Pyrethroid Toxicity In The Water Column: Is There Reason For Concern?

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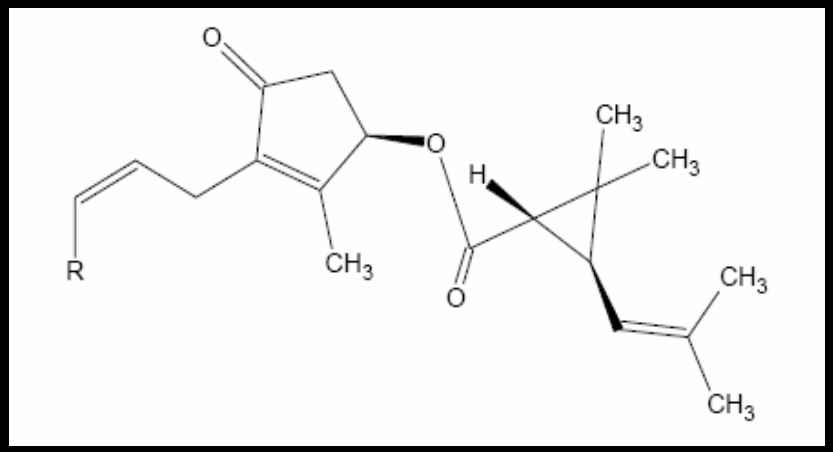
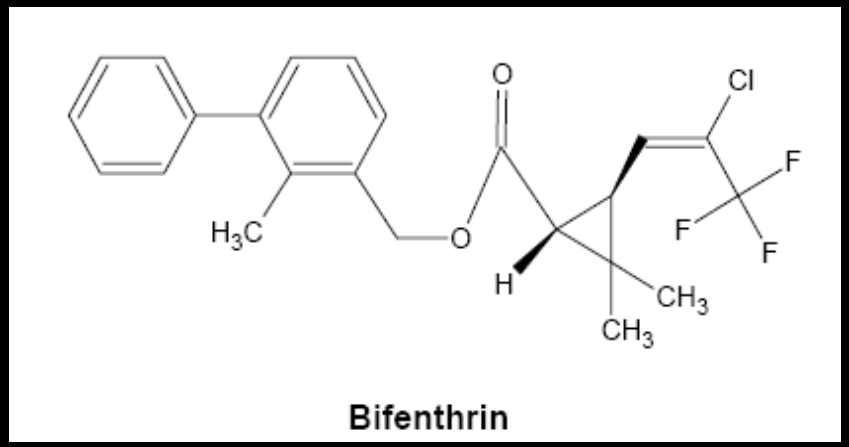
PYRETHRINS versus PYRETHROIDS

= naturally occurring components of "pyrethrum," made from chrysanthemums.

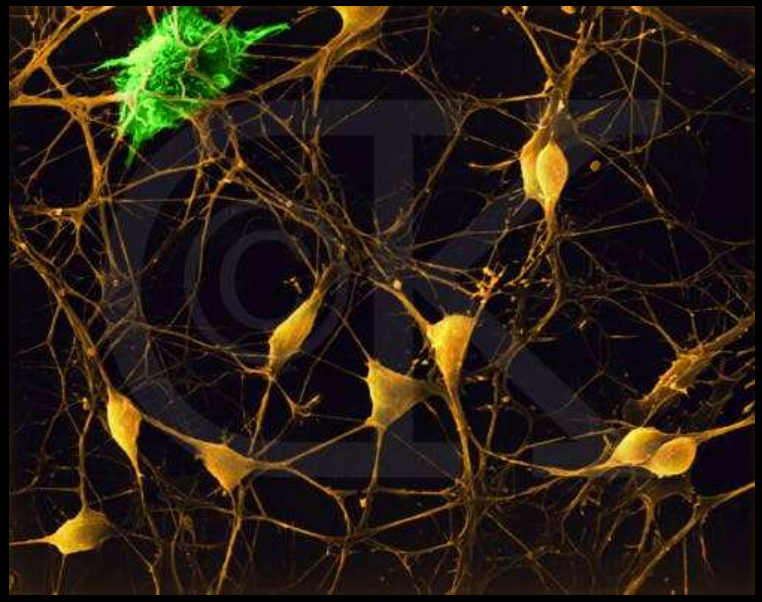
= synthetic analogs of pyrethrins, which are more chemically stable and more toxic.





