STRANDBÚNAÐUR 2018

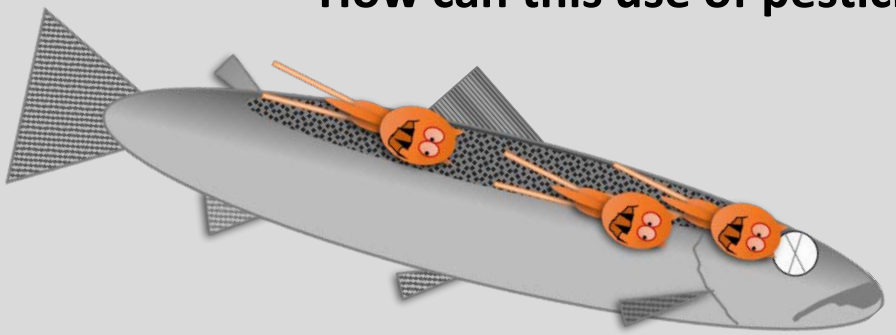
Grand Hótel Reykjavík, 19. – 20. mars 2018

Renée Katrin Bechmann

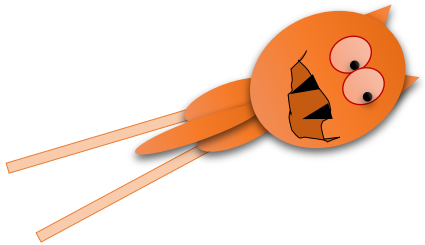
Environmental effects of chemicals used against salmon lice

In aquaculture, pesticides are used against parasitic salmon lice to protect the health of farmed and wild Atlantic salmon.

- How can this use of pesticides as medicine affect our coastal marine environment?



Salmon lice and the war against lice



How to get rid of lice

- Kill them with chemicals
- Use cleaner fish and other non-chemical methods
- Protect the salmon from lice in (semi-)closed cages

Economic consequences

- Costs billions for the aquaculture industry

Environmental concequences

- Animal welfare for farmed and wild salmon
- Risk for reduced stocks of wild salmon
- Animal welfare and overfishing of cleaner fish
- Risk for non-target crustaceans, and the rest of the coastal ecosystem

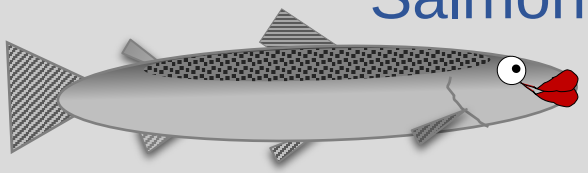
IRIS

The perfect anti-salmon lice medicine

Low toxicity to:

Humans

Salmon



Must eat the chemical or swim in a solution

✓ Fast depuration after treatment of the fish

The environment

including *non-target* crustaceans

✓ Fast degradation
✓ Low bioavailability
✓ Low toxicity

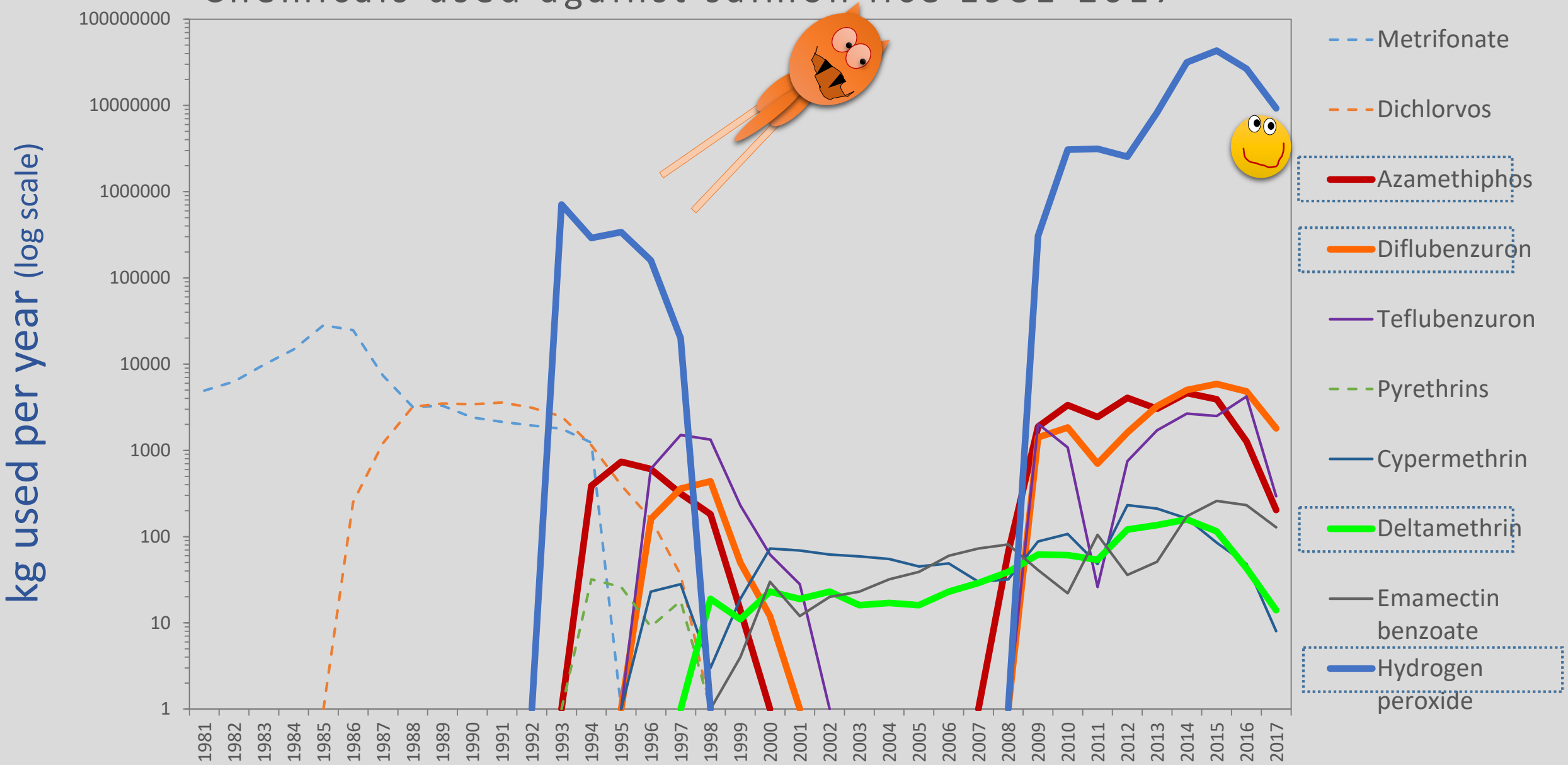
High toxicity to:

