Aquatic effects and risk assessment of pesticides:

Dutch approaches to meet the requirements of the PPP Regulation and the European Water Framework Directive

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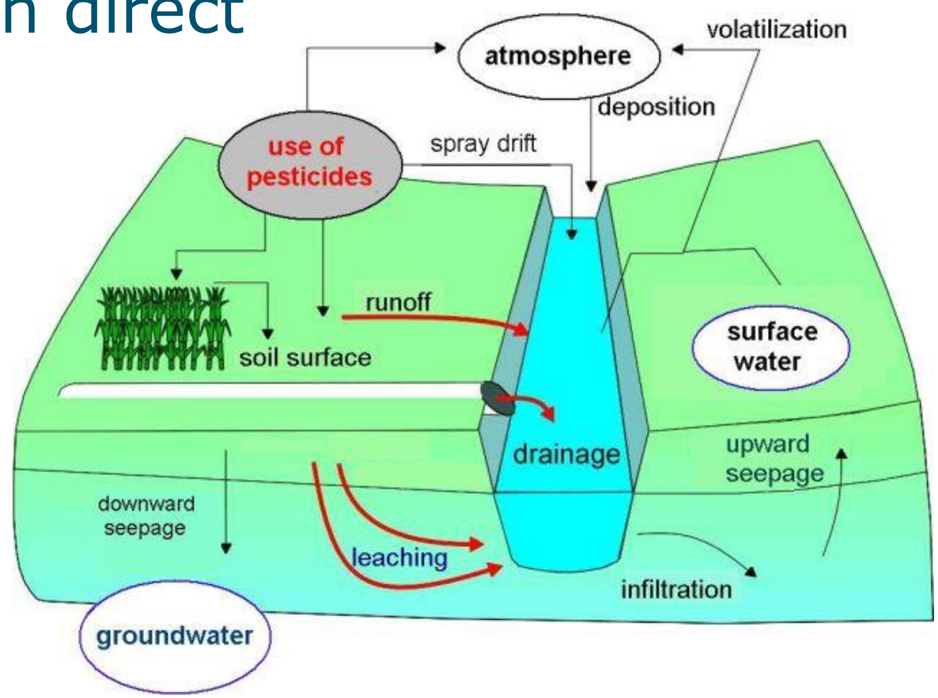
Theo C.M. Brock

Surface water and pesticides in the Netherlands

- Netherlands situated in a delta area of the rivers Rhine, Scheldt, Ems and Meuse
- Dense surface water network, with a relatively low rate of flow
- High agricultural activity in direct vicinity of surface waters

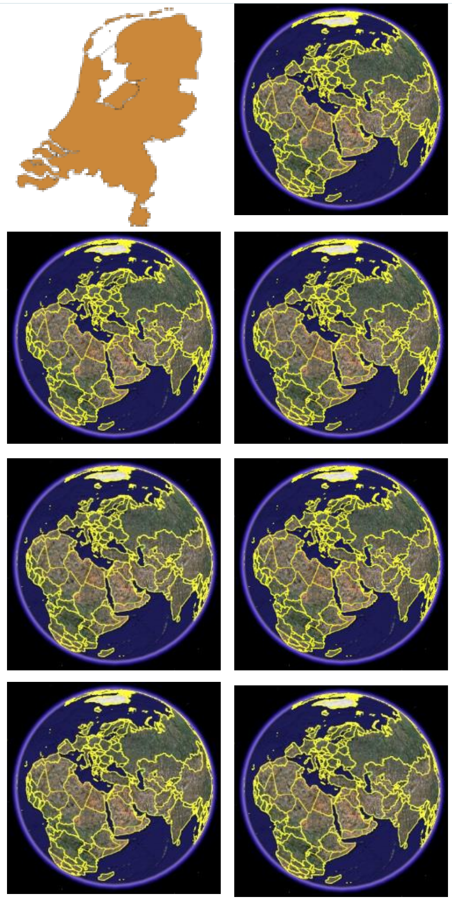
Therefore

- Vulnerability of Dutch water systems in terms of PPP emission



Quantitative data on surface water in NL

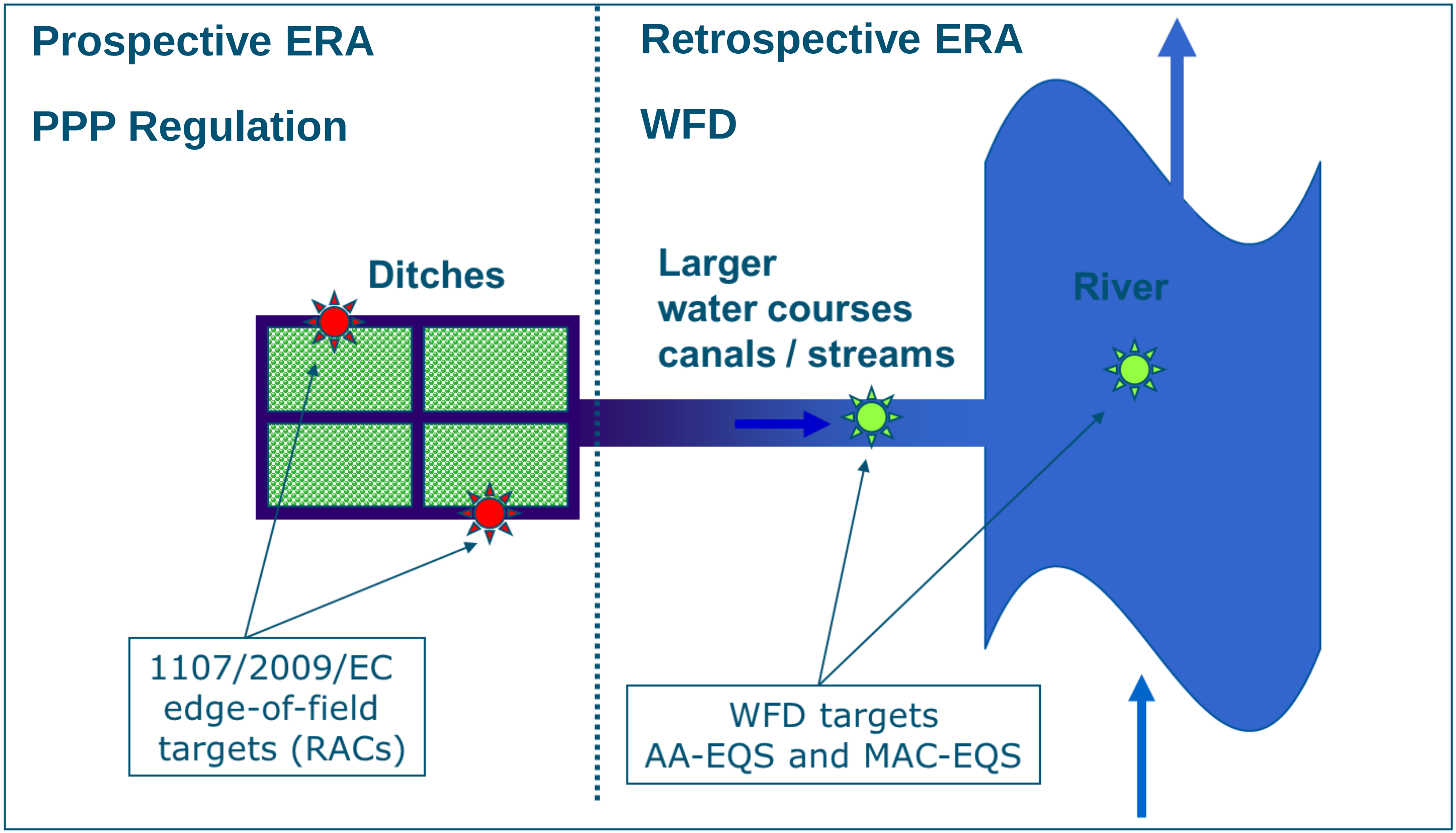
91 000 km small, temporarily dry ditches
159 000 km ditches < 3 m
56 000 km water ways > 3 m
total 300 000 km: 7 × perimeter of earth



A **crop-free buffer strip** of up to 5 m may be obligatory in NL (but wider buffer strips on many places not very realistic).

Risk mitigation measures: buffer strips, drift-reducing techniques (nozzles), screens and vegetation to reduce drift etc.