Bifenthrin

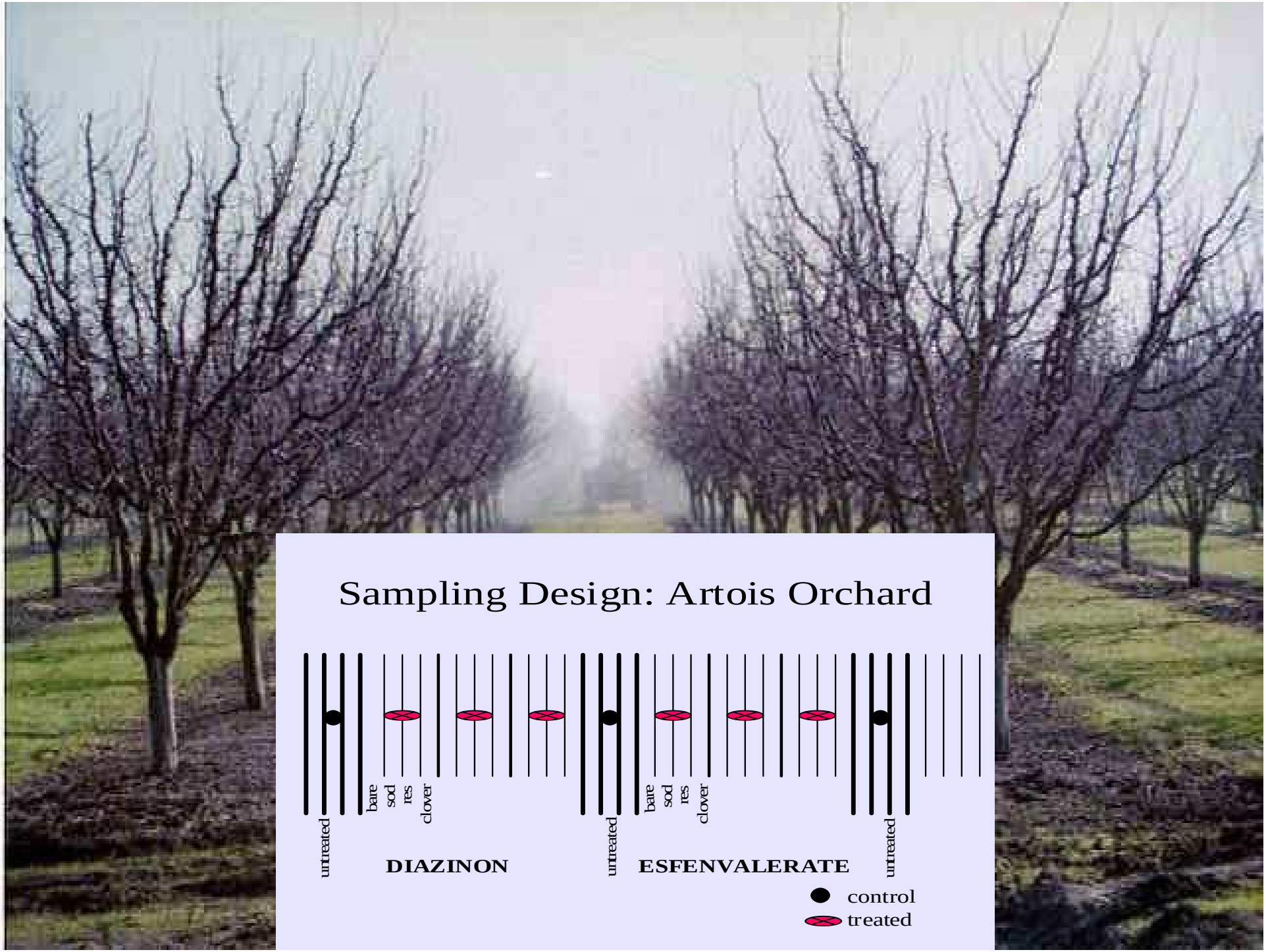
PYRETHROIDS: MODE OF ACTION



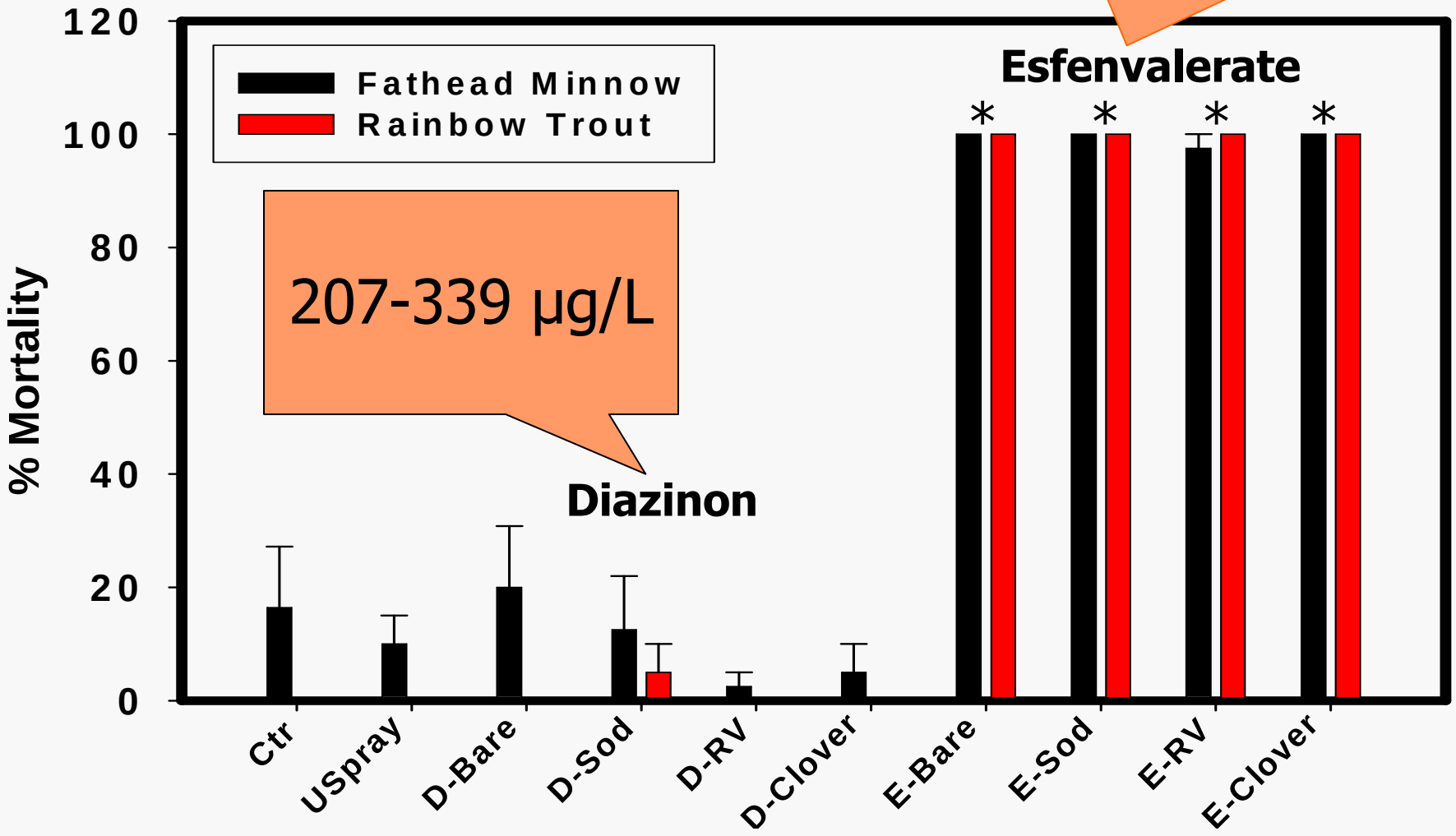
- **Potent neurotoxic insecticides**
- **Disrupt sodium and other ion channels in nerve cells**
- **Symptoms: hyperexcitation, tremors, convulsions, followed by lethargy and paralysis**
- **Detoxification by esterases and P450 enzymes**

PYRETHROIDS AND WATER QUALITY

- **Sources: stormwater runoff, aerial drift, tailwater, irrigation return water**
- **Hydrophobic: K_{ow}=4-7.6**
- **Low solubility in water: 0.2-100 µg/L**
- **Tendency to bind to particles, organic carbon**
- **Half-life: days to 1+ year**