Salmon lice
= target crustaceans

Must die!
… and not develop resistance

IRIS

Chemicals used against salmon lice 1981-2017



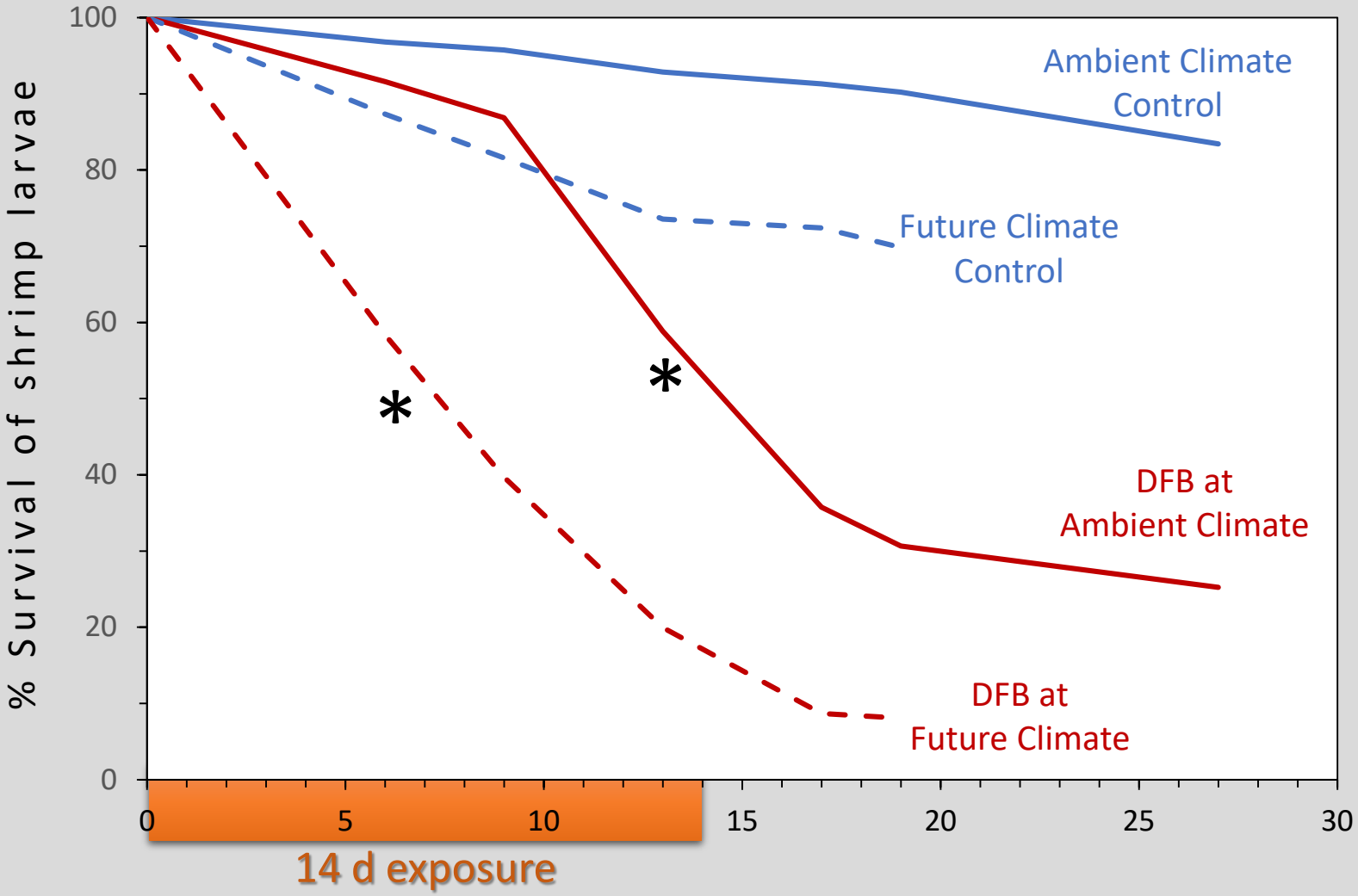
IRIS

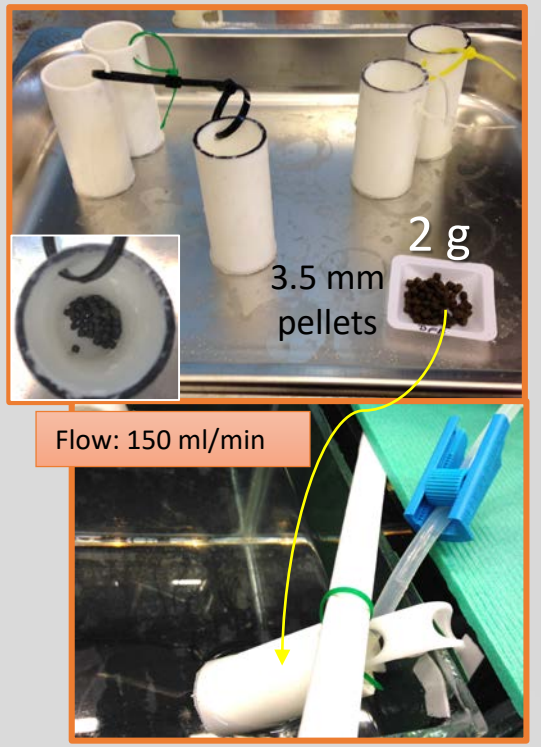
Effects of Releeze

medicine feed

containing diflubenzuron

High mortality of shrimp larvae exposed to tiny particles of medicated feed with diflubenzuron (DFB) as the active ingredient