Dutch policy model (risks aquatic organisms)



Two connected spatial targets (domains) in the water system

Spatial differentiation in compliance to different EU requirements

Post-registration feedback mechanism

Comparison PPP Regulation and WFD

PPP Regulation

- Prospective ERA for PPPs (a.s. and formulations)
- Field exposure predicted
- Emissions based on GAP
- Effects: Following SANCO/EFSA guidance
- Tiered approach (*e.g. SSDs mesocosms, models*)
- Tests with standard test species as data requirement
- Recovery of effects may be considered (ERO-RAC) under strictly defined conditions

WFD

- Retrospective ERA all chemicals
- Field exposure measured
- All emission routes
- Effects: Guidance EC Technical Report 2011-055
- Weight of evidence (*focus on SSDs, considering cosms*)
- Mining of dossier and open literature toxicity data
- Population recovery not considered in EQS setting

Differences may lead to different acceptable concentrations but recently effect assessment was ‘harmonised’

Examples aquatic norm concentrations in NL

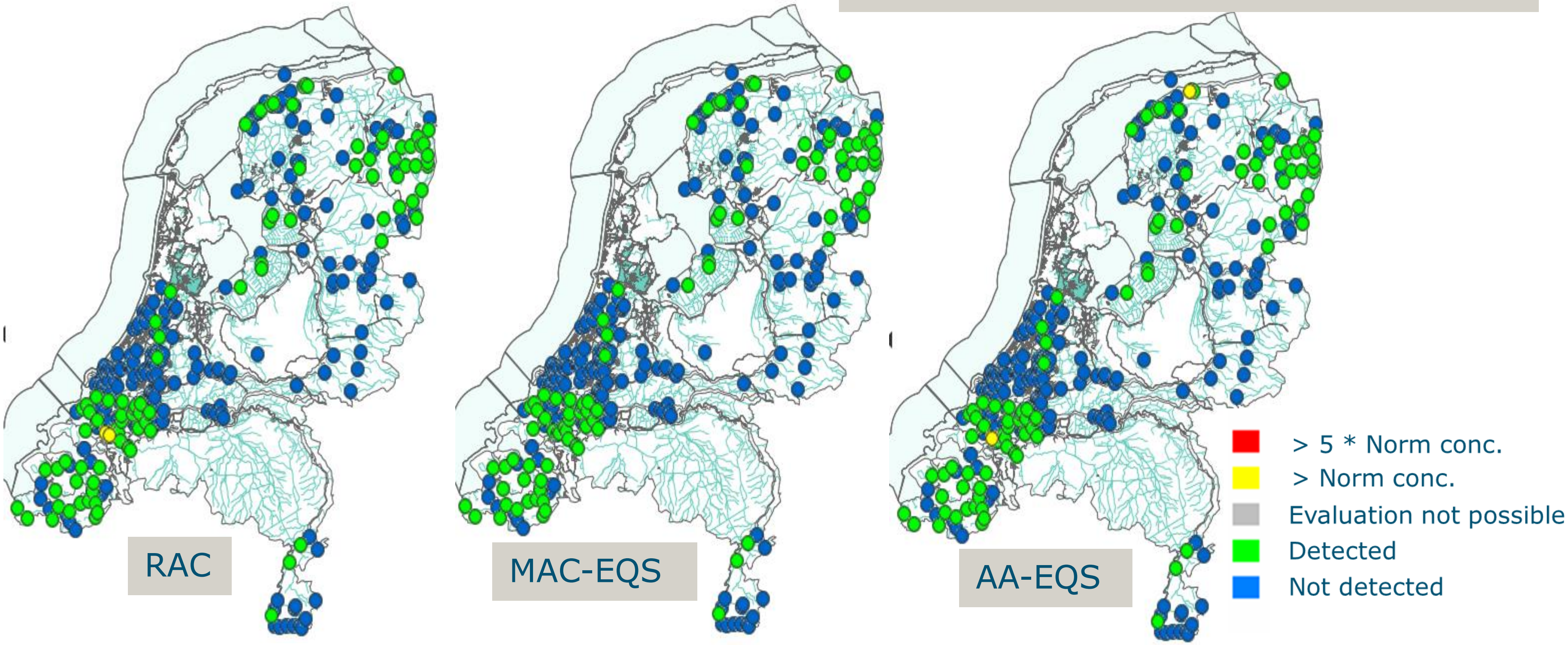
	PPP Regulation	Water Framework Directive	
	Lowest RAC (µg/L) Old guidance	MAC-EQS (µg/L) Old/new guidance	AA-EQS (µg/L) Old/new guidance
Herbicides			
Dimethenamide-P	2.68	1.6	0.13
Metribuzin	0.79	1.1	0.12
Metsulfuron-methyl	0.036	0.03	0.01
Insecticides			
Abamectin	0.6	0.018	0.001
Lambda-cyhalothrin	0.01	0.00047	0.00002
Imidacloprid	1.27	0.2	0.067
Fungicides			
Carbendazim	0.19	0.6	0.6
Cyprodinil	6.5	0.46	0.16
Tebuconazole	1	14	0.63

AA-EQS values usually are lower (particularly for insecticides)

In risk assessment the different norm concentrations are linked differently to exposure estimates !

Chemical monitoring metribuzin (2012)

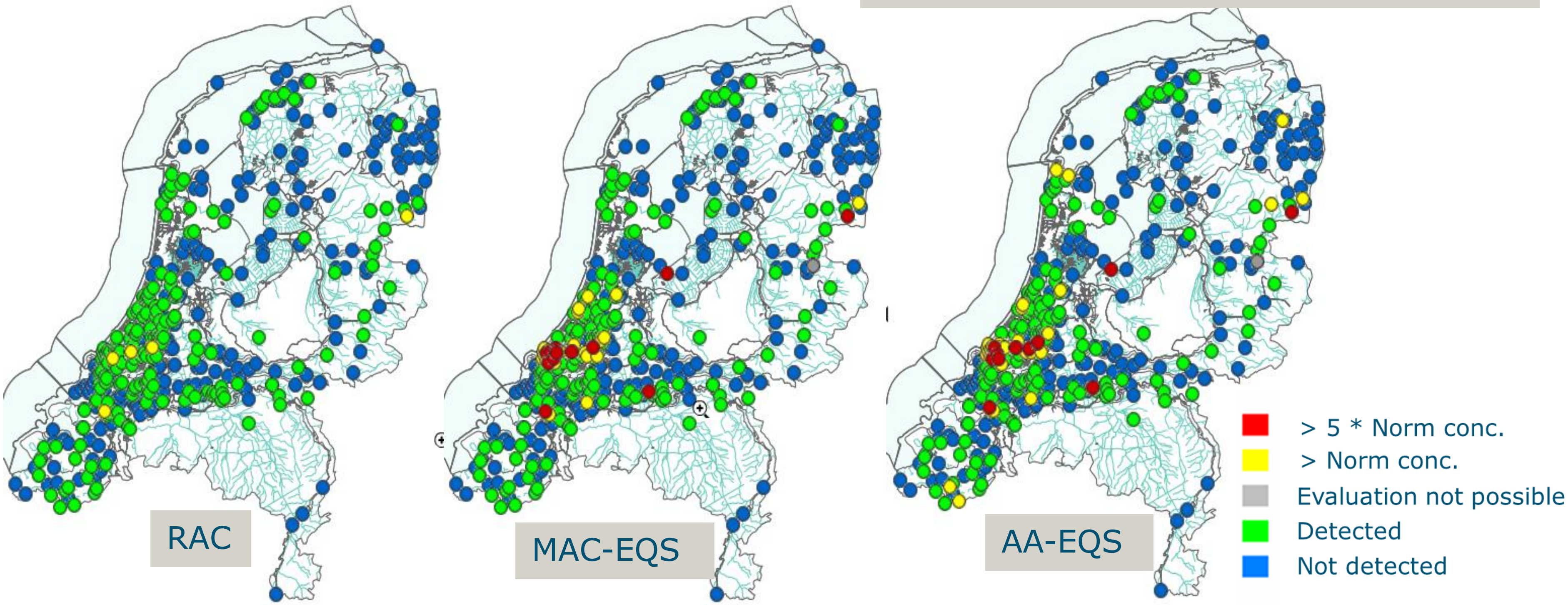
www.bestrijdingsmiddelenatlas.nl (CML, 2014)



The herbicide metribuzin hardly exceeds the current RAC (0.79 µg/L), MAC-EQS (1.1 µg/L) and AA-EQS (0.12 µg/L)

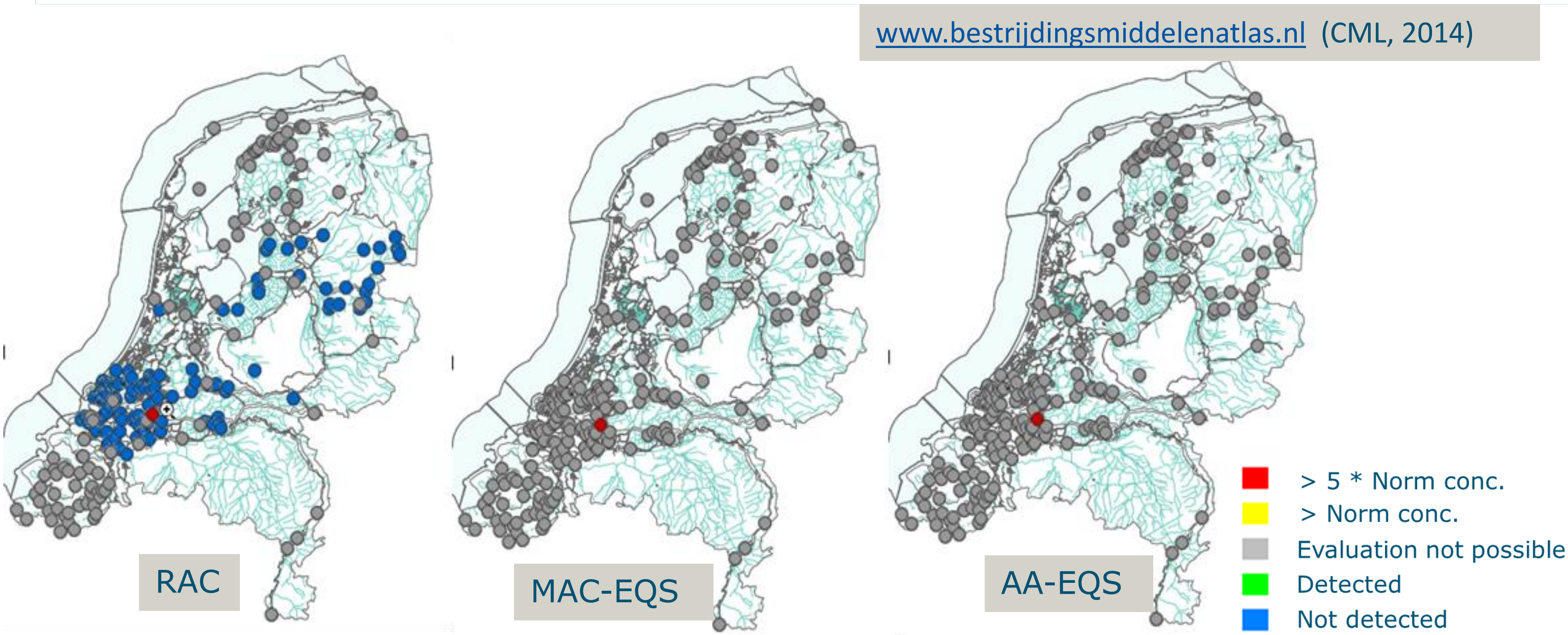
Chemical monitoring imidacloprid (2012)

www.bestrijdingsmiddelenatlas.nl (CML, 2014)