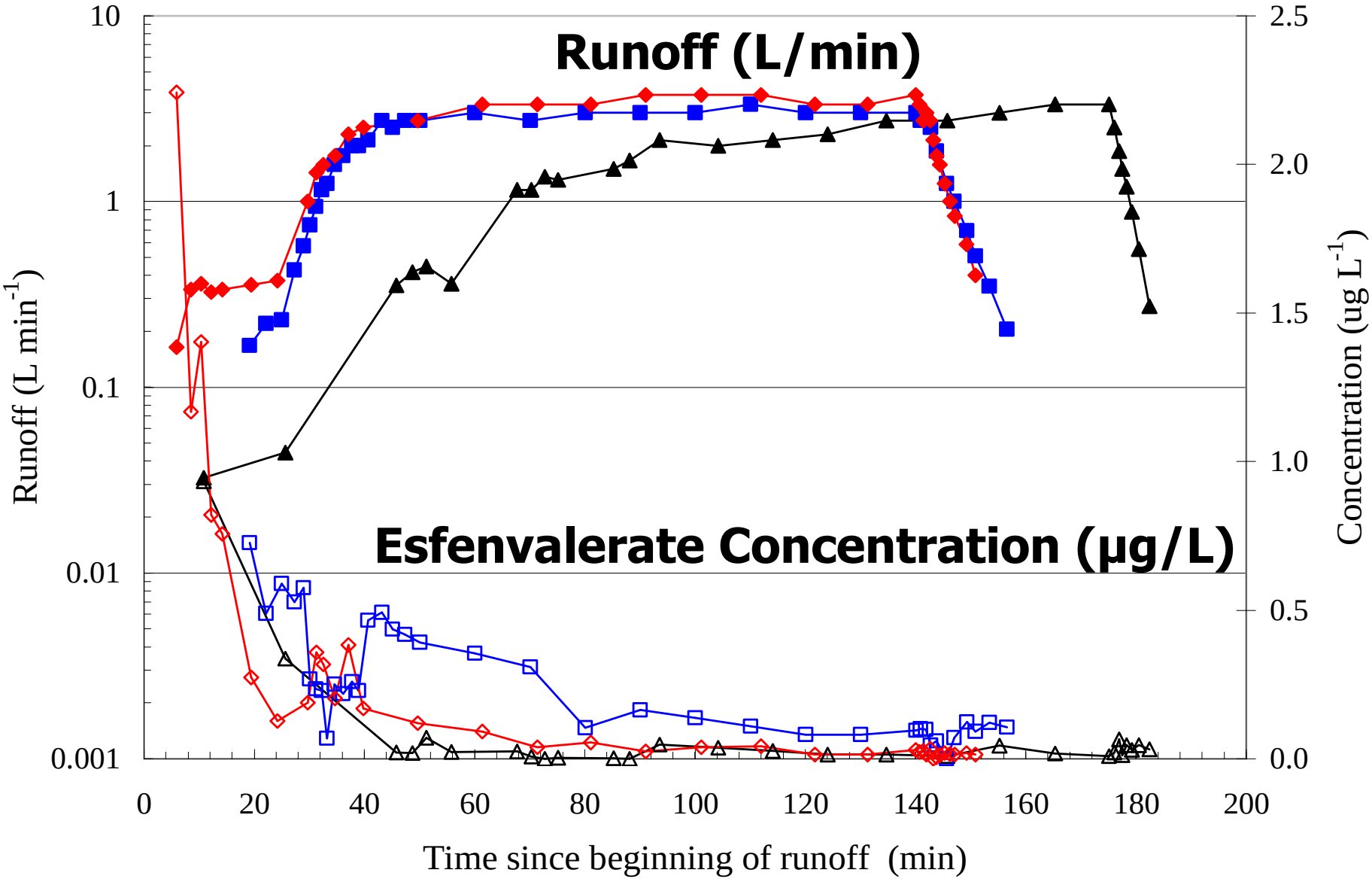

Sampling Design: Artois Orchard
untreated
bare
sod
res
clover
DIAZINON
untreated
bare
sod
res
clover
ESFENVALERATE
untreated
control
treated

Mortality of Fish Larvae Exposed to S
from a French Prune Orc



Werner et al., *Environ. Toxicol. Chem.* 23(11), 2004

Runoff Hydro- and Chemographs for Esfenvalerate (Brady et al., 2006)



PYRETHROIDS IN SURFACE WATERS

Esfenvalerate:

424-3,060 ng/L (drainage ditch)

4-37 ng/L (diss.; CV stream)

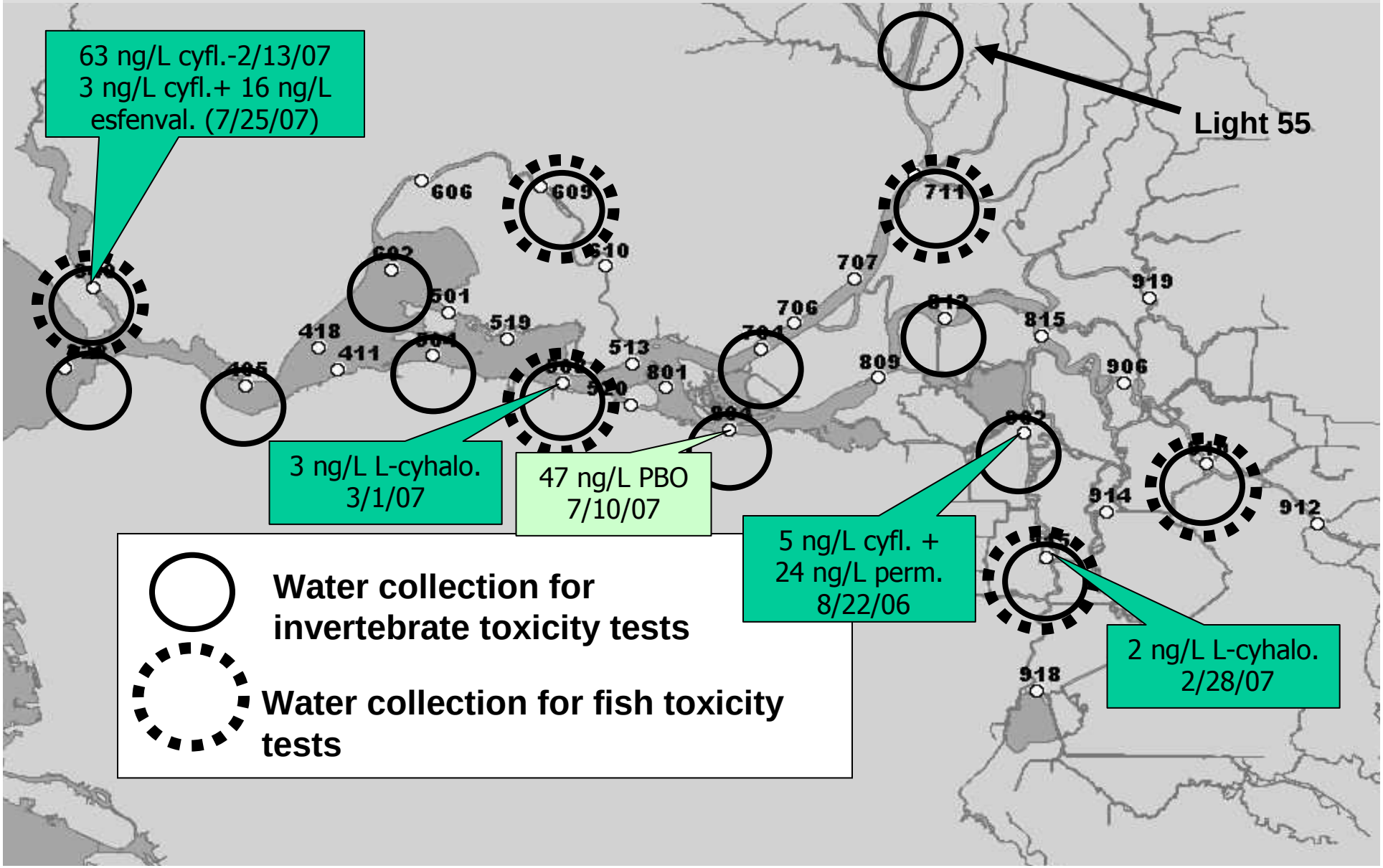
Lambda-cyhalothrin:

110-140 ng/L (San Joaquin Valley)

Other detections in CA:
Permethrin (7- 32 ng/L); Bifenthrin: 18 ng/L; Cyfluthrin: 5-13 ng/L; Cypermethrin: 55 ng/L

Water Toxicity Sampling Locations Based on IEP Summer Townet Survey Stations, 2006 Sampling.

(Map provided by R. Baxter, CDFG, Bay-Delta Branch)



PYRETHROIDS & INVERTEBRATES*

Solubility: 0.2-100 µg/L

	LC50 (24-96 h) [ng/L]	Sublethal Effects [ng/L]
deltamethrin	2 - 100	-
permethrin	39 - 2,750	<10
esfenvalerate	8 - 300	50
cypermethrin	5 - 530	0.8-2.8
bifenthrin	4 - 320	-
cyfluthrin	2 - 170	-
λ-cyhalothrin	5,690 (0.5 h)	40