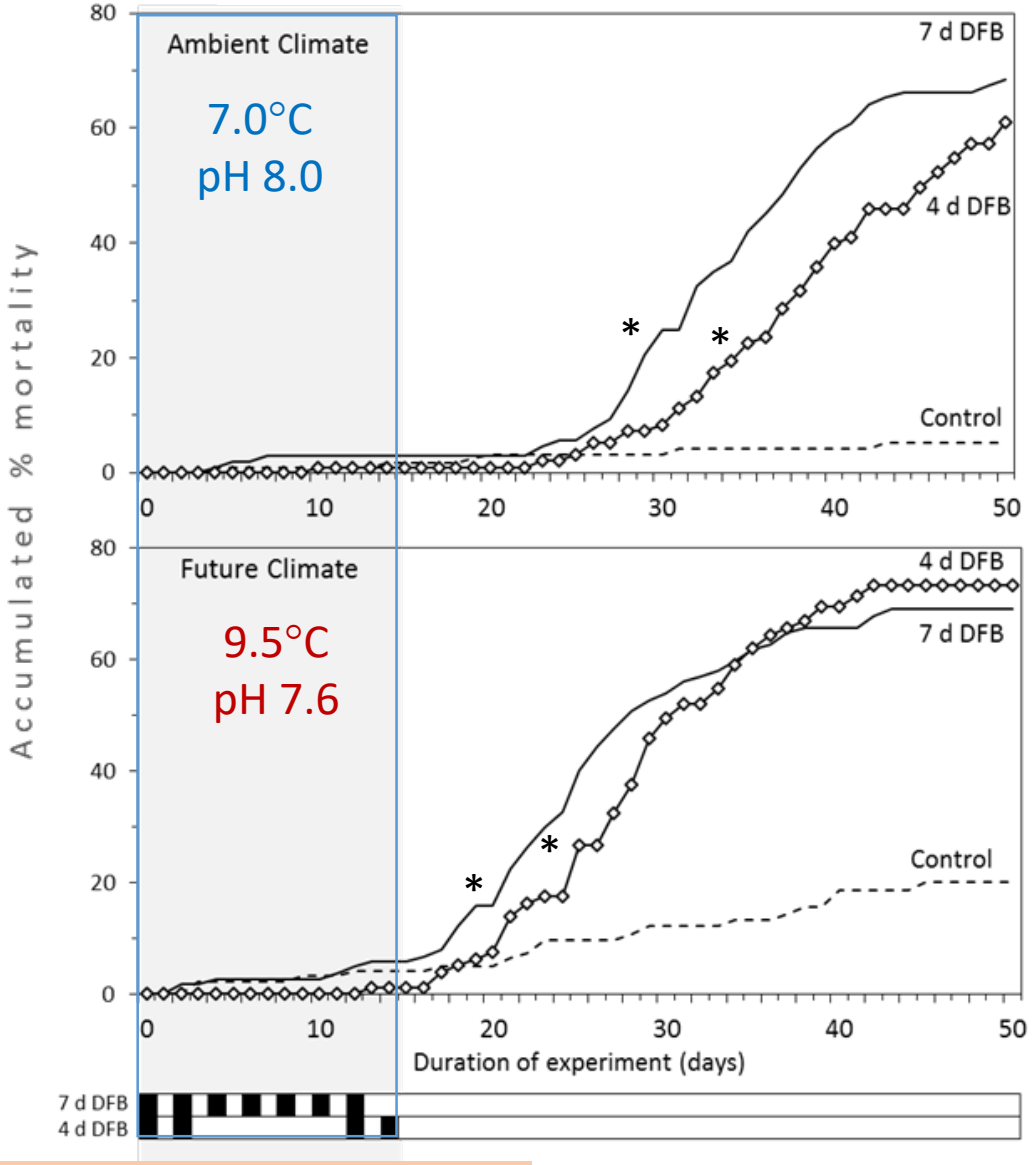


Pandalus borealis

Ambient climate: pH 8.0, 7.0 °C
Future Climate: pH 7.6, 9.5 °C

IRIS

Mortality



Female shrimp were fed Releeze a few times before moulting

High mortality of adult shrimp eating a few pellets Releeze

- Control shrimp moulted successfully
- Hardly any shrimp exposed to medicine feed for two weeks managed to moult, and most died during moulting
- 4 pellets Releeze (ca 0.1 gram) is enough to kill adult shrimp that need to moult during the next 2-3 weeks
- 8 million kg of this medicine feed was used in 2016

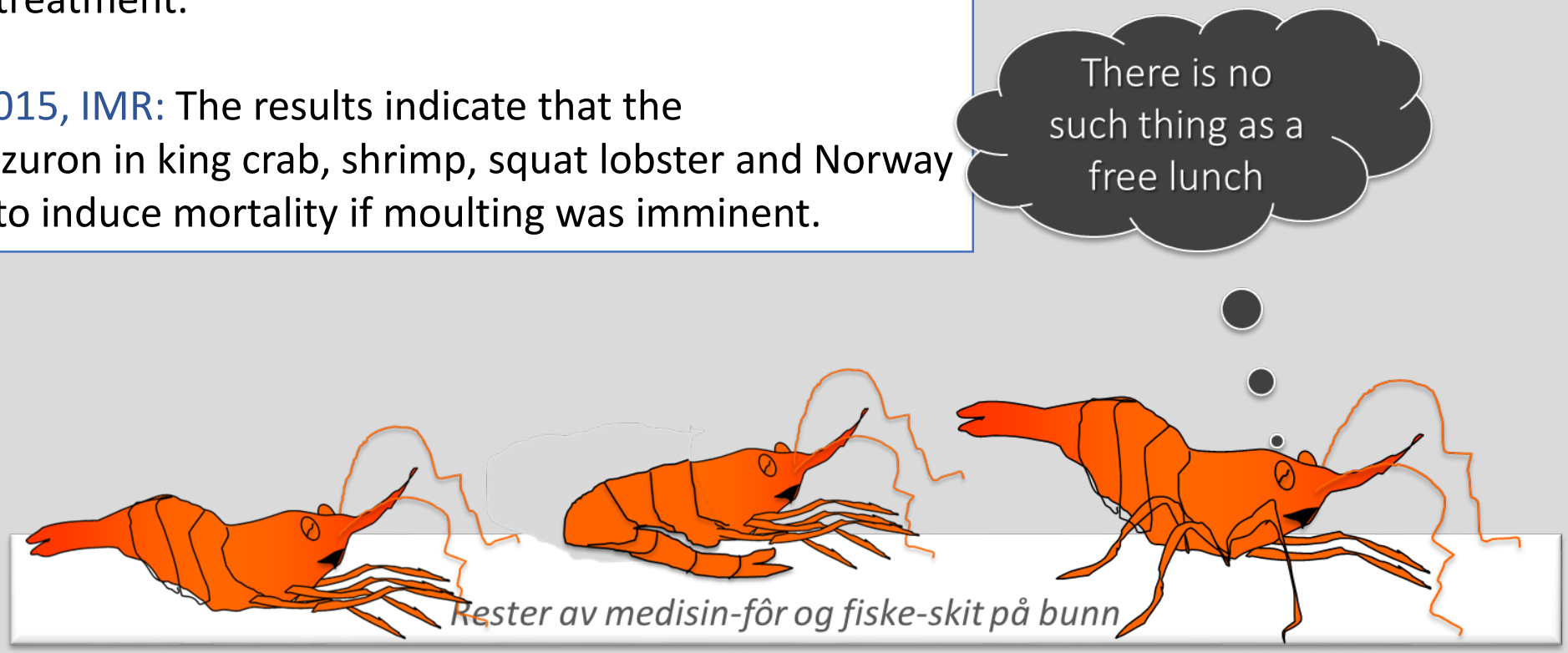
Mean for 6 replicate tanks with 17 shrimps in each

IRIS

- Are flubenzurones (from feed) bioavailable for crustaceans in the field?

- Yes

- ✓ Langford *et al.* 2014, NIVA: Diflubenzuron and teflubenzuron were detected in shrimp, crab and blue mussels sampled 3 weeks after treatment.
- ✓ Samuelsen *et al.* 2015, IMR: Teflubenzuron was still detected in crustaceans and polychaets 8 months after treatment.
- ✓ Samuelsen *et al.* 2014 & 2015, IMR: The results indicate that the concentrations of teflubenzuron in king crab, shrimp, squat lobster and Norway lobster were high enough to induce mortality if moulting was imminent.



IRIS

Effects of «bath chemicals»

Hydrogen peroxide – in Paramove

Strong oxidizing agent, non-specific

Azamethiphos – in Salmosan

Neurotoxic acetylcholinesterase inhibitor

..... leading to paralysis

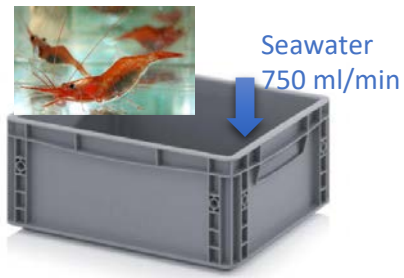
Deltamethrin – in AlphaMax

Neurotoxic ... leading to paralysis

IRIS

Experiment with shrimp (*Pandalus borealis*)