The insecticide imidacloprid exceeds on several locations the current RAC (1.27 ng/L), MAC-EQS (0.2 µg/L) and AA-EQS (0.067 µg/L)

Chemical monitoring lambda-cyhalothrin (2012)



The insecticide lambda-cyhalothrin exceeds on one location the current RAC (10 ng/L), MAC-EQS (0.47 ng/L) and AA-EQS (0.02 ng/L)

However, the norm concentrations are lower than the concentrations that trustfully can be measured in monitoring programmes

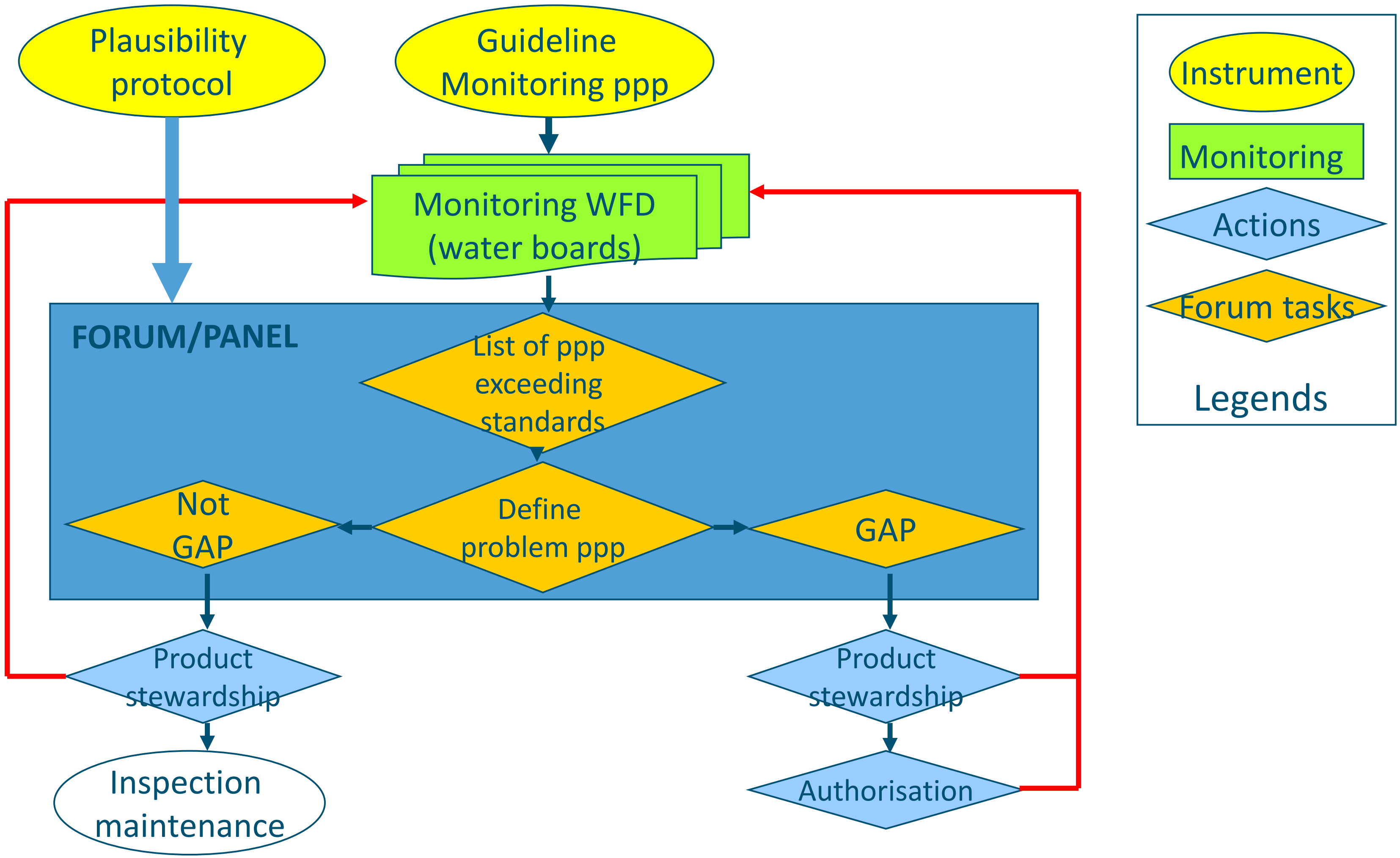
Top 10 PPPs exceeding norm conc. in 2004 - 2012

	AA-EQS or MPC (MTR)		
	2004	**2009**	**2012**
1	imidacloprid	captan	methiocarb
2	fenamifos	Desethyl-terbtylazin	primifos-methyl
3	aldicarbsulfoxide	imidacloprid	teflubenzuron
4	ETU	triflumuron	imidacloprid
5	primifos-methyl	dicofol	thiacloprid
6	chlorpyrifos	omethoaat	abamectin
7	abamectin	phorate	esfenvalerate
8	carbendazim	captafol	DDT, 44
9	cypermethrin	fipronil	spiromesifen
10	aclonifen	pyraclostrobin	dimethenamide-P

In different years it often are different PPPs that frequently exceed norm concentrations in Dutch surface waters

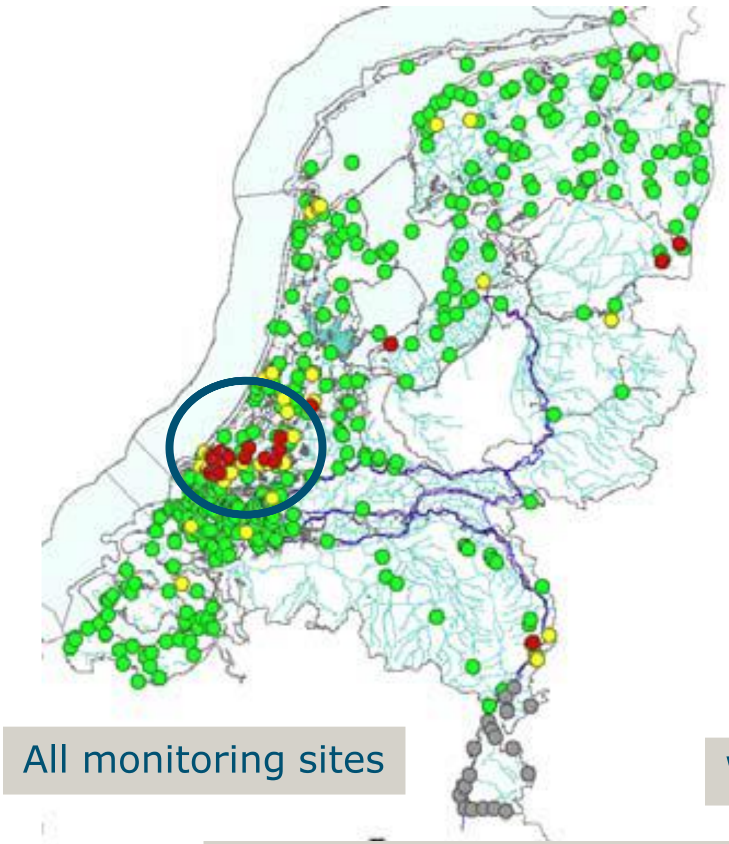
If the same PPP is identified frequently in space and time a causal analysis has to be performed

