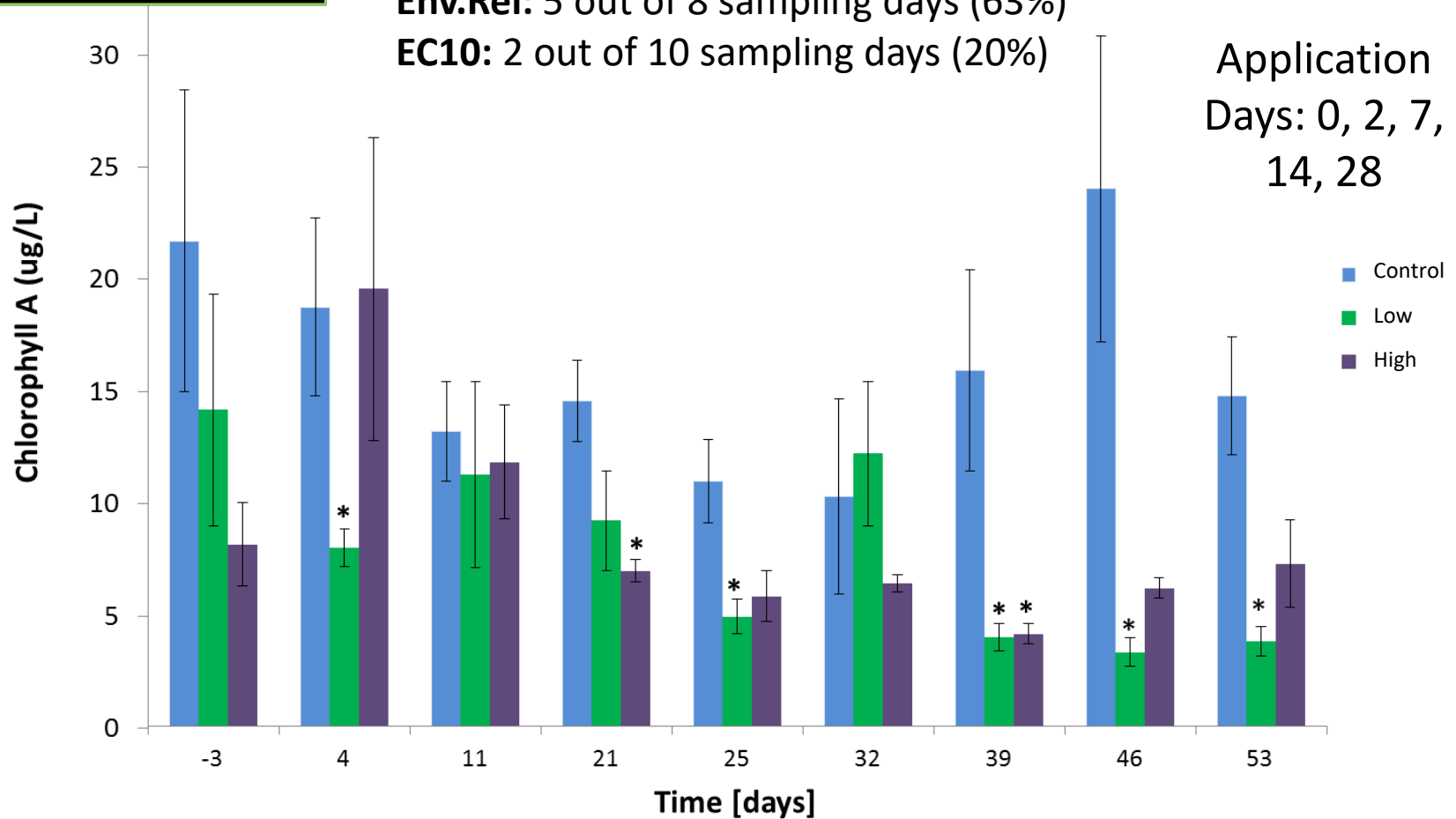
Treatments (ng/L)	Control	Env.Rel.	EC10
Diuron	0	10	1090
Hexazinone	0	40	550