10 shrimp with eggs



x 6 tanks

Control

AlphaMax

DEL

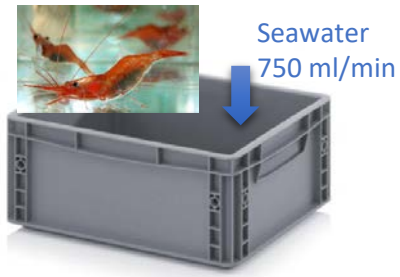
Deltamethrin

5 L
stock solution

3.2 ml/min

Peristaltic pump
with 6 pump heads

10 shrimp with eggs



x 6 tanks

DEL

Salmosan

AZA

Azamethiphos

5 L
stock solution

Peristaltic pump
with 6 pump heads

10 shrimp with eggs

x 6 tanks

AZA

AlphaMax

DEL

Deltamethrin

5 L
stock solution

Peristaltic pump
with 6 pump heads

Salmosan

AZA

Azamethiphos

5 L
stock solution

Peristaltic pump
with 6 pump heads

10 shrimp with eggs

x 6 tanks

AZA + DEL

Paramove

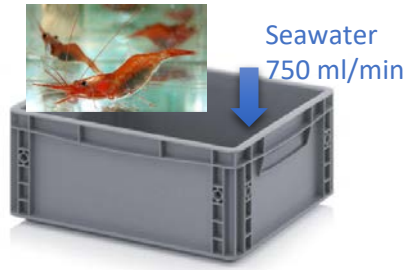
H_2O_2

Hydrogen peroxide

5 L
stock solution

Peristaltic pump
with 6 pump heads

10 shrimp with eggs

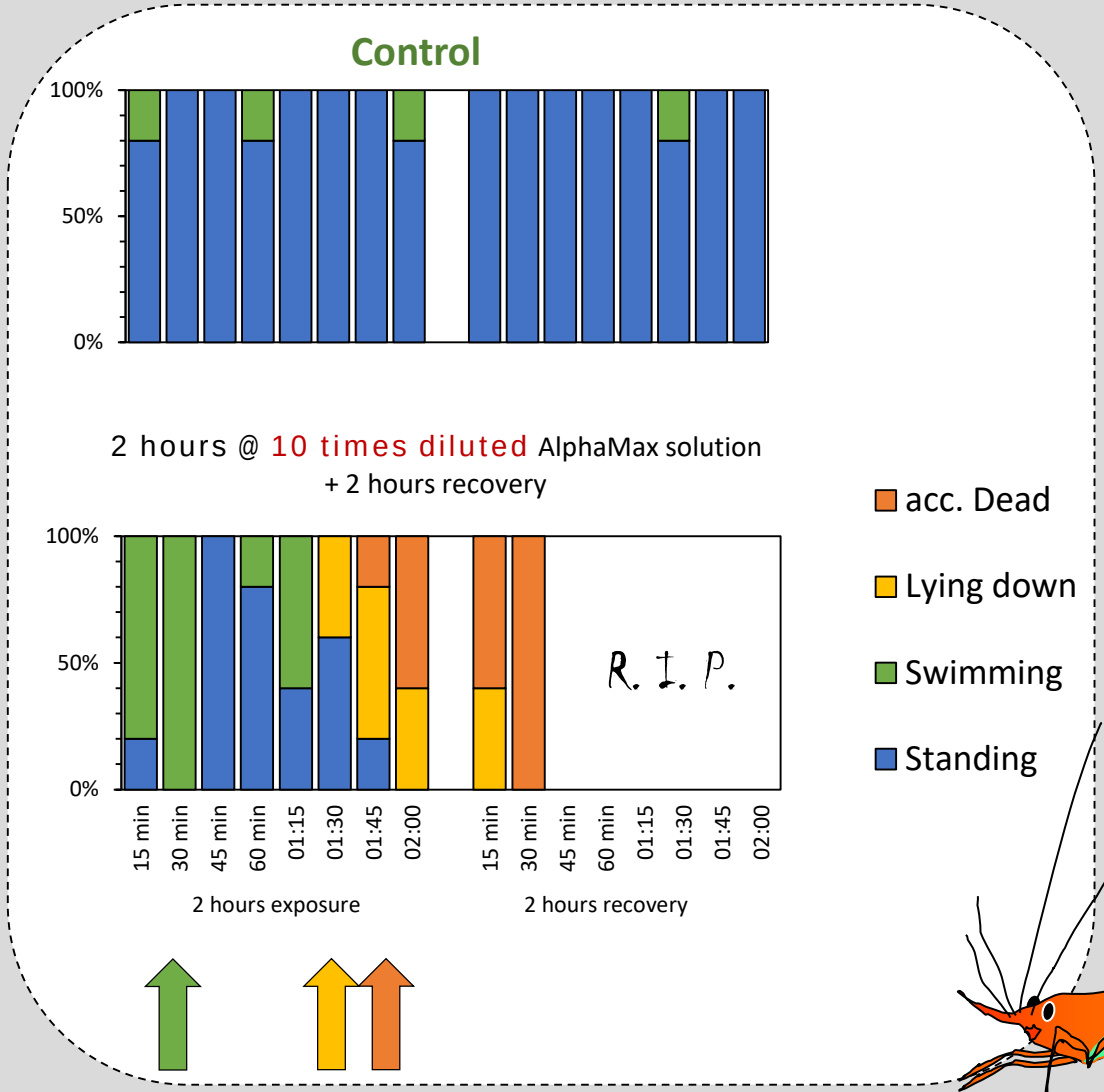


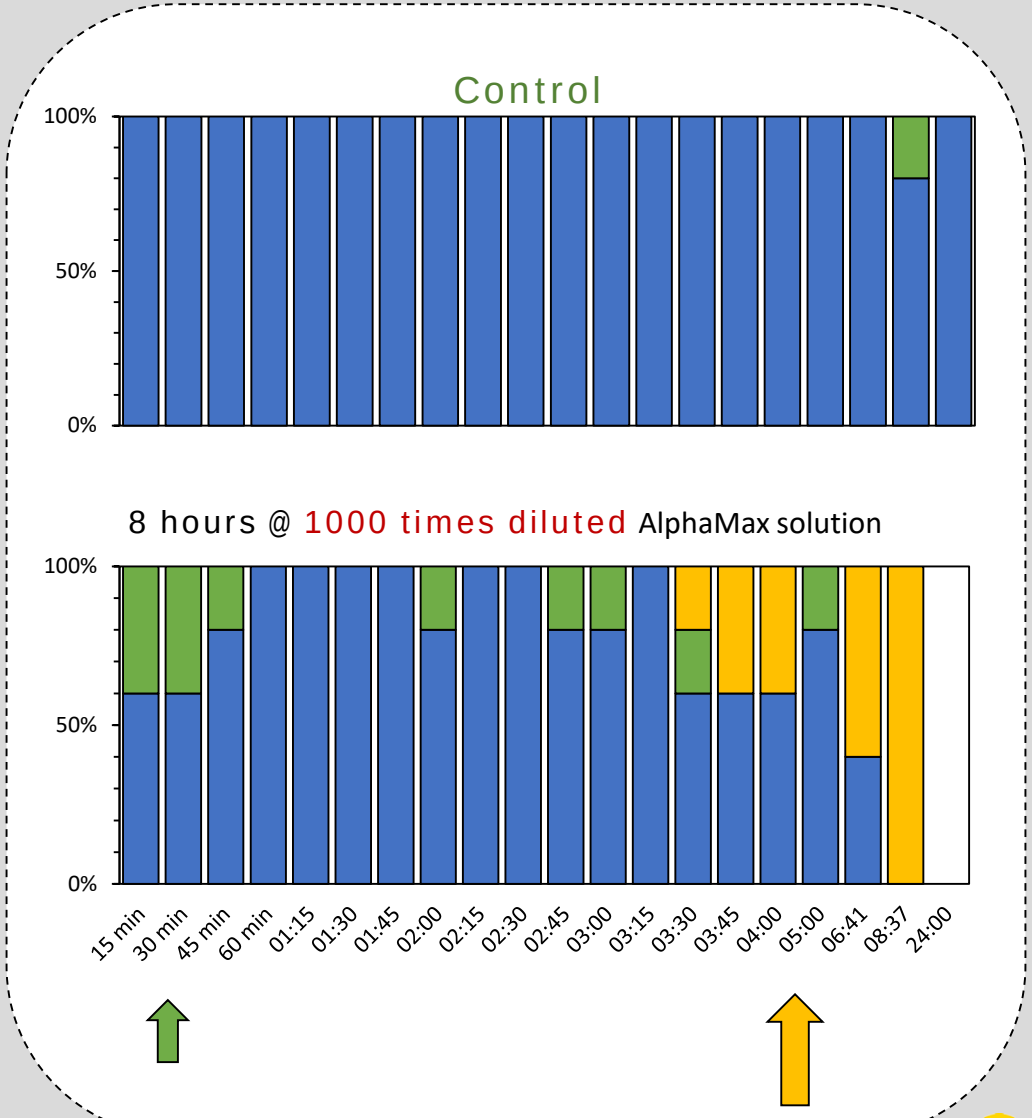
x 6 tanks

H2O2

IRIS

Sceening tests with AlphaMax (deltamethrin)