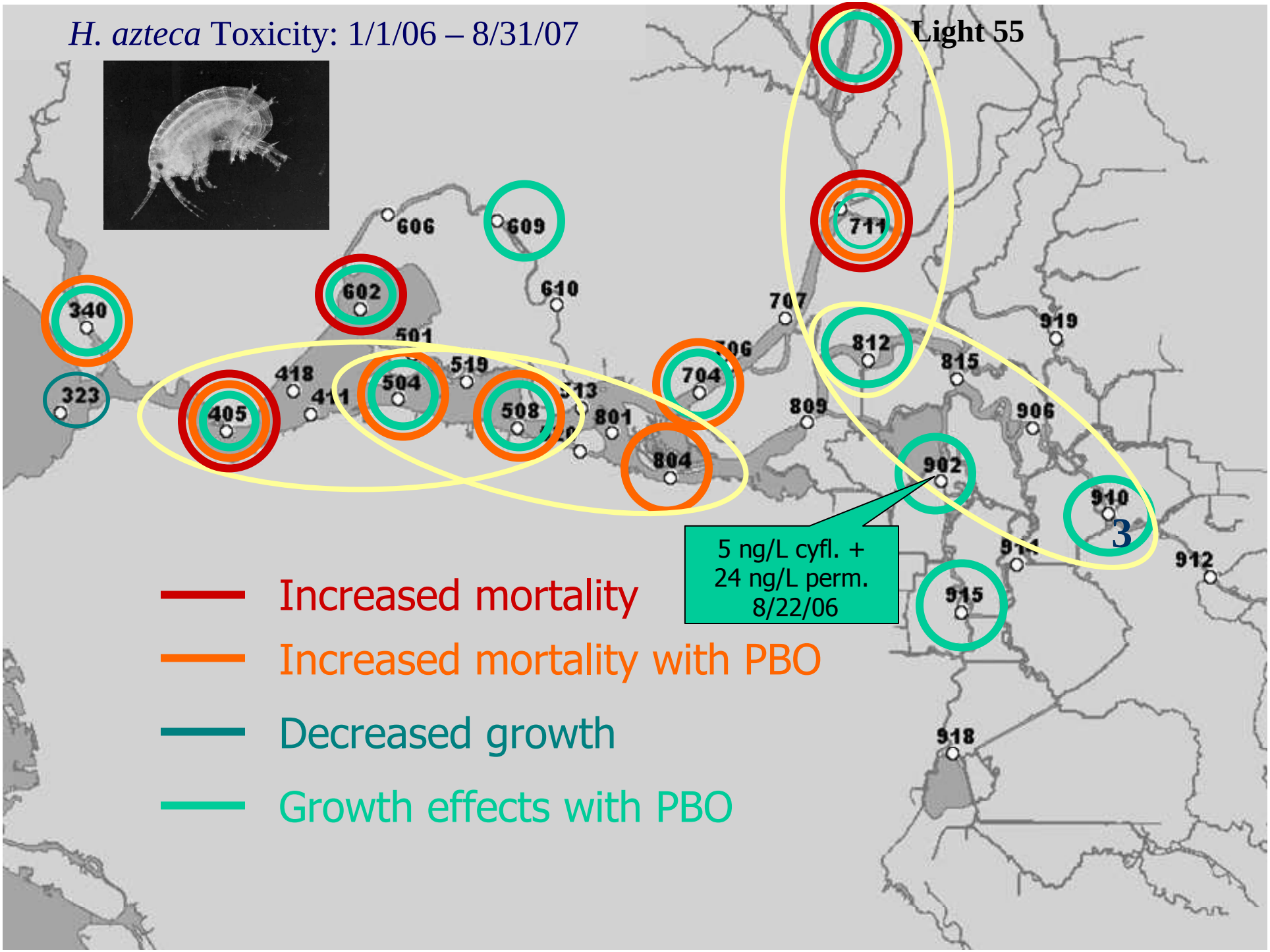
* w/o molluscs

Oros & Werner, 2005

Toxicity Testing: Invertebrates

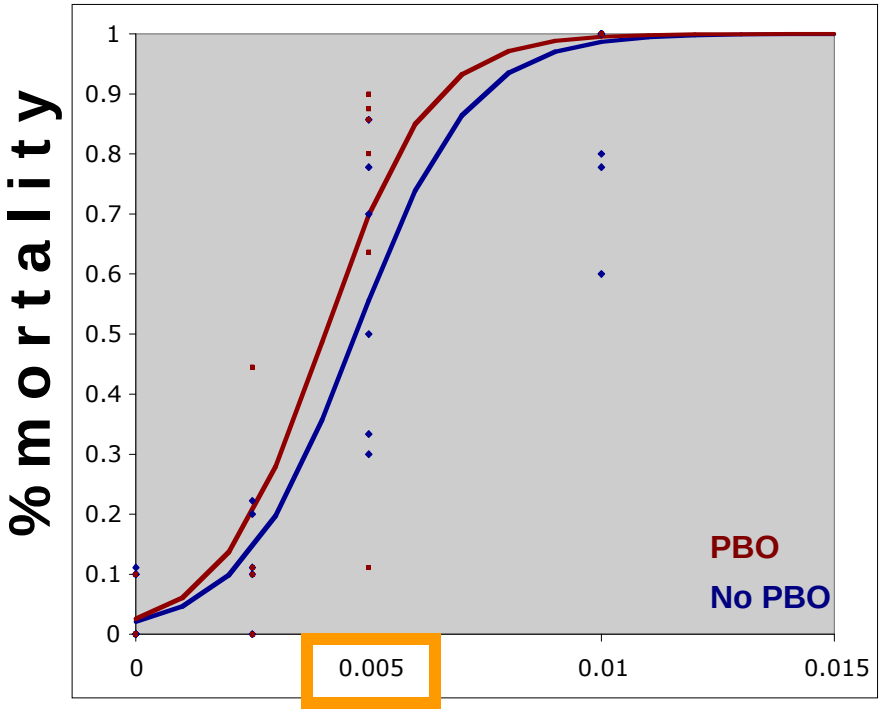
Study Period	Reduced Survival	Red. Survival w. PBO	Growth Effect w. PBO
1/1/06-8/31/07	**1.5% (9/622)**	**0.3% (2/610)**	**5.7% (35/610)**

Hyalella azteca
10-d survival & growth

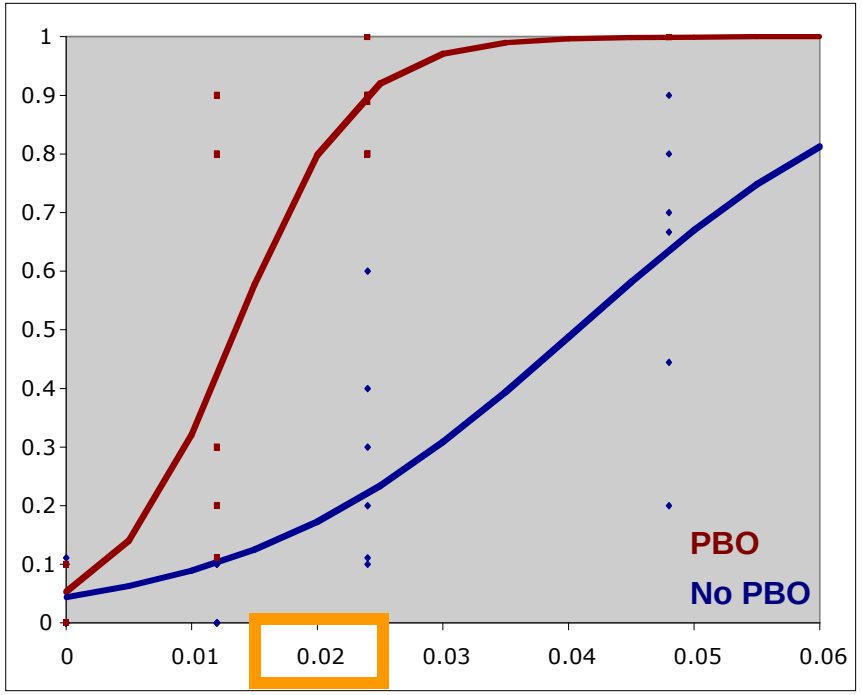

H. azteca Toxicity: 1/1/06 – 8/31/07
Light 55
606
609
602
610
340
501
707
711
812
919
323
418
504
519
704
815
405
508
801
809
906
804
902
910
3
912
915
5 ng/L cyfl. +
24 ng/L perm.
8/22/06
Increased mortality
Increased mortality with PBO
Decreased growth
Growth effects with PBO
918

Toxicity of Pyrethroids to *H. azteca* (*Brander et al.*)

Cyfluthrin (Type II)



Permethrin (Type I)



d o s e (µg/L)

LC50 no PBO 0.005 ug/L

LC50 w/PBO 0.004 ug/L

LC50 no PBO 0.039 ug/L

LC50 w/PBO 0.013 ug/L

POTENTIAL CAUSES FOR REDUCED TOXICITY IN DELTA WATER

- **Adsorption to suspended sediments and phytoplankton**
- **Adsorption to sampling & testing containers**
- **Chemical breakdown during transport and storage**