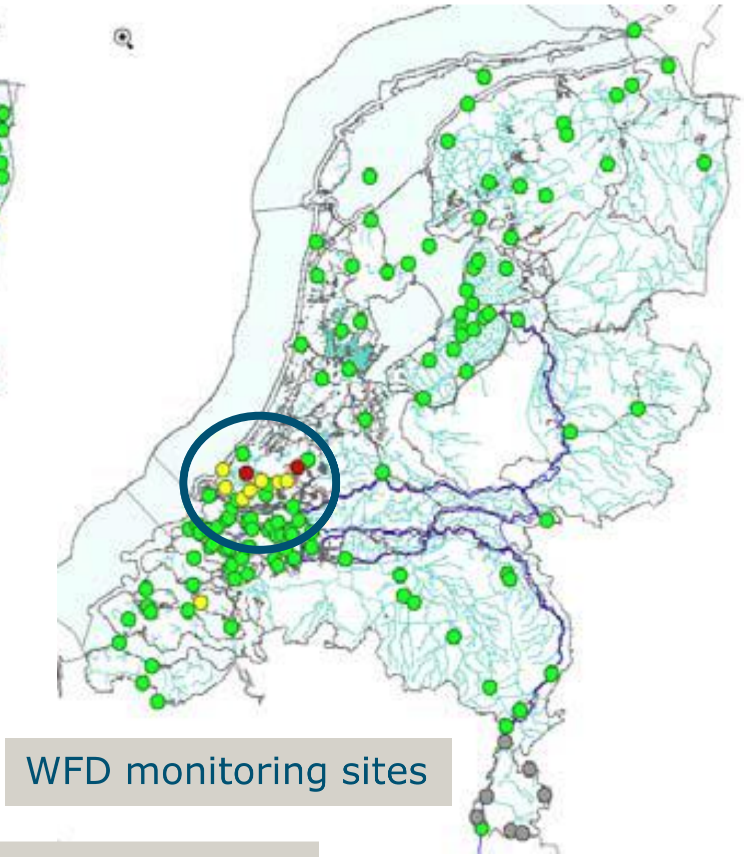
Interpretation of surface water monitoring results



De Werd & Kruijne *Eds* (2013) Interpretation of surface water monitoring results in the authorisation procedure of PPPs in the Netherlands. Applied Plant Research Report 2013-02 (Wageningen UR)

Monitoring sites with exceedance of AA-EQS concentrations for imidacloprid in 2010





www.bestrijdingsmiddelenatlas.nl (CML, 2014)

The majority of exceedances can be found in a restricted area

→ Causal analysis

Causal analysis exceedance imidacloprid norm concentration

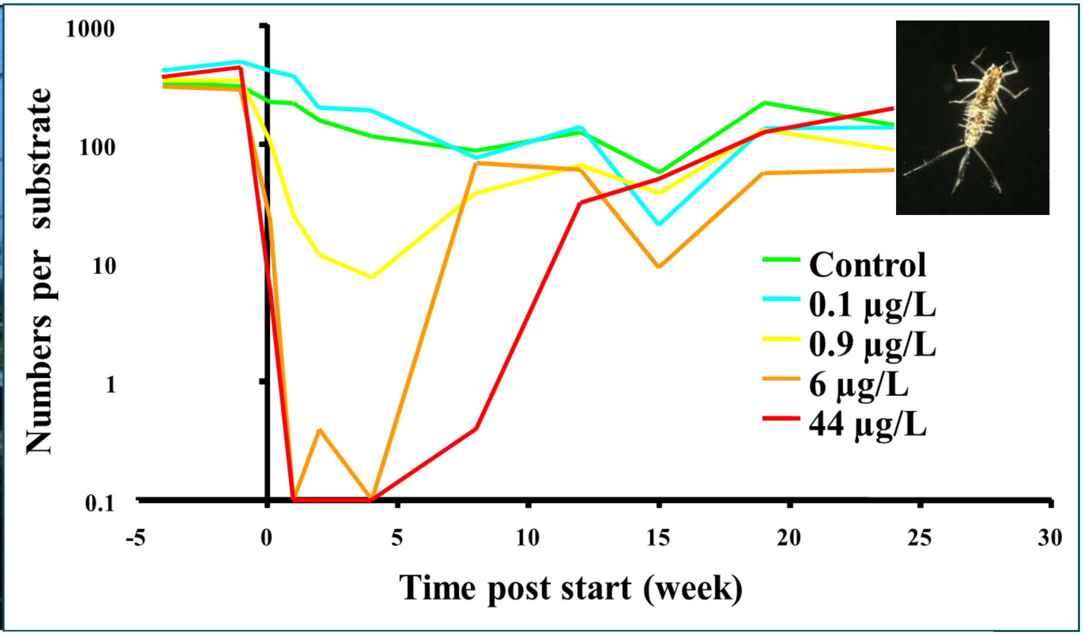
Problem area characterised by many greenhouses.

Imidacloprid is frequently used in covered crops.

- Emission of pesticides from covered crops to surface water is underestimated
- Re-registration evaluation of the authorisation
- Improving procedure of norm derivation

Are norm concentrations sufficiently protective?

Calibrating norm concentrations with mesocosms



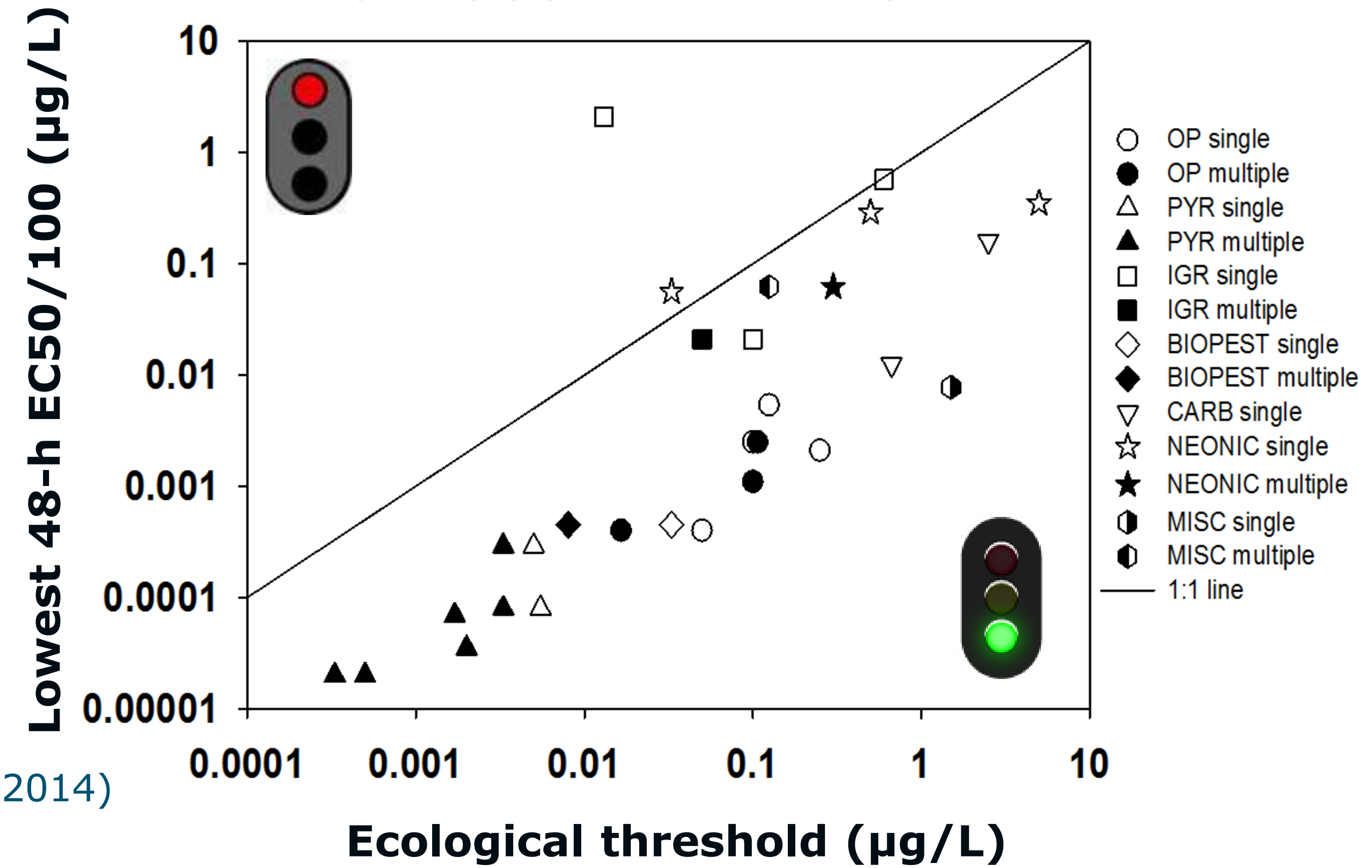
Ecological threshold concentration derived from pesticide treated micro-/mesocosm experiments

Most sensitive population-level endpoint	Assessment Factor
Effect class 1 concentration (no treatment-related effect most sensitive endpoint)	2
Effect class 2 concentration (slight effect for most sensitive endpoint on isolated sampling)	3

EFSA PPR (2013)

Standard test species - AF approach

Individual insecticides !