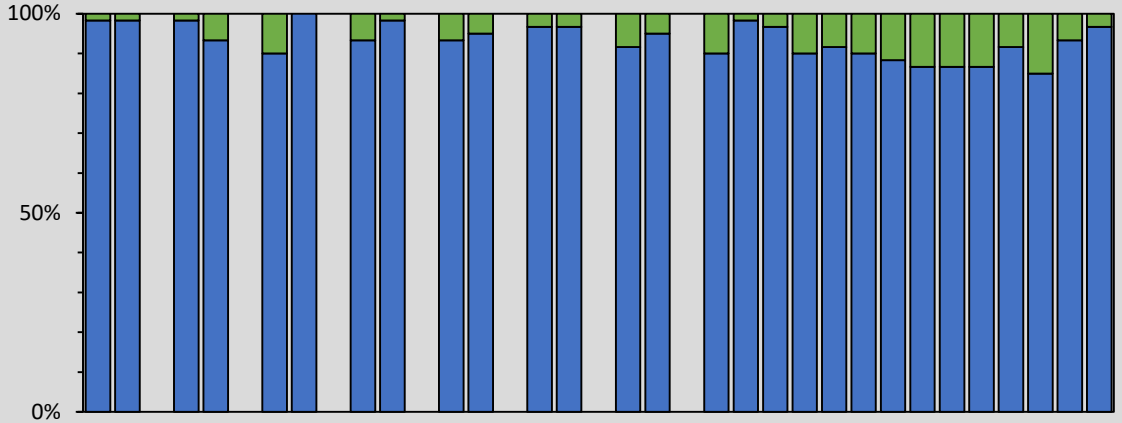




Main experiment, adult shrimp, means, n = 6

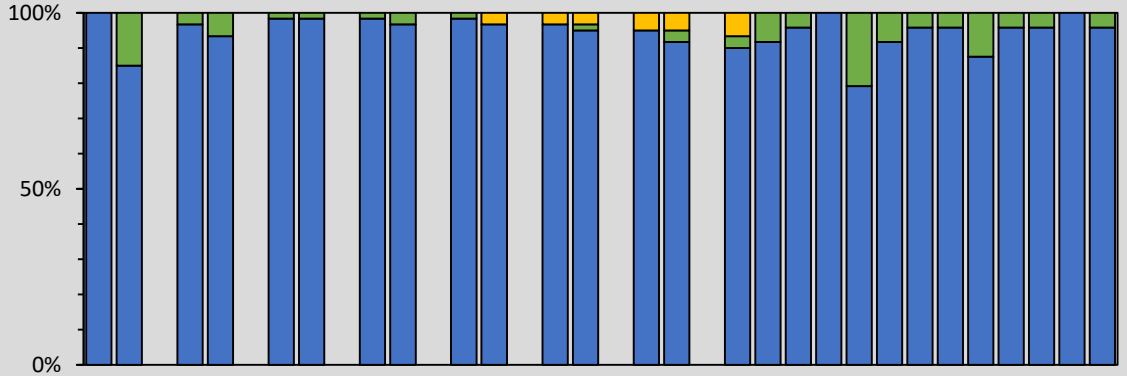
acc. Dead
Lying down
Swimming
Standing

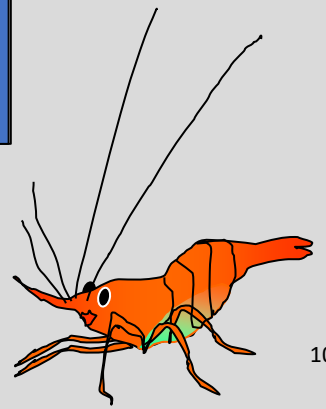
Control



2 ng/L deltamethrin

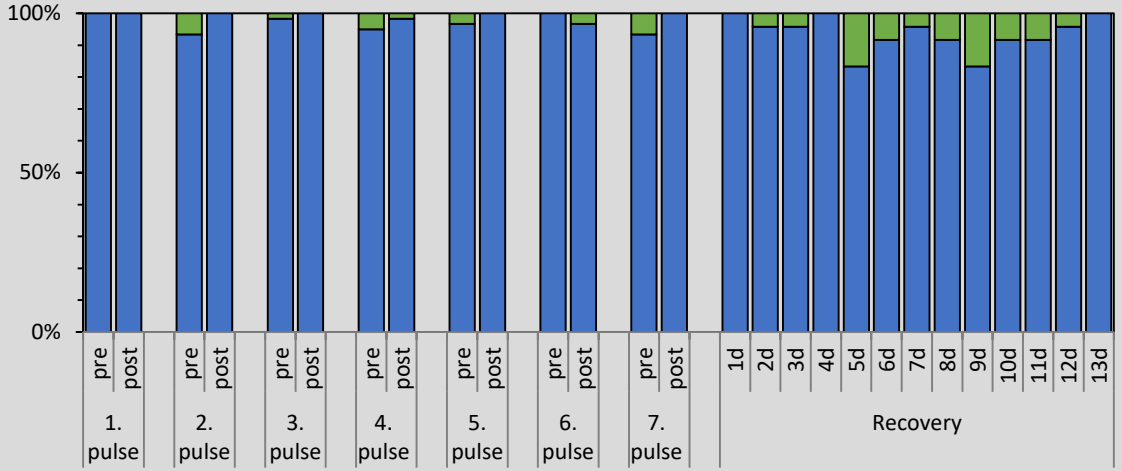
1000 times diluted salmon treatment concentration of AlphaMax