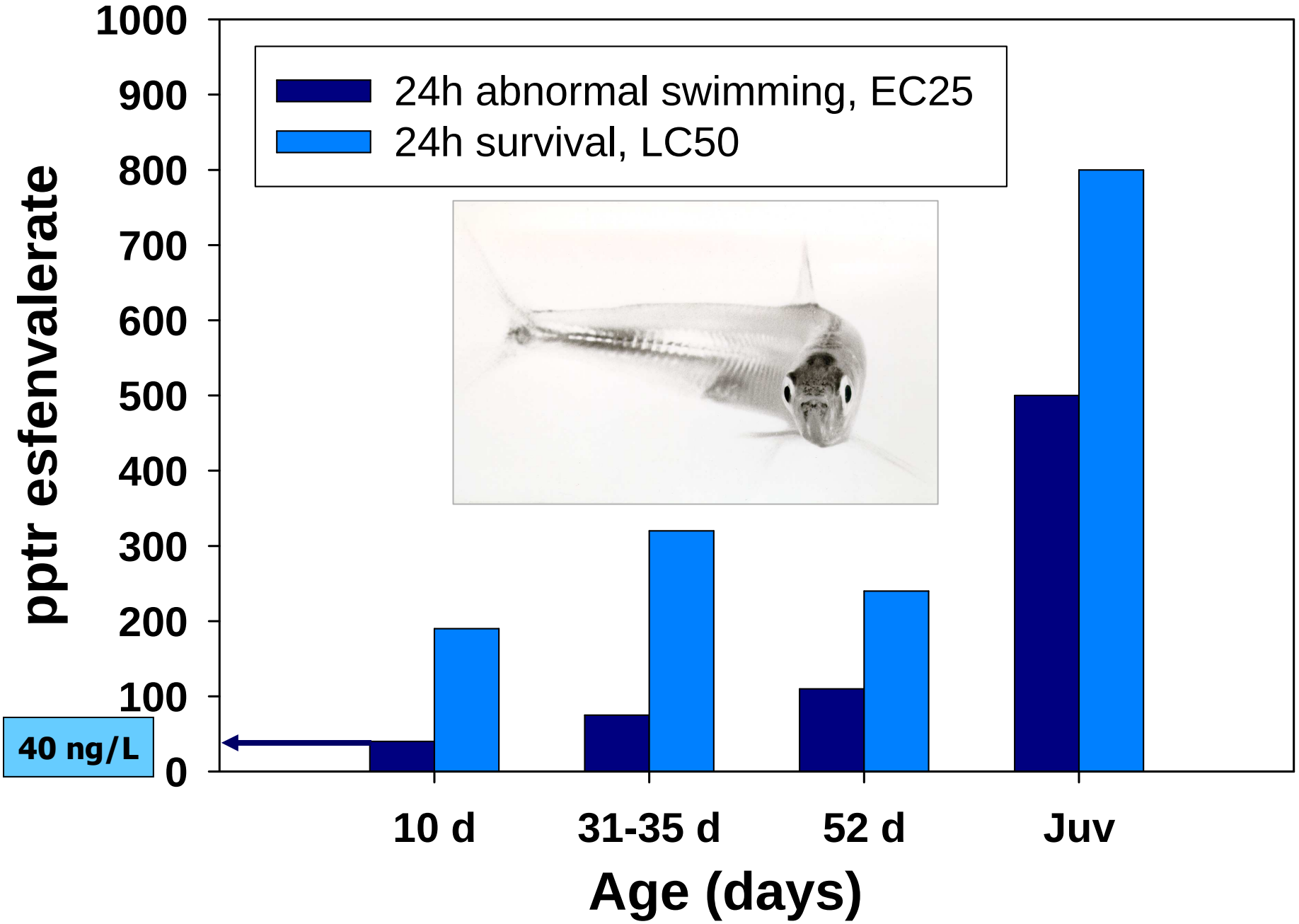
PYRETHROIDS & FISH

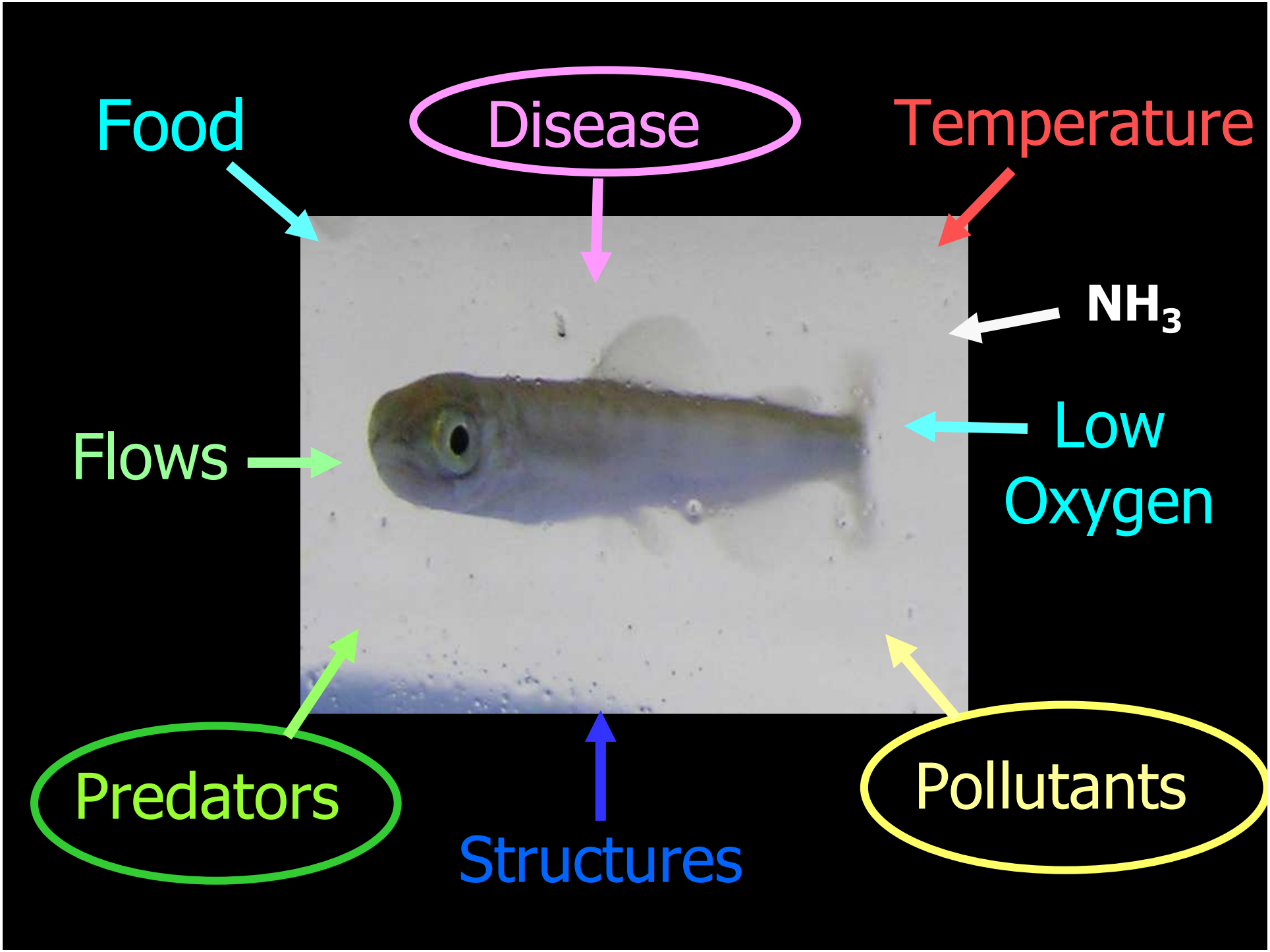
	LC50 (24-96 h)	Sublethal Effects*
	[ng/L]	[ng/L]
deltamethrin	250 - 700	-
permethrin	600 - 27,500	-
esfenvalerate	70 - 500	10-1000
cypermethrin	900 - 5,000	0.7-840
bifenthrin	150 - 350	90
cyfluthrin	300 - 2,500	-
λ-cyhalothrin	60 - 700	-