Significant effects:

Env.Rel: 5 out of 8 sampling days (63%)

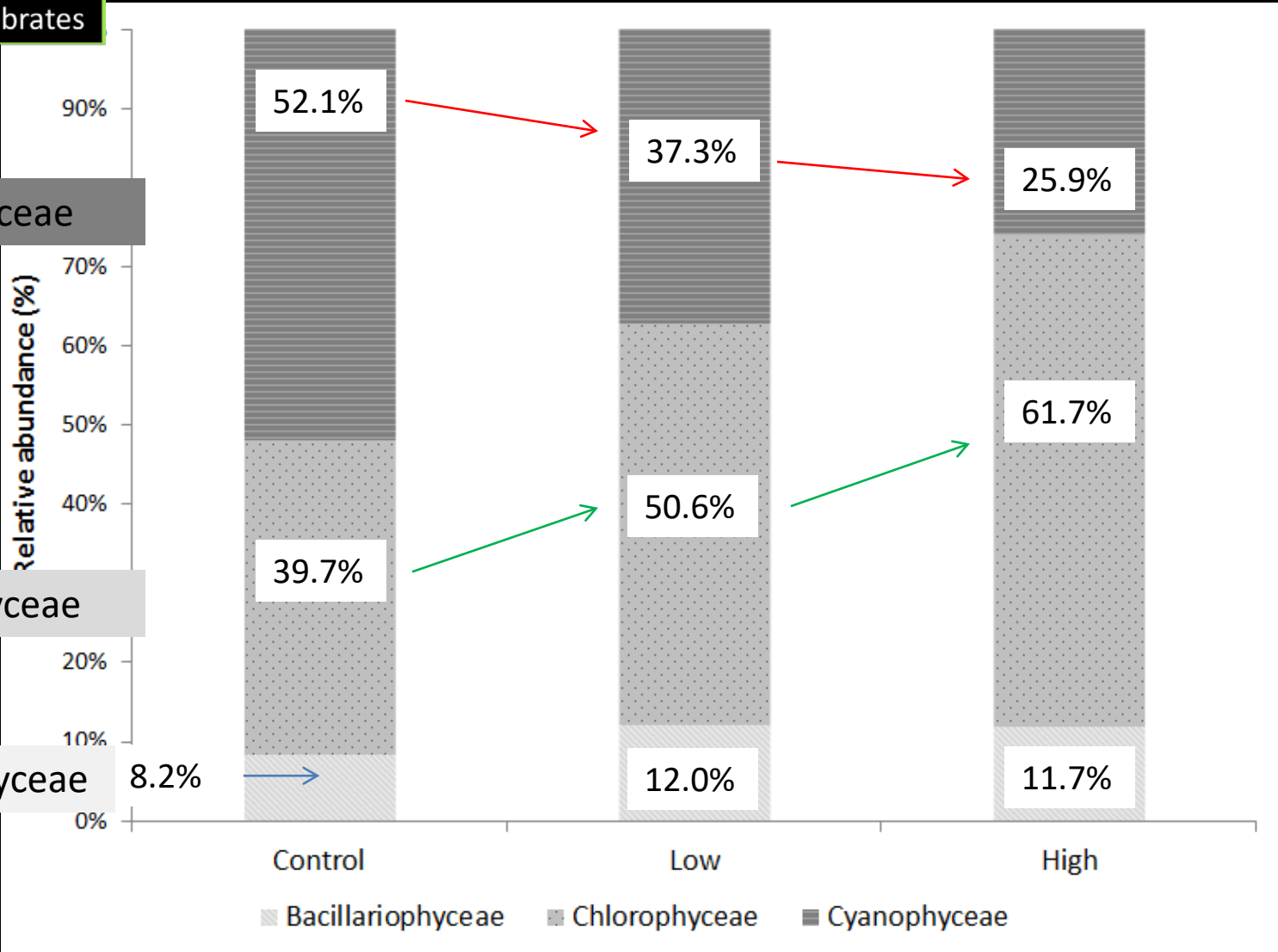
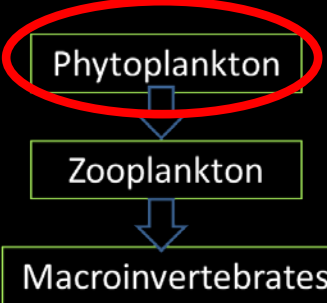
EC10: 2 out of 10 sampling days (20%)