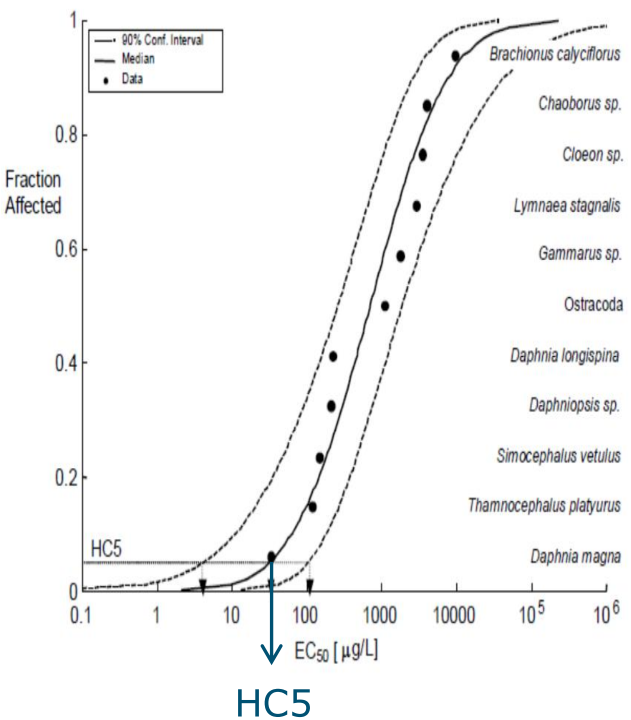
Van Wijngaarden et al (2014)
: *Pest Man Sci*

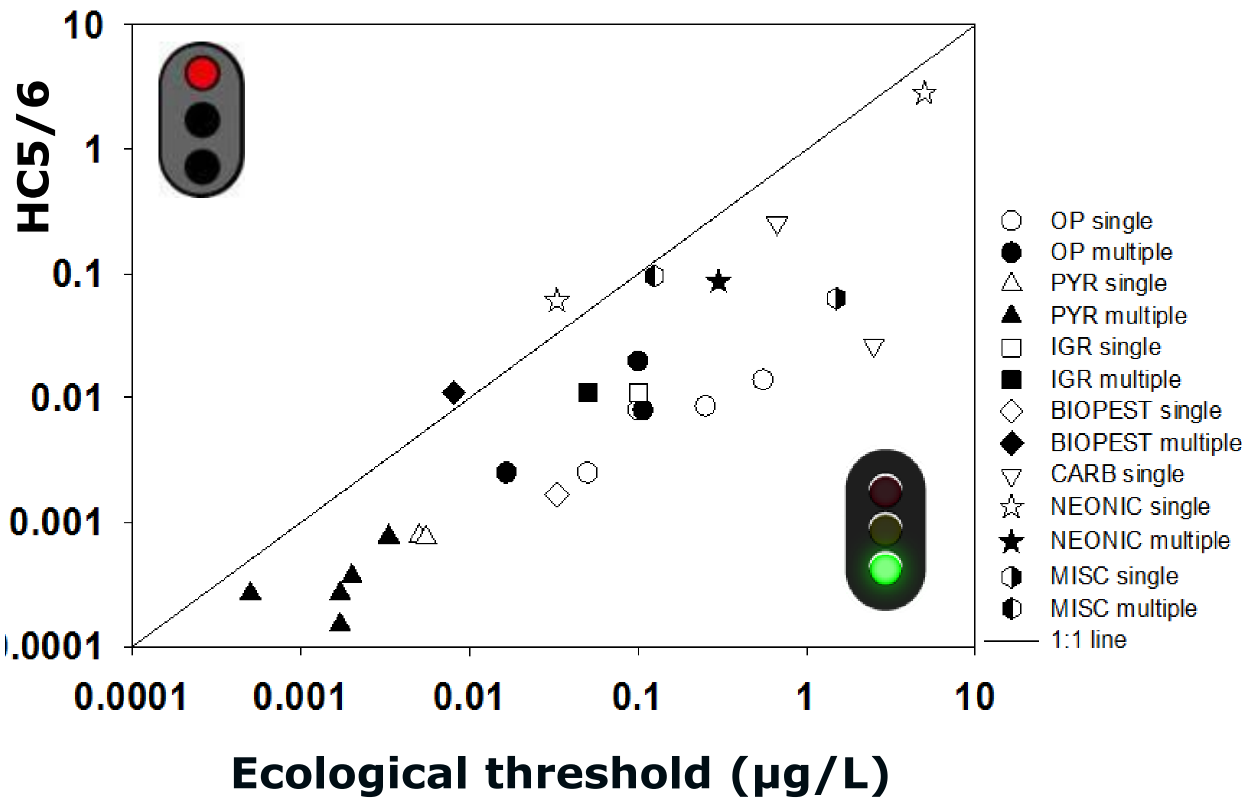
Standard test species-AF approach overall protective for evaluated insecticides, but not for IGR fenoxicarb and to a lesser extent for the neonicotinoid thiacloprid

SSD approach insecticides

Van Wijngaarden et al (2014) : *Pest Man Sci*

SSD constructed with EC50's arthropods; AF of 6 applied to HC5





In 25 out of the 27 insecticide cases the SSD approach is protective, but two borderline cases within a factor of 2 (thiacloprid and abamectin)

Ecological risks of exposure to pesticides

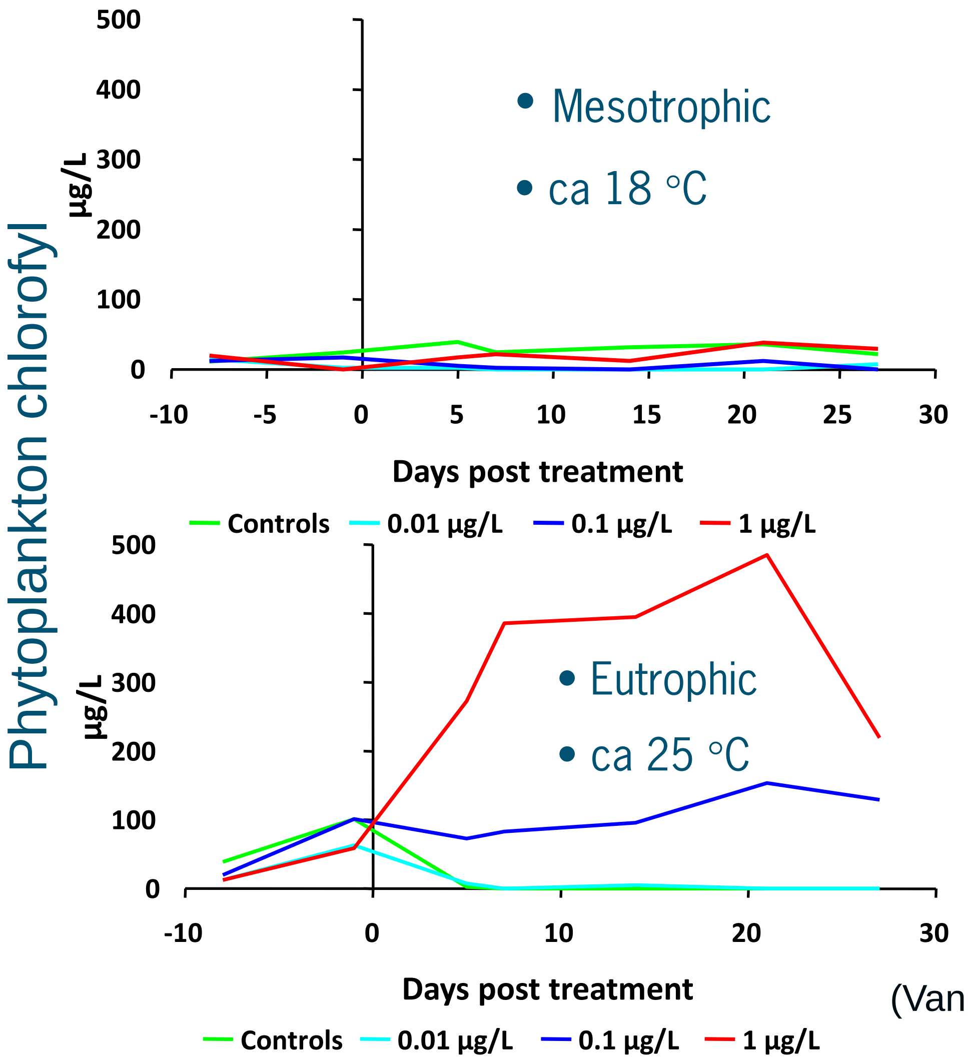
- Prospective (PPP Regulation) and retrospective (WFD) norm concentrations <u>for individual PPPs</u> overall are sufficiently protective to prevent adverse ecological effects
- What are the ecological consequences of exceeding norm concentrations?
- What are the ecological consequences of cumulative stress of exposure to different pesticides?

Chlorpyrifos: semi-field experiments, short-term exposure

Application regime	Class 1 NOEC	Class 2 LOEC	Class 3A LOEC	Type of test system	Location Reference
6 h pulse	0.1 µg/L	-	(5.0 µg/L)	Experimental streams	Australia Pusey et al. 1994
Single	0.1 µg/L	0.3 µg/L	1.0 µg/L	Outdoor microcosms	USA, Kansas Biever et al. 1994
Single	-	0.1 µg/L	<0.9 µg/L	Experimental ditches	Netherlands Van den Brink et al. 1996
Single	0.1 µg/L	-	1.0 µg/L	Lab microcosms Cool, Mesotr.	Netherlands Van Wijngaarden et al. 2005
Single	0.1 µg/L	-	≤1.0 µg/L	Lab microcosms Warm, Eutrophic	Netherlands Van Wijngaarden et al. 2005
Single	0.1 µg/L	-	1.0 µg/L	Outdoor mesocosms	Spain López-Mancisidor et al. 2005
Single	0.1 µg/L	-	1.0 µg/L	Outdoor microcosms	Thailand Daam et al. 2008
Single	-	-	0.5 µg/L	Pond enclosures	USA, Minnesota Siefert et al. 1989

Threshold levels for effects can be extrapolated with lower uncertainty than responses caused by higher exposures (but representatives of sensitive taxonomic groups need to be present).