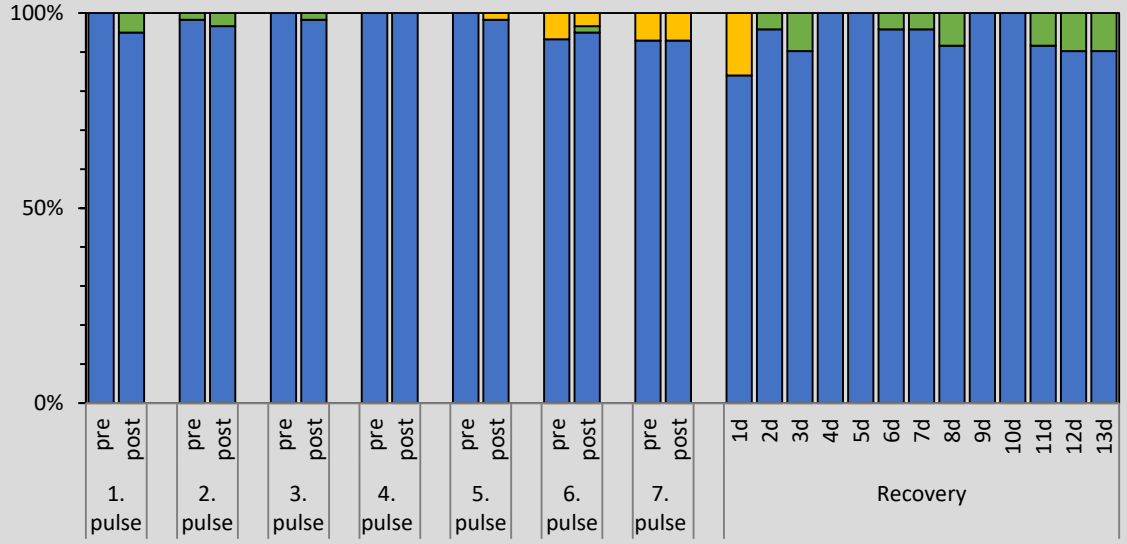
0.1 µg/L azamethiphos

1000 times diluted salmon treatment concentration of Salmosan



0.1 µg/L azamethiphos + 2 ng/L deltamethrin

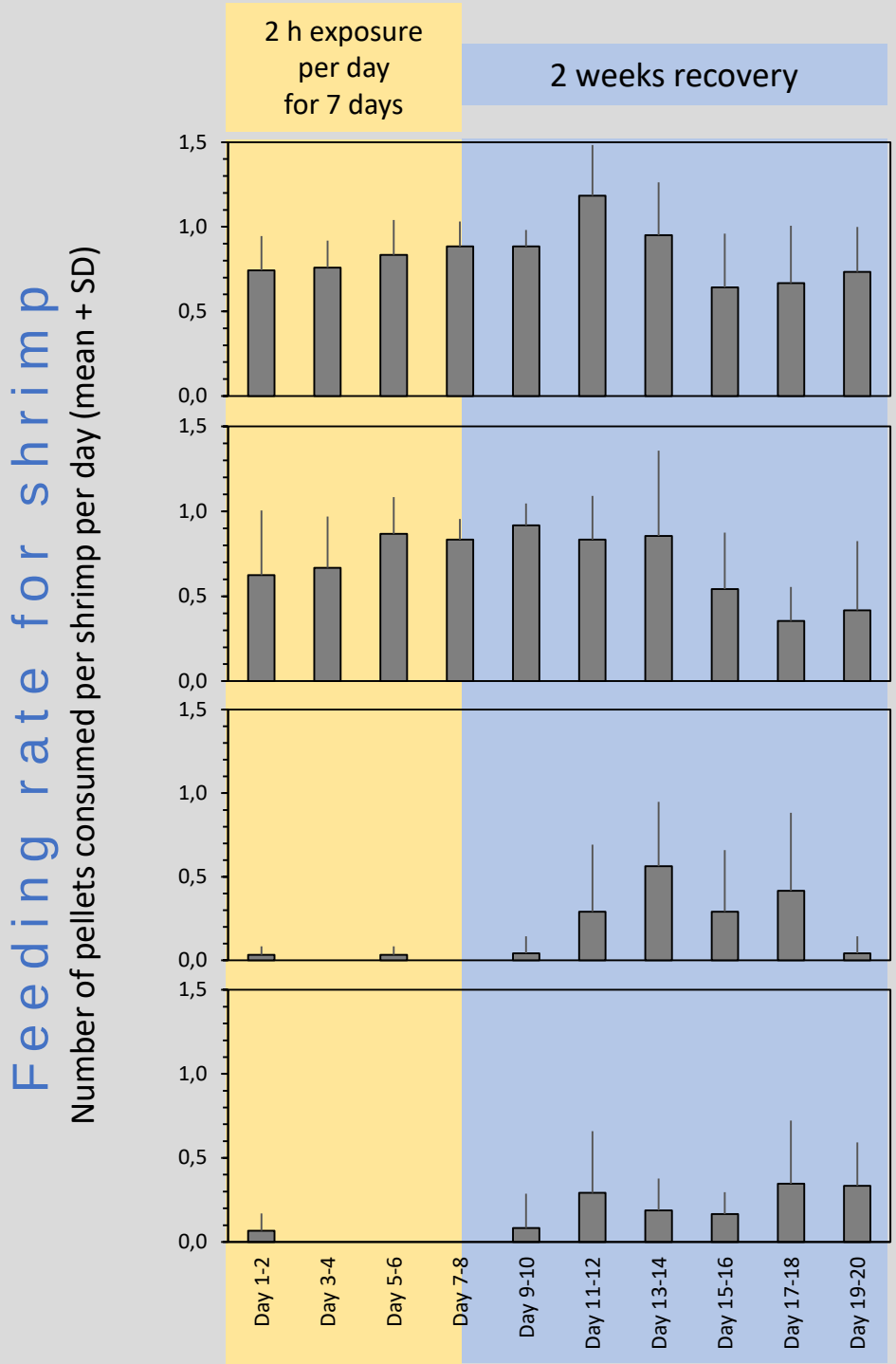
1000 times diluted of the salmon treatment concentrations of Salmosan and AlphaMax



1 dead shrimp after 7 pulses

IRIS

1000 times diluted AlphaMax solution caused reduced feeding for adult shrimp



Control

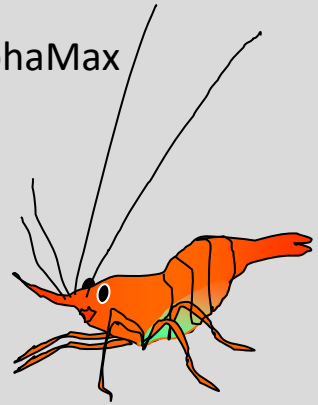
0.1 µg/L azamethiphos

1000 times diluted salmon treatment concentration of Salmosan

2 ng/L deltamethrin (AlphaMax)

1000 times diluted salmon treatment concentration of AlphaMax

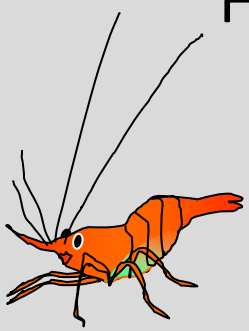
1000 times diluted mix of Salmosan and AlphaMax



n = 6 replicate tanks per treatment, each with 10 shrimp at start

IRIS

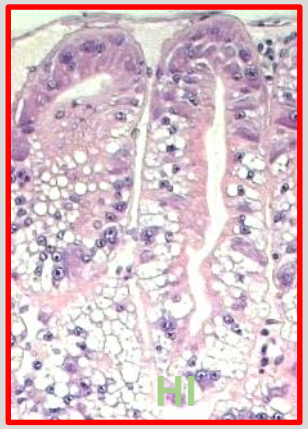
Histological assessment of adult shrimp – Digestive gland alterations *(work in progress)*



7 x 2 hours exposure to 1000 times diluted treatment water of Salmosan and/or AlphaMax

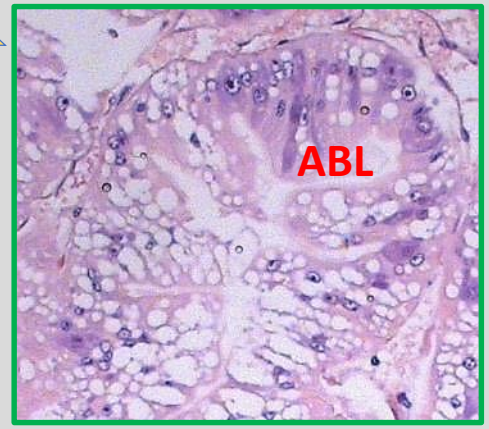
Control

Salmosan



Rc

AlphaMax

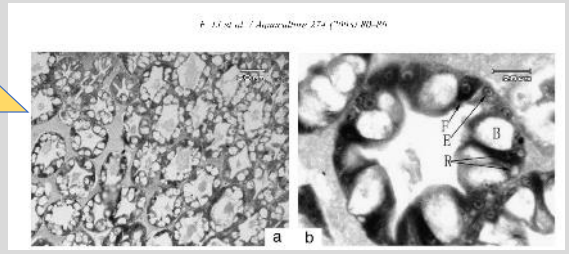


Rc

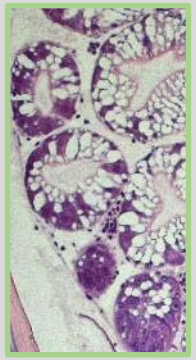
Salmosan + AlphaMax

Rc

Bc



Abnormal lumen (ABL) and hemocytic infiltration (HI) in the interstitial sinus (IS) were observed.