Application
Days: 0, 2, 7,
14, 28



* = One-way ANOVA, Dunnett's test (P < 0.05)

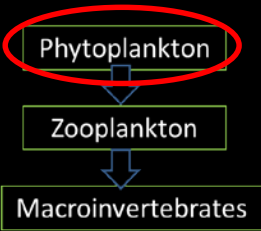
Relative Abundance Orders



Cyanophyceae

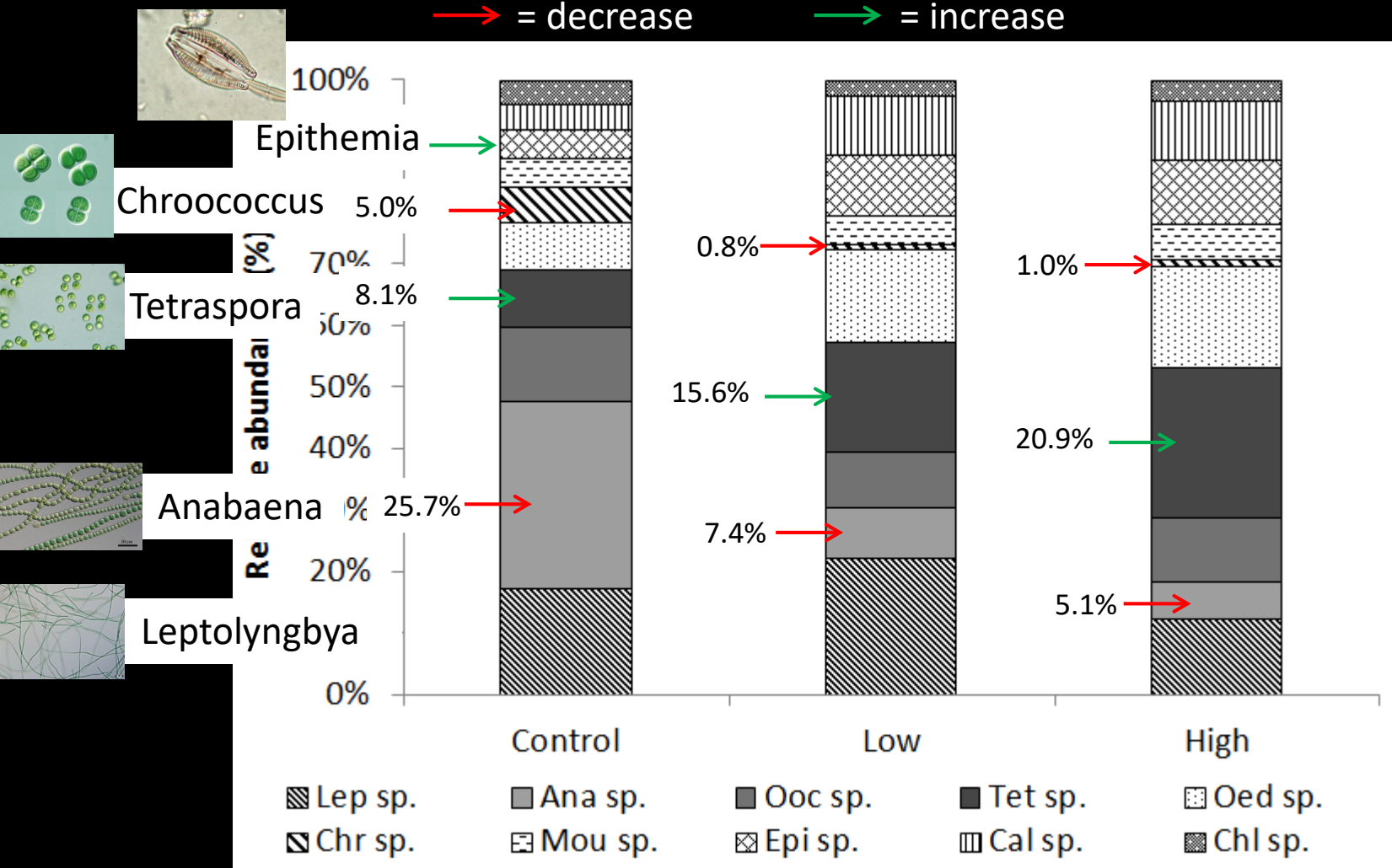
Chlorophyceae

Bacillariophyceae



Relative Abundance 'Top 10'

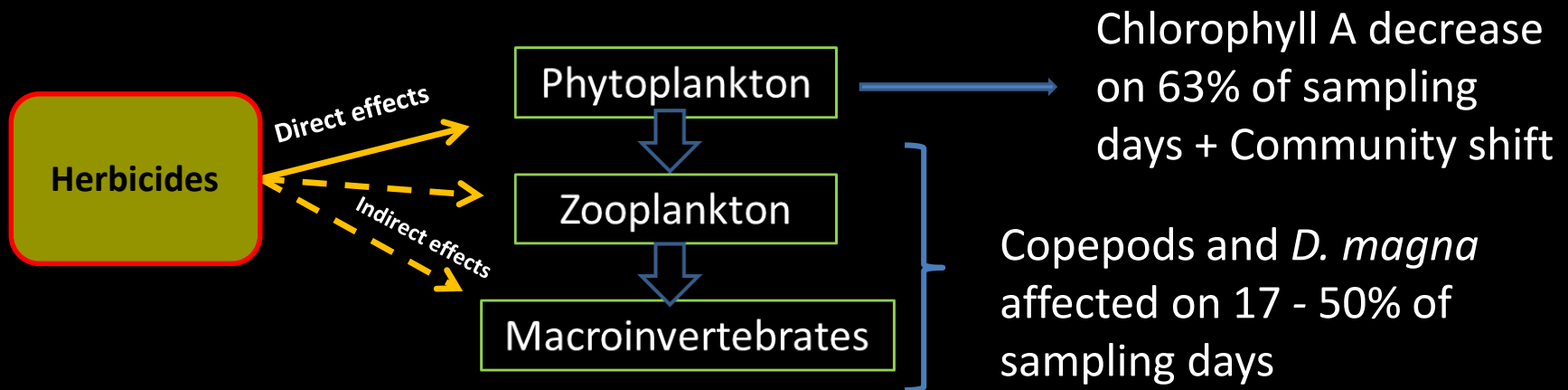
→ = decrease → = increase



Lep sp. = *Leptolyngbya* sp., Ana sp. = *Anabaena* sp., Ooc sp. = *Oocystis* sp., Tet sp. = *Tetraspora* sp., Oed sp. = *Oedogonium* sp., Chr sp. = *Chroococcus* sp., Mou sp. = *Mougeotia* sp., Epi sp. = *Epithemia* sp., Cal sp. = *Calothrix* sp., Chl sp. = *Chlorella* sp.

What does this mean for aquatic ecosystems?

Mixtures of Diuron and Hexazinone → synergistic effects on algae species



Implications for Ecosystems

Water
diversion

Wetland
loss

Larval Fish

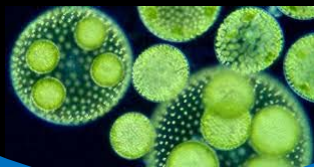


Feed on



Introduced
species

Contaminants



Current and Future Work

Effects of binary mixtures of herbicides and insecticides

- Insecticides: Sublethal effects below LOD (Hasenbein et al. 2015)
- Impairments more pronounced in mixtures → additive or synergistic effects (Belden and Lydy 2000)



Acknowledgments



- Michelle Hladik, USGS
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Thank you!!

Questions?