* Behavior, Reproduction, Growth, Cellular/Immune Function

Oros & Werner, 2005

Delta Smelt 24-h LC50/EC25

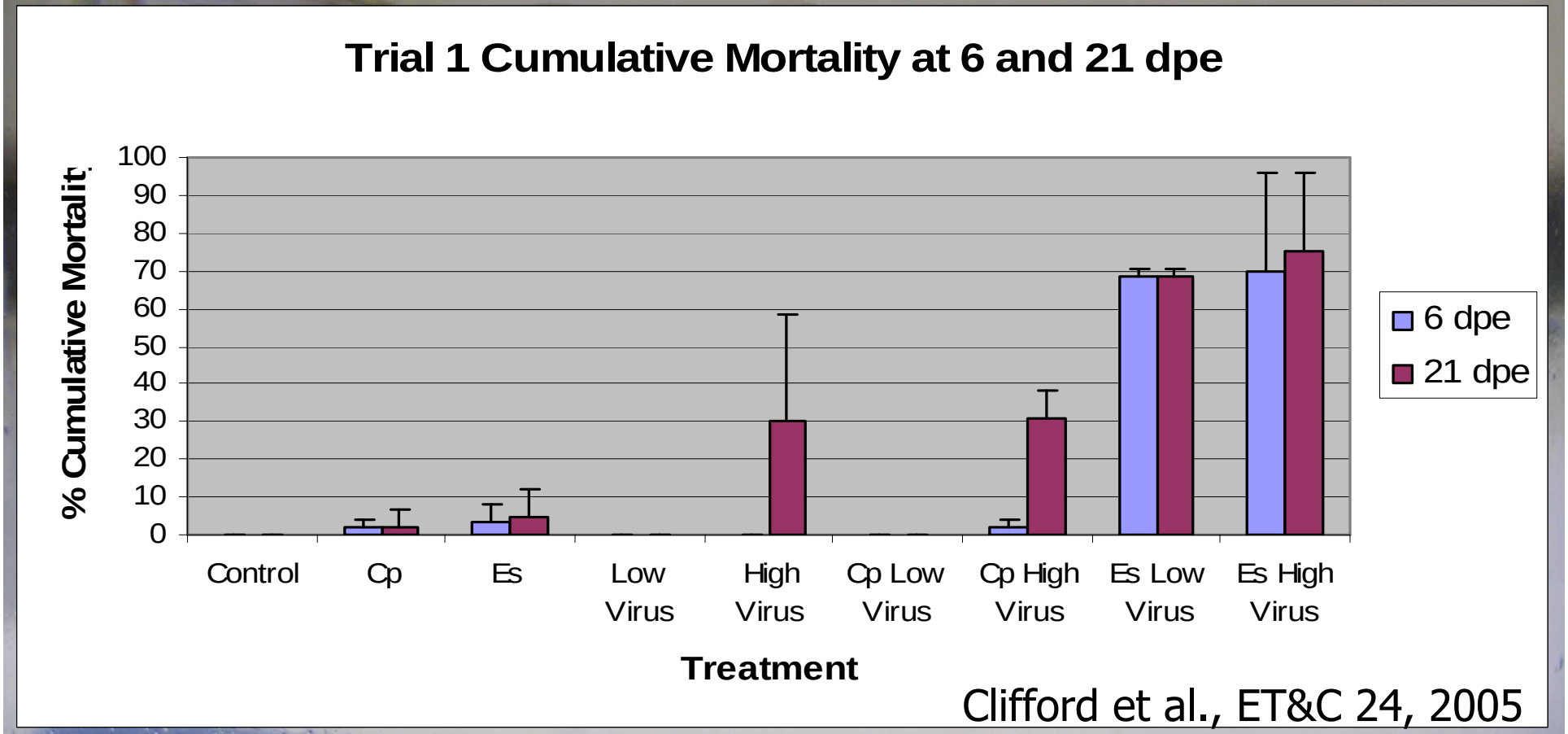



Food
Disease
Temperature
NH_3
Flows
Low Oxygen
Predators
Structures
Pollutants

PYRETHROIDS AND DISEASE

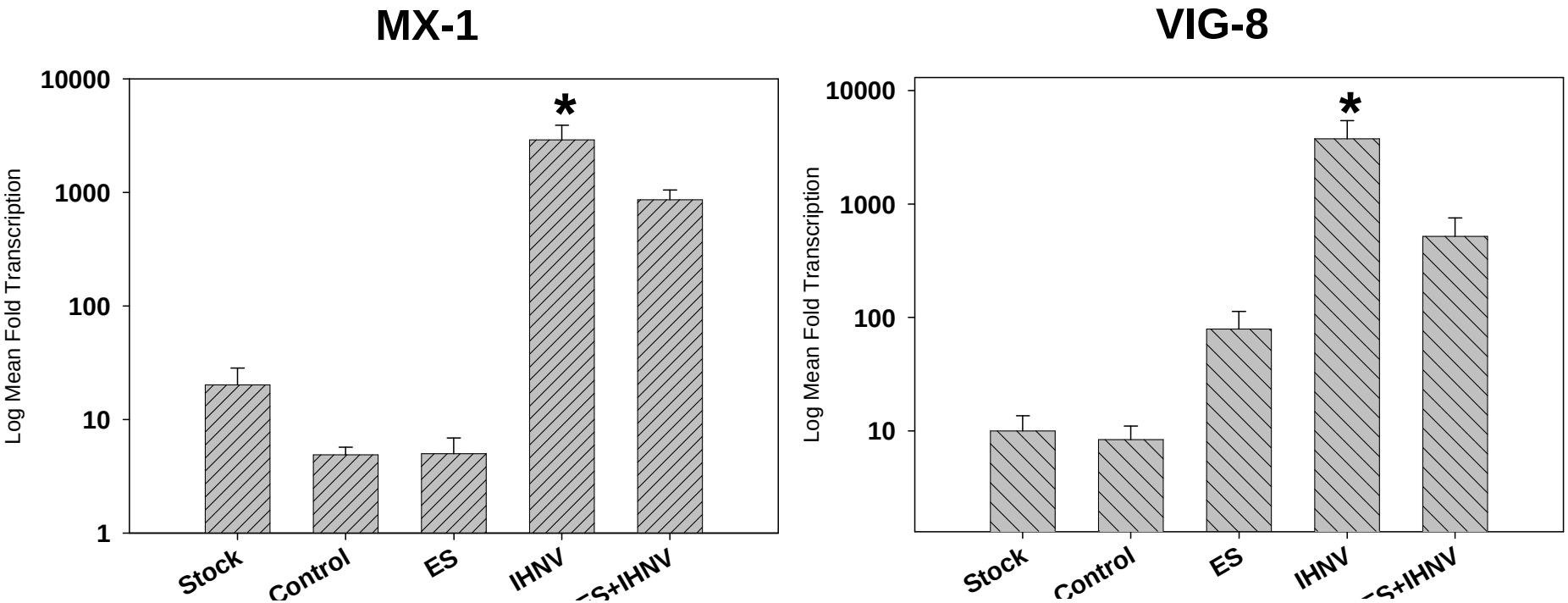
Esfenvalerate + **IHNV: Infectious Hematopoietic Necrosis Virus**

80 pptr/96 h



Clifford et al., ET&C 24, 2005

Relative Transcription of Immune Genes Mx1 and VIG8 in Juvenile Chinook Salmon Spleen (65-72 h post-exposure)



Clifford et al., in prep.