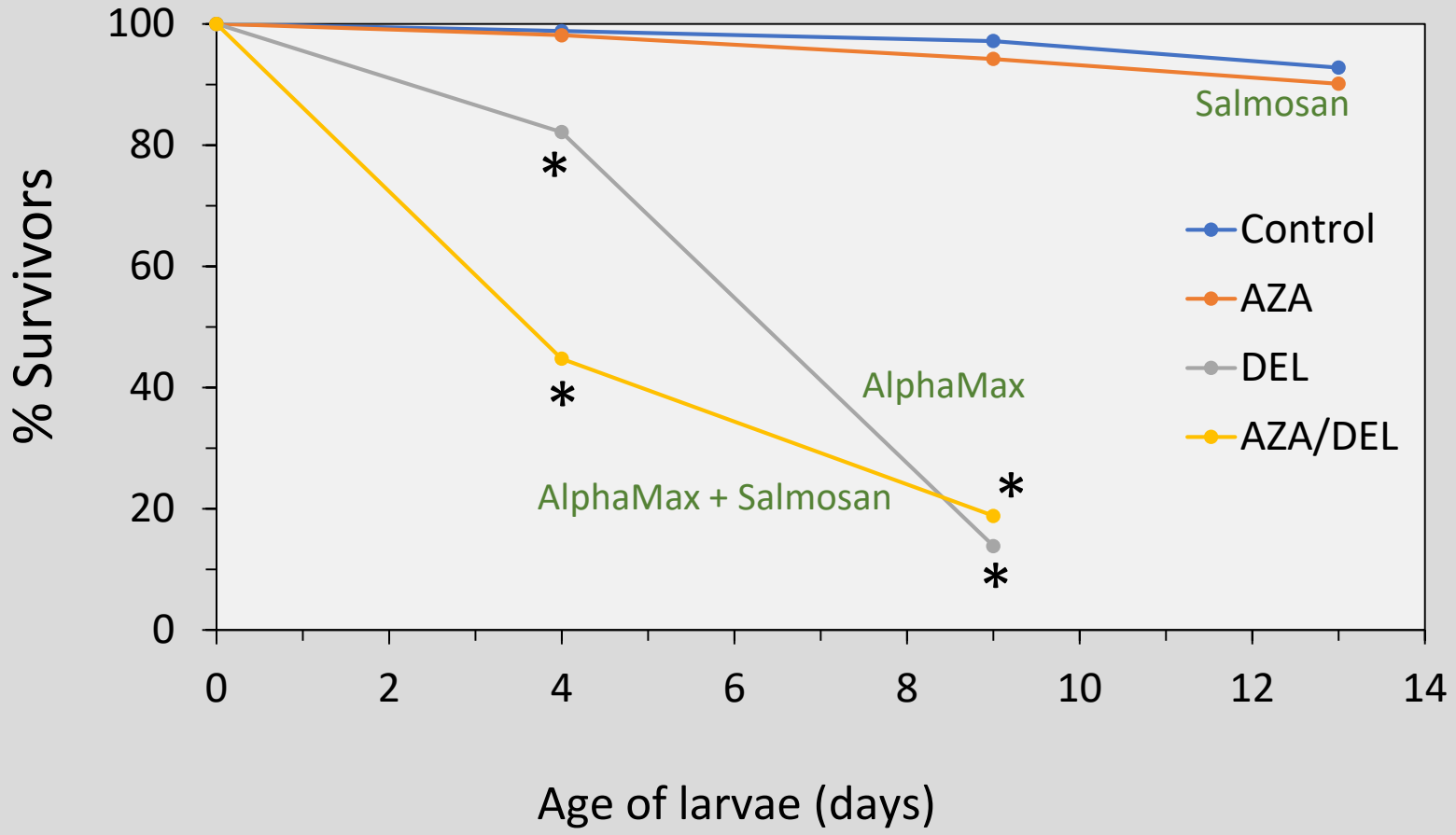
<u>Preliminary</u> conclusion:

Both Salmosan and AlphaMax caused tissue damage, and it was worse in the combined exposure

IRIS

DIRECT EXPOSURE OF SHRIMP LARVAE

High mortality of larvae exposed for 2 hours to 1000 times diluted AlphaMax or AlphaMax + Salmosan