Ecosystem interactions and indirect effects are context dependent



1 μg/L chlorpyrifos

- reduction Cladocera (direct effect)
- no algal bloom

1 μg/L chlorpyrifos

- reduction Cladocera (direct effect)
- pronounced algal bloom (indirect effect)

(Van Wijngaarden et al. 2005: *Pest Man Sci* 61:923-935)

Magnitude and duration of direct and indirect effects is context dependent

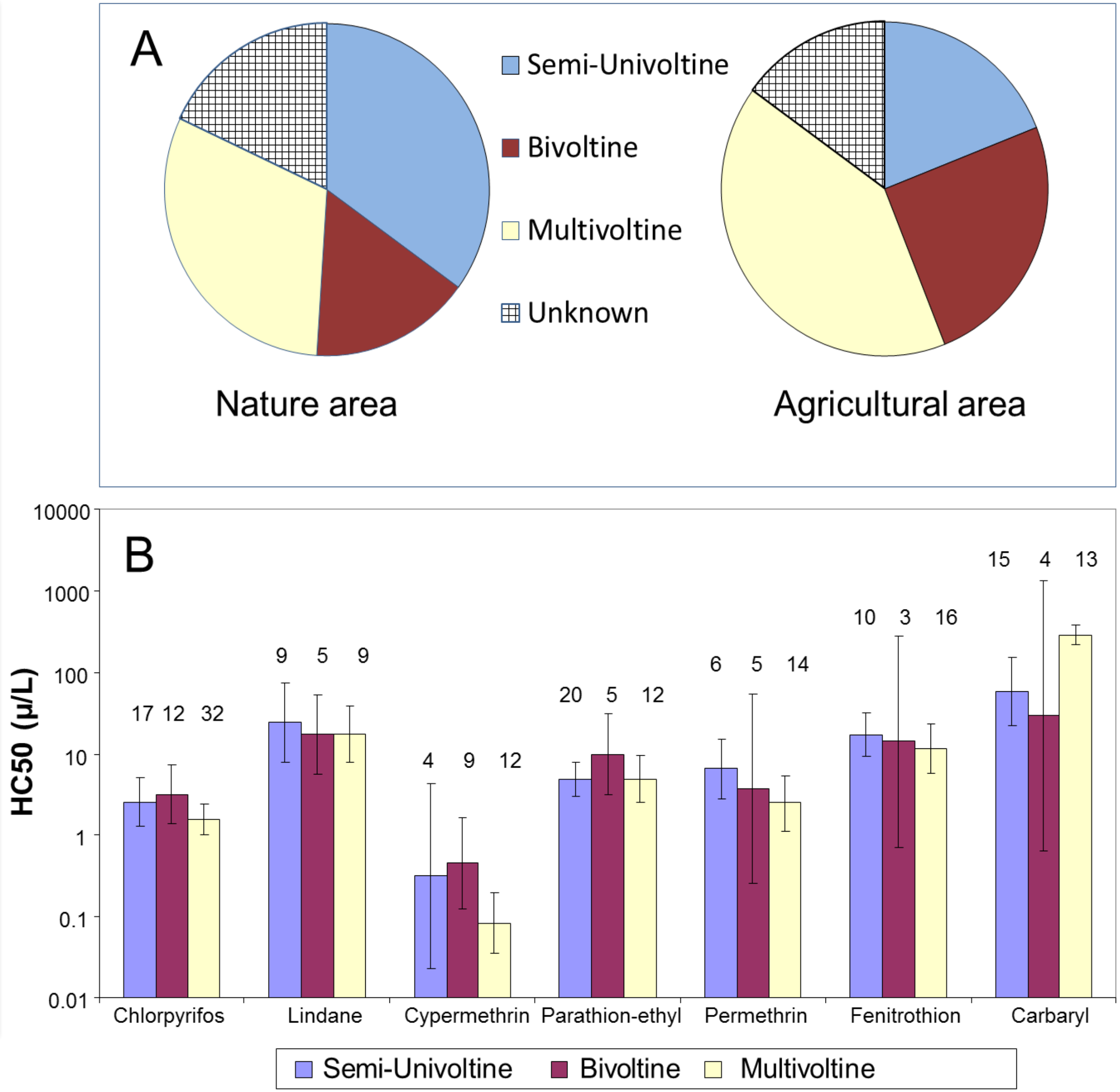
Vulnerability and toxicological sensitivity

In Dutch surface waters invertebrate taxa with longer generation times (semi-univoltine) are less common in agricultural areas

but

Overall sensitivity to insecticides seems not to be higher for these taxa

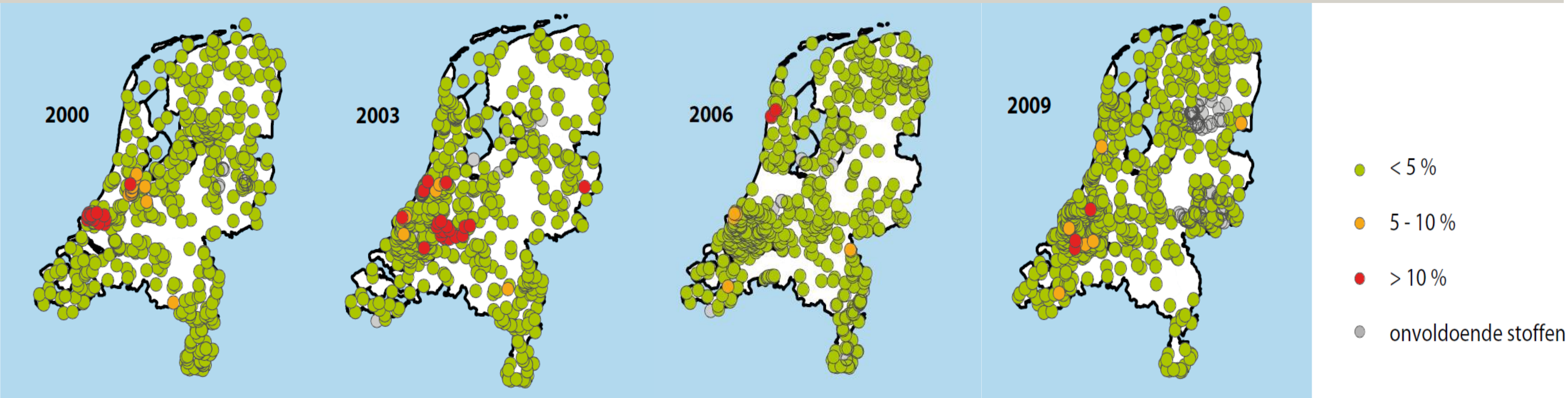
Vulnerability particularly important for recovery option!



Brock (2013) *IEAM 9:e64-e74*

mixture toxicity of pesticides

Evaluation of exposure to measured pesticide mixtures in Dutch surface waters by means of the msPAF method (multi substances Potentially Affected Fraction)



De Zwart 2005; Vijver et al. 2012; www.bestrijdingsmiddelenatlas.nl (CML, 2014)

In most sites the potentially affected fraction of species is < 5%

The localities with a msPAF >5% vary per year

Per locality it usually is a limited number of substances that contribute to mixture toxicity

Composition of mixtures differs between localities

The msPAF approach may underestimate risks (not all substances measured or toxicity below detection limit)

Mixture toxicity of pesticides: the crop approach

What is the impact of realistic exposure to pesticides in edge-of-field surface waters?

- Crop approach (realistic package of pesticides)
- Scenario for normal agricultural practise in **potato**

Study was performed in complex experimental ditches that sufficiently resemble field ditches (Arts et al. 2006; *IEAM 2:105-125*)

Application schedule

Week	Pesticide (A.I.)	Pesticide type	N
17	Prosulfocarb	Herbicide	1
19	Metribuzin	Herbicide	1
22 & 26	λ-cyhalothrin	Insecticide	2
23 - 25	Chlorothalonil	Fungicide	4
27- 34	Fluazinam	Fungicide	8