PYRETHROIDS AND PREDATION

<u>Predator:</u> 3-Spine Stickleback

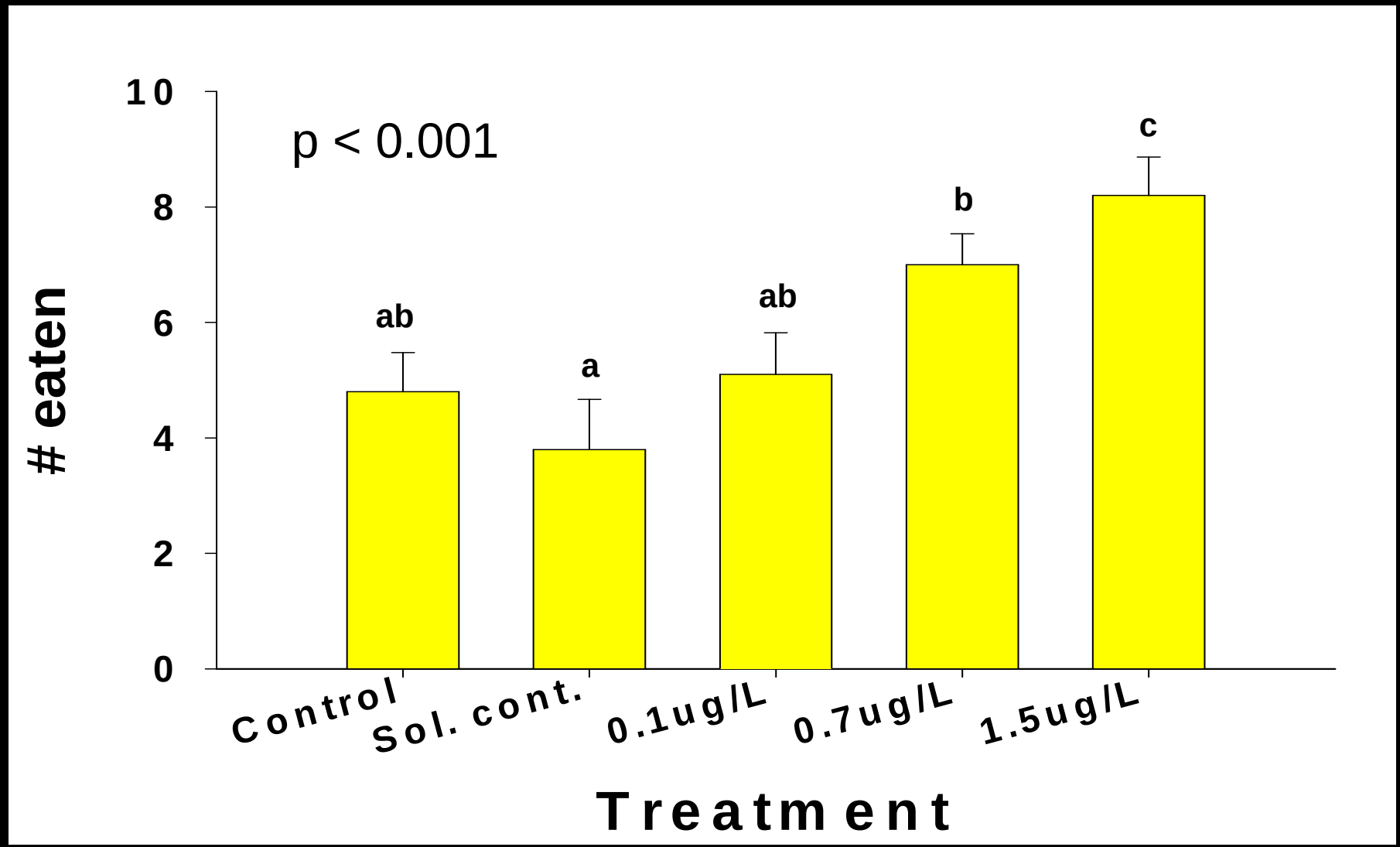
<u>Prey:</u> Fathead Minnow Larvae (8 d old)