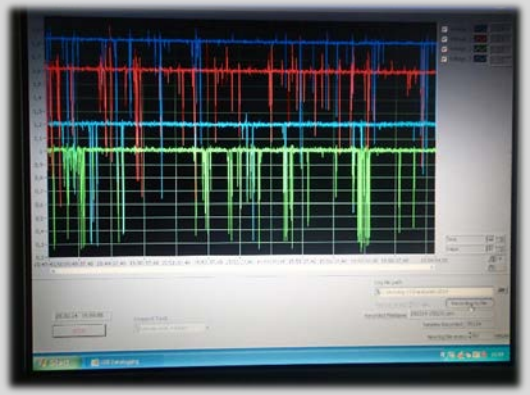
2 hour exposure
+ two weeks recovery

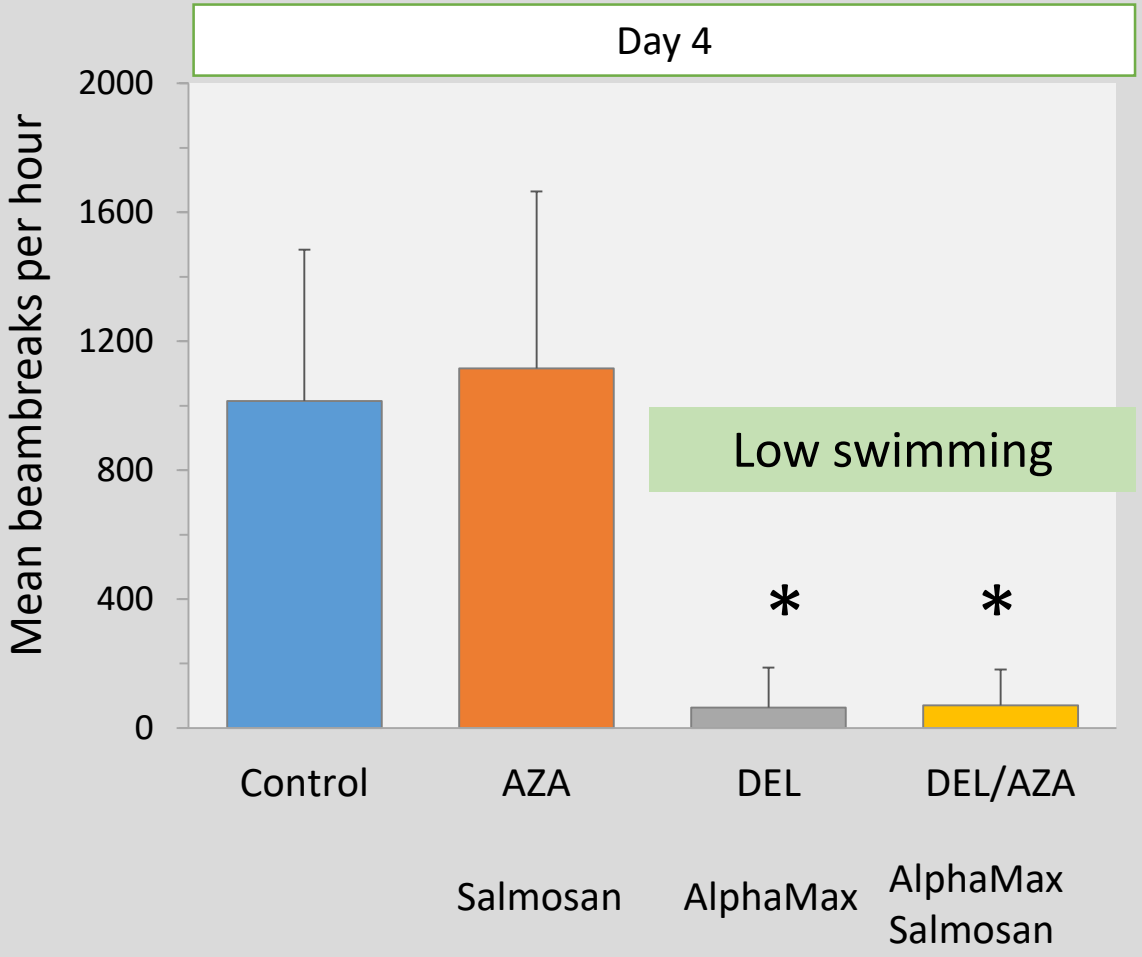
IRIS

DIRECT EXPOSURE OF SHRIMP LARVAE

Low swimming activity of larvae exposed for 2 hours to 1000 times diluted

AlphaMax or AlphaMax + Salmosan





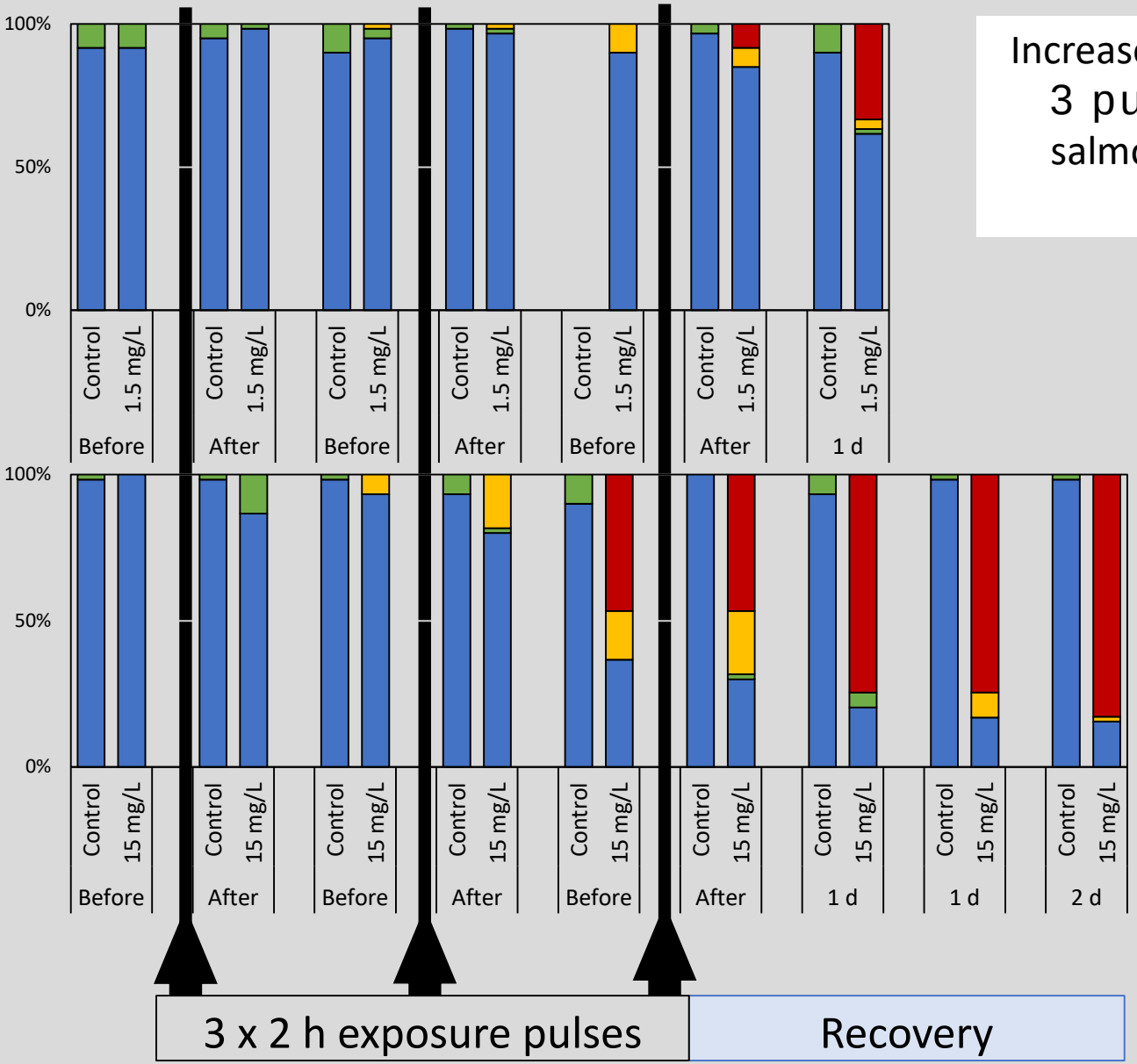
2 hours exposure
+ two weeks recovery

IRIS

- How do shrimp respond to pulses of diluted Paramove (H_2O_2) treatment water?

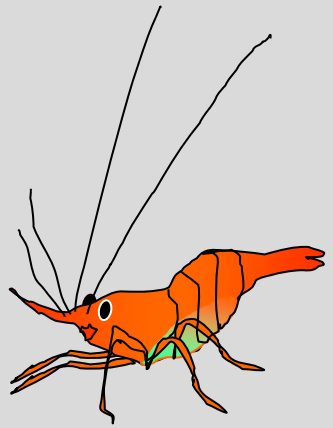
IRIS

High mortality of adult shrimp exposed to diluted Paramove (H_2O_2)



Dead
Immobilized
Swimming
Standing

Increased mortality after exposure to 3 pulses of 1000 times diluted salmon treatment concentration



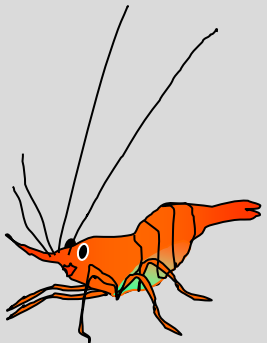
Very high mortality after exposure to 3 pulses of 100 times diluted salmon treatment concentration