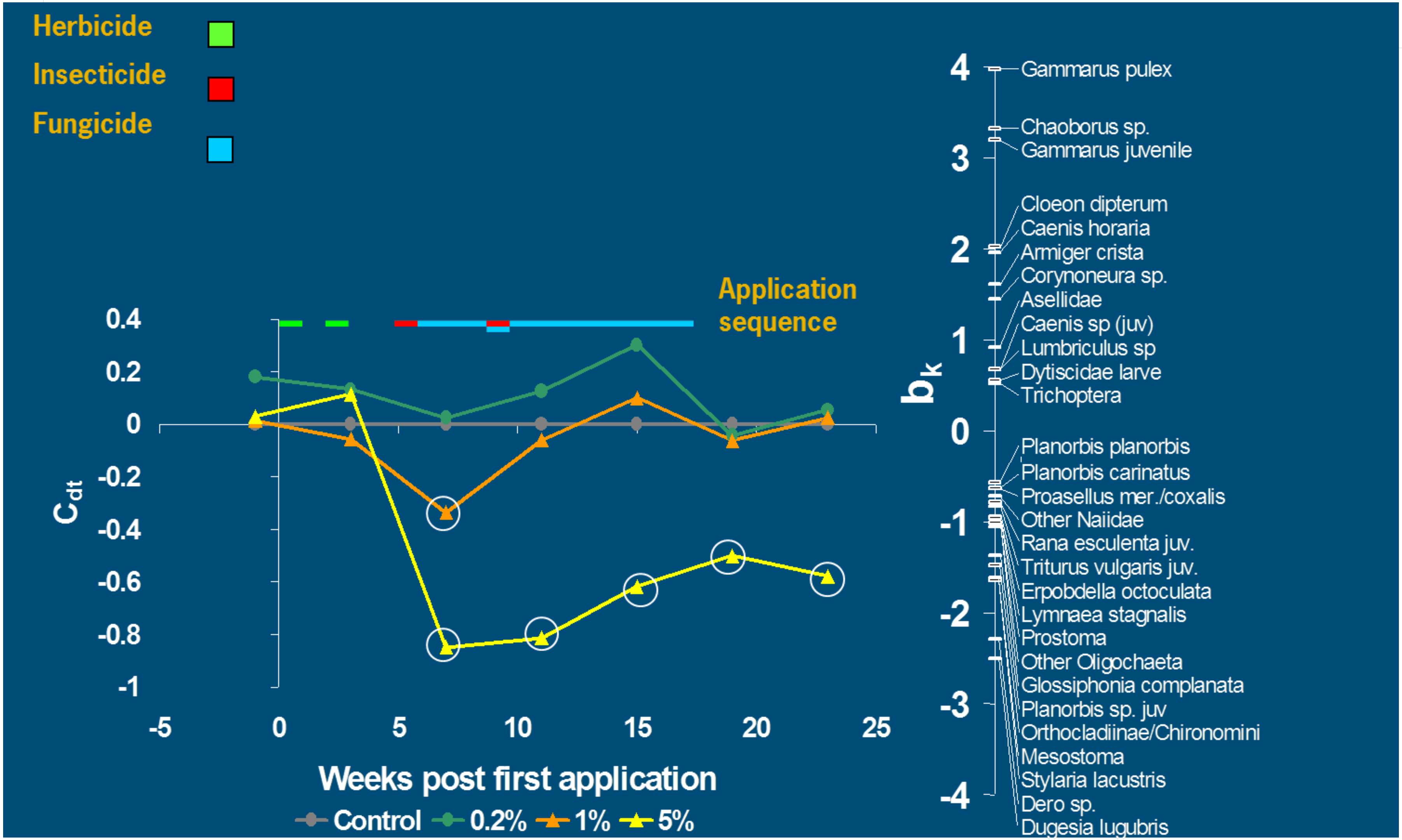
N = number of applications
A.I. = Active Ingredient

Exposures tested: different drift emissions

Drift	5 %	1 %	0.2 %	
Exposure	(in μg/L)			NOEC most sensitive endpoint individual compound (in μg/L)
Prosulfocarb	**76**	**15**	**3.0**	**3.0 (mesocosm)**
Metribuzin	**8.3**	**1.7**	**0.33**	**2.5 (mesocosm)**
L-cyhalothrin	**0.12**	**0.024**	**0.0048**	**0.005 (mesocosm)**
Chlorothalonil	**24**	**4.8**	**0.96**	**2.8 (mesocosm)**
Fluazinam	**4.76**	**0.95**	**0.19**	**0.95 (microcosm)**

Hypothesis: Based on the ecological threshold levels for individual substances effects are expected in the 5% and 1% drift emission treatments. If effects are observed in the 0.2% treatment this is caused my cumulative stress

PRC diagram macro-invertebrates

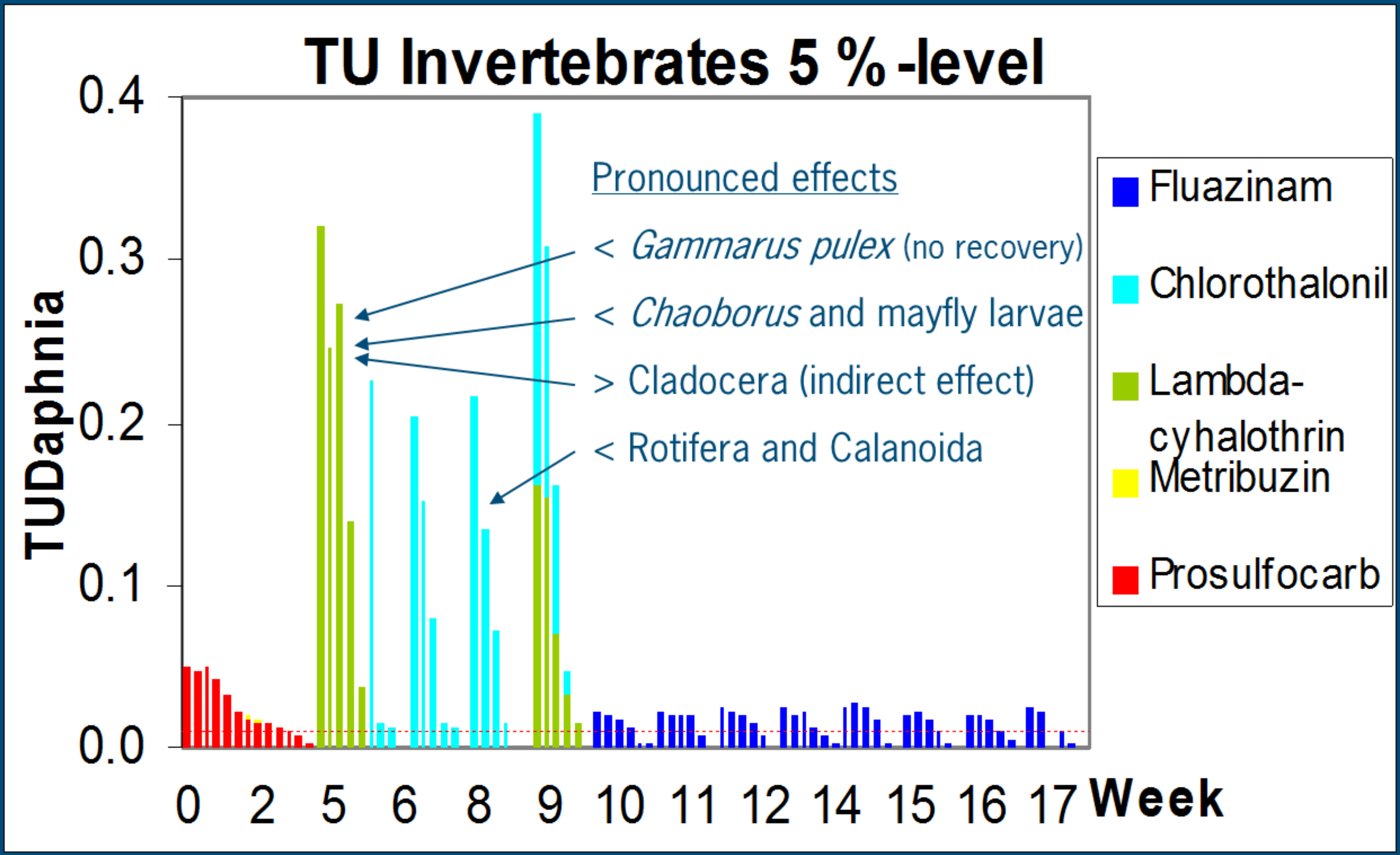


5% drift: Pronounced long-term direct and indirect effects

1% drift: short-term effect

0.2% drift: no effects

Exposure concentrations in ∑ Toxic Unit



1 to 2 substances contribute to effects on individual samplings.
Effects can be mainly explained by exposure to the insecticide.

Prospective and retrospective ERA

- Prospective ERA procedures within the context of pesticide registration will not be able to always exclude unacceptable effects

- Management of aquatic risks can be improved by implementing feed-back mechanisms between *Regulation 1107/2009/EC* (PPP Regulation), the *Sustainable Pesticide Use Directive* and the *Water Framework Directive*