<u>Chemical</u>: Esfenvalerate

<u>Exposure Time</u>: 4h

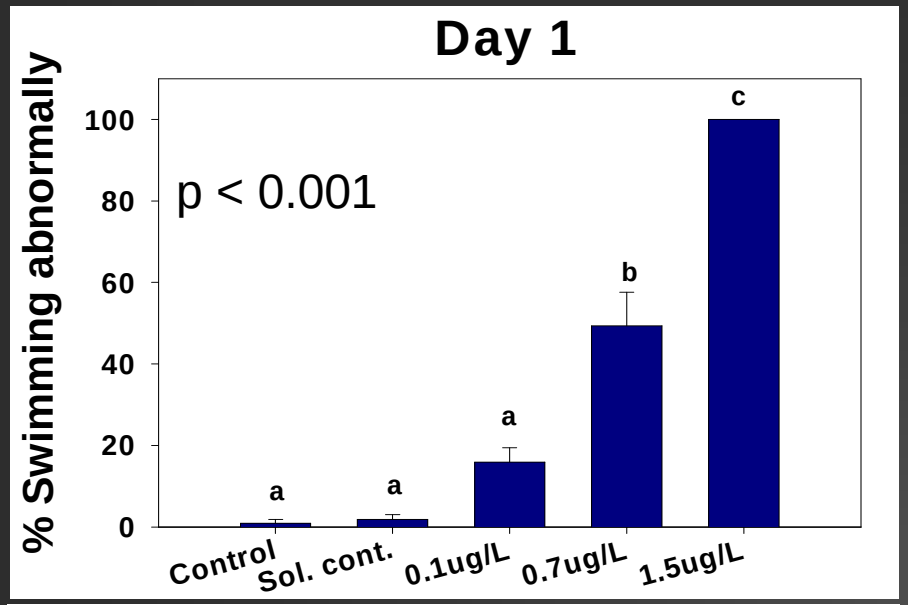
4h-LC50: >3 ppb

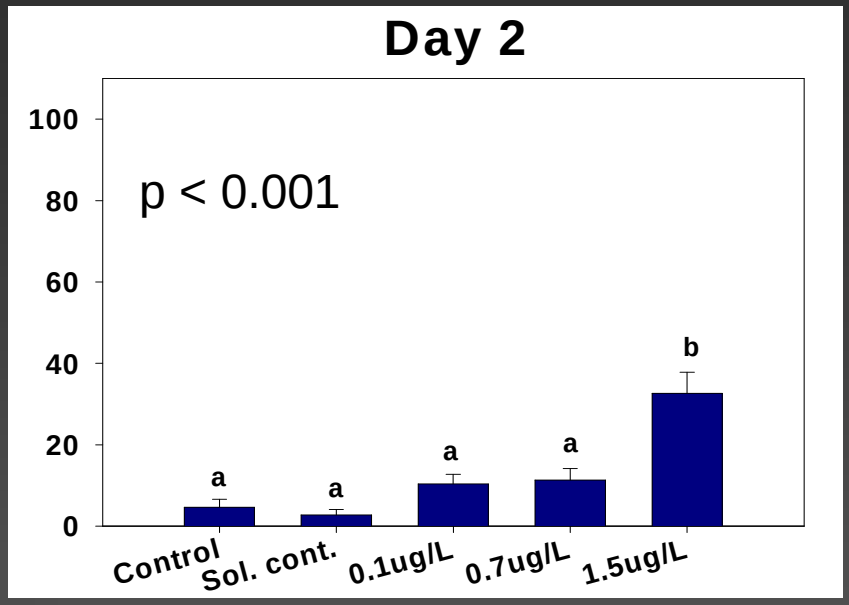
PREDATION

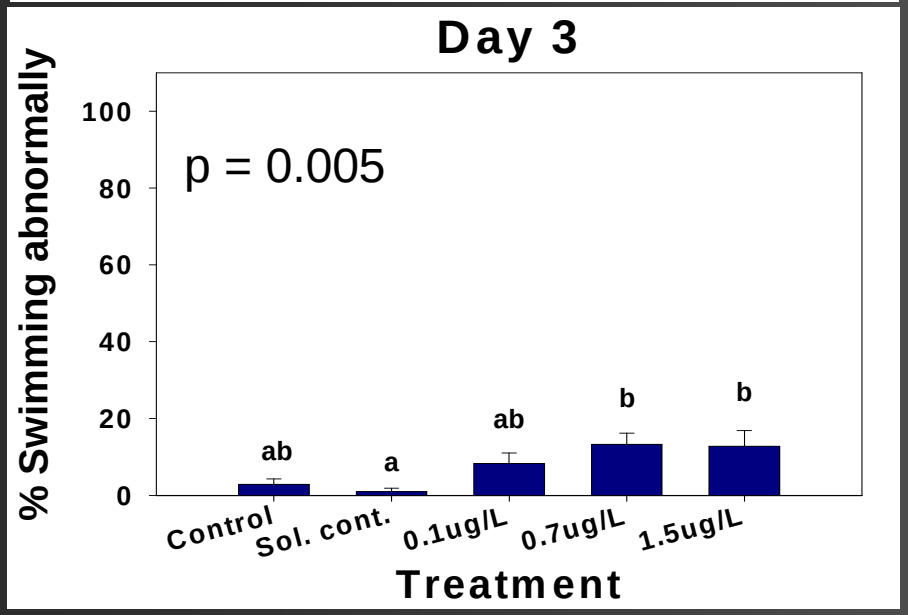


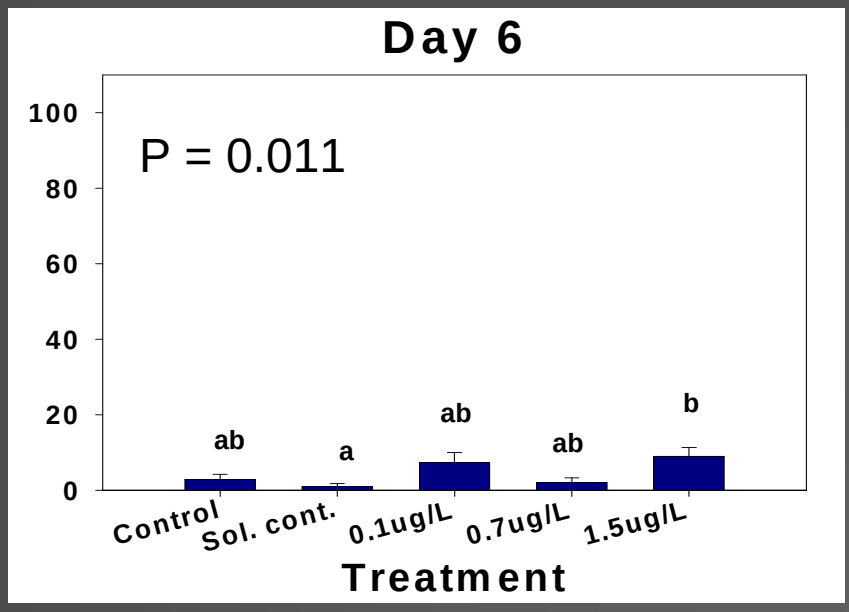
Floyd et al., in review

SWIMMING ABILITY



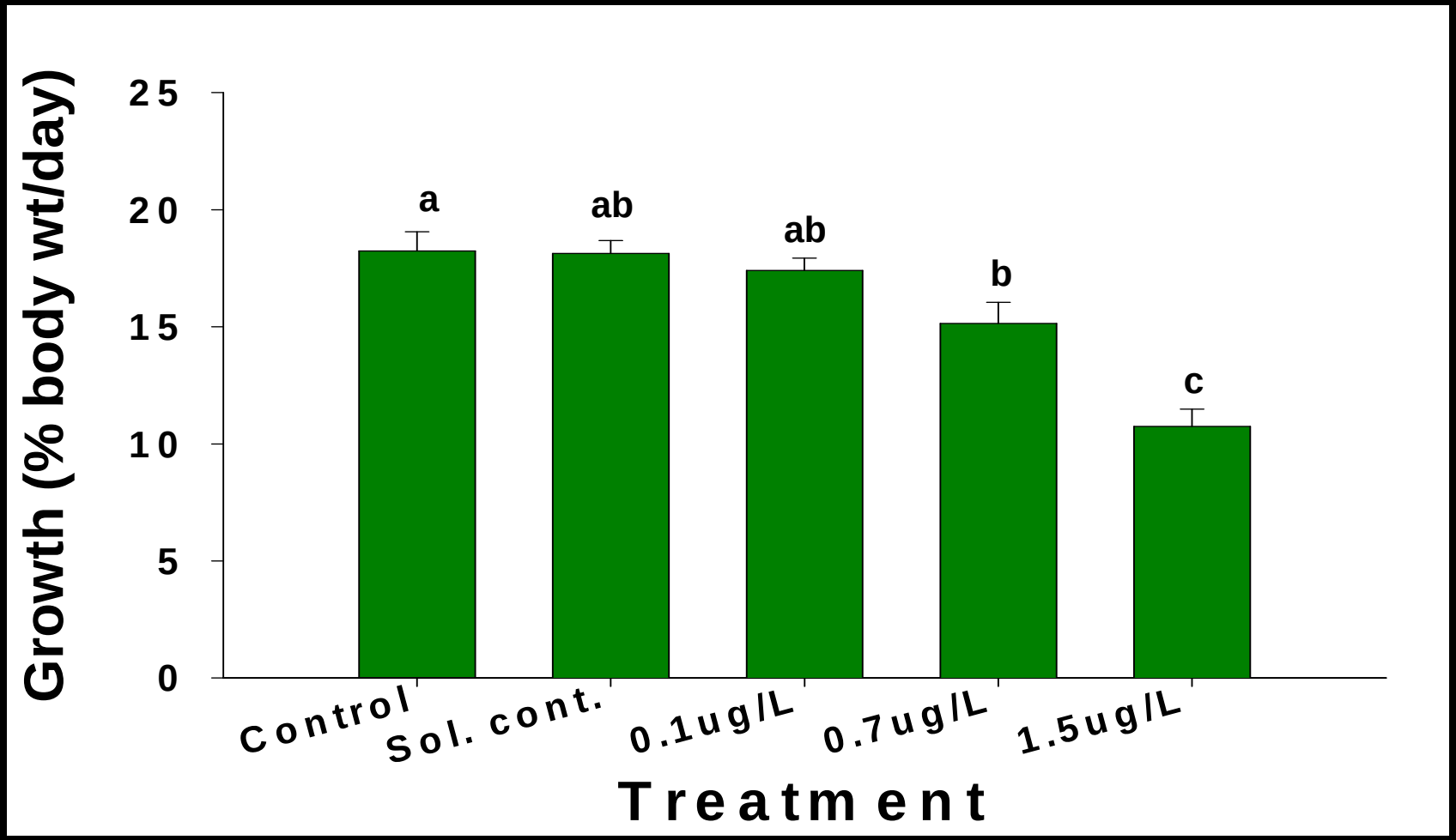






Floyd et al., in review

7-d GROWTH



Floyd et al. (in review)

SUMMARY AND CONCLUSIONS

- **Hydrophobic, less water soluble & less mobile**
- **Exposure time in water column may be short**
- **Environmental concentrations reported so far are within the range of acutely toxic concentrations for aquatic organisms.**
- **Pyrethroids at sublethal concentrations and in combination with other stressors (disease, predators) likely decrease ecological fitness.**

The End