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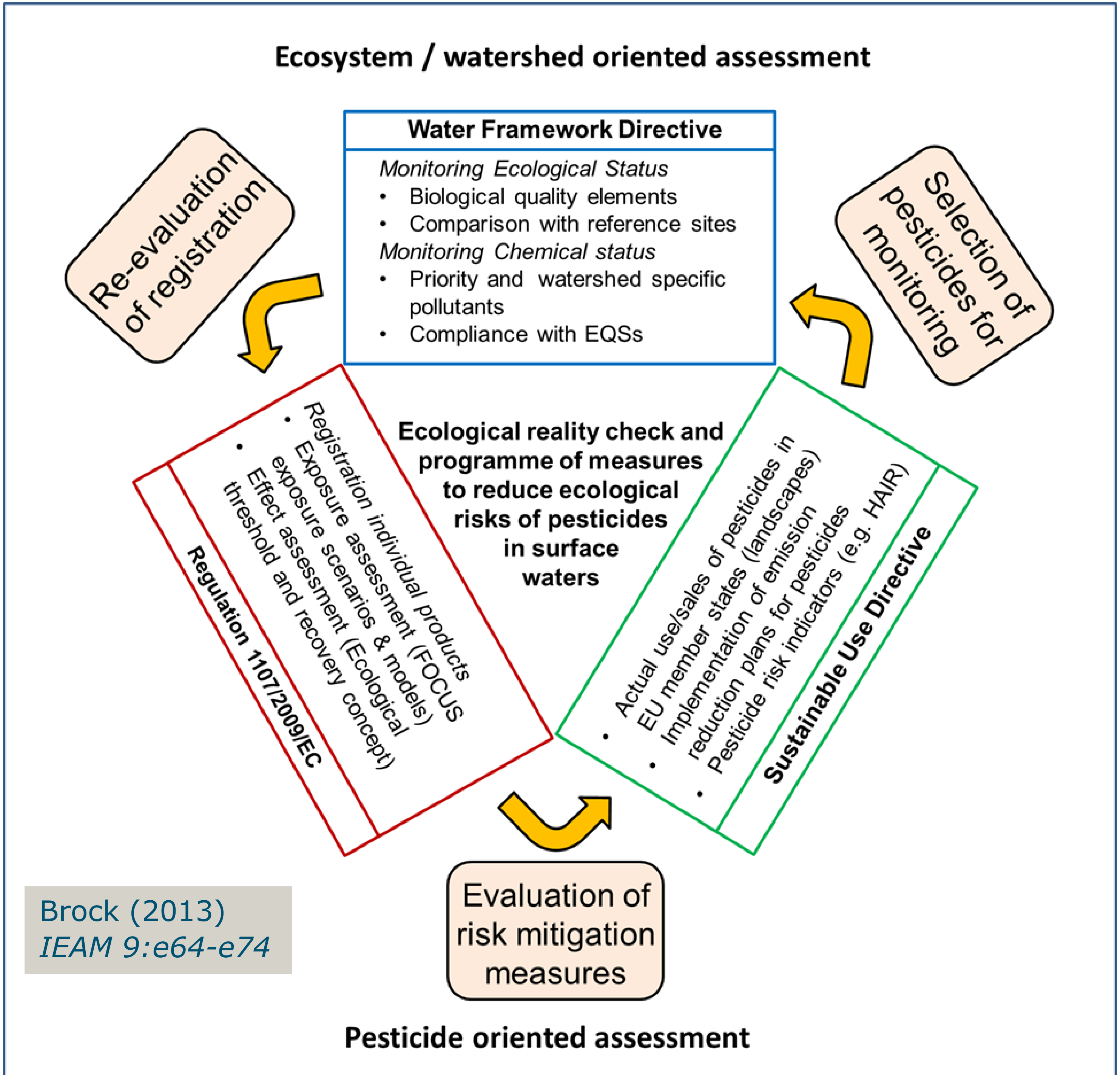
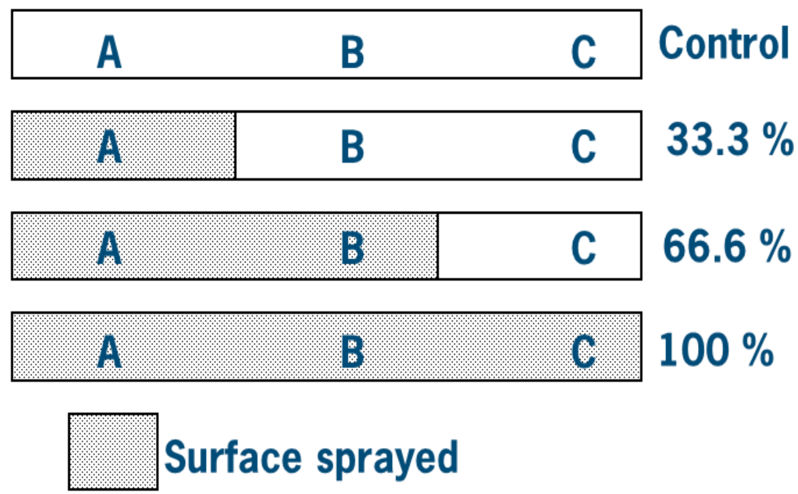

Ecosystem / watershed oriented assessment
Water Framework Directive
Monitoring Ecological Status
• Biological quality elements
• Comparison with reference sites
Monitoring Chemical status
• Priority and watershed specific pollutants
• Compliance with EQSs
Re-evaluation of registration
Selection of pesticides for monitoring
Ecological reality check and programme of measures to reduce ecological risks of pesticides in surface waters
Regulation 1107/2009/EC
• Registration individual products
• Exposure assessment (FOCUS exposure scenarios & models)
• Effect assessment (Ecological threshold and recovery concept)
Sustainable Use Directive
• Actual use/sales of pesticides in EU member states (landscapes)
• Implementation of emission reduction plans for pesticides
• Pesticide risk indicators (e.g. HAIR)
Evaluation of risk mitigation measures
Brock (2013)
IEAM 9:e64-e74
Pesticide oriented assessment

Long-term sediment exposure to hydrophobic PPPs

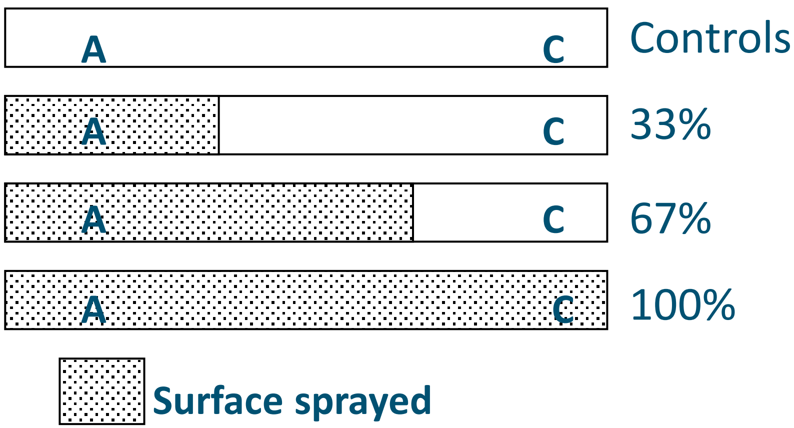
- Current ERA procedures focus on risks of pesticide exposure in the water column
- Sediment exposure to pesticides may be more long-term and needs more attention



Brock et al. 2010; *ETC 29: 1994-2008*

Lufenuron experiment

Response of ephemeropteran *Caenis* in ditch sections A and C
Sediment dwelling organisms

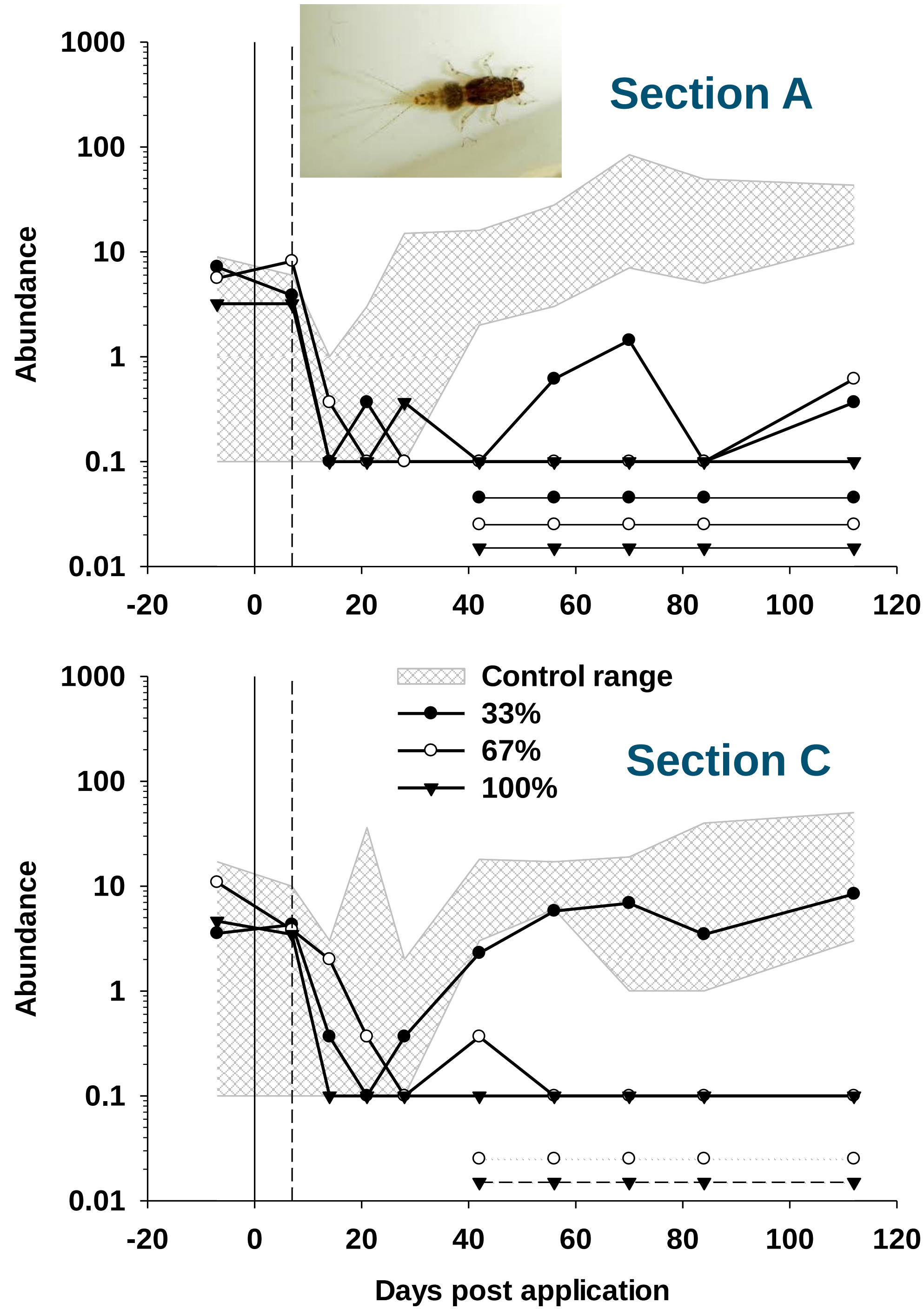


No effects in untreated section C of 33% treated ditch.

No recovery in treated ditch section.

Long-term sediment exposure !

Larvae less mobile and species with long life-cycle



Thank you for your attention
Questions ?

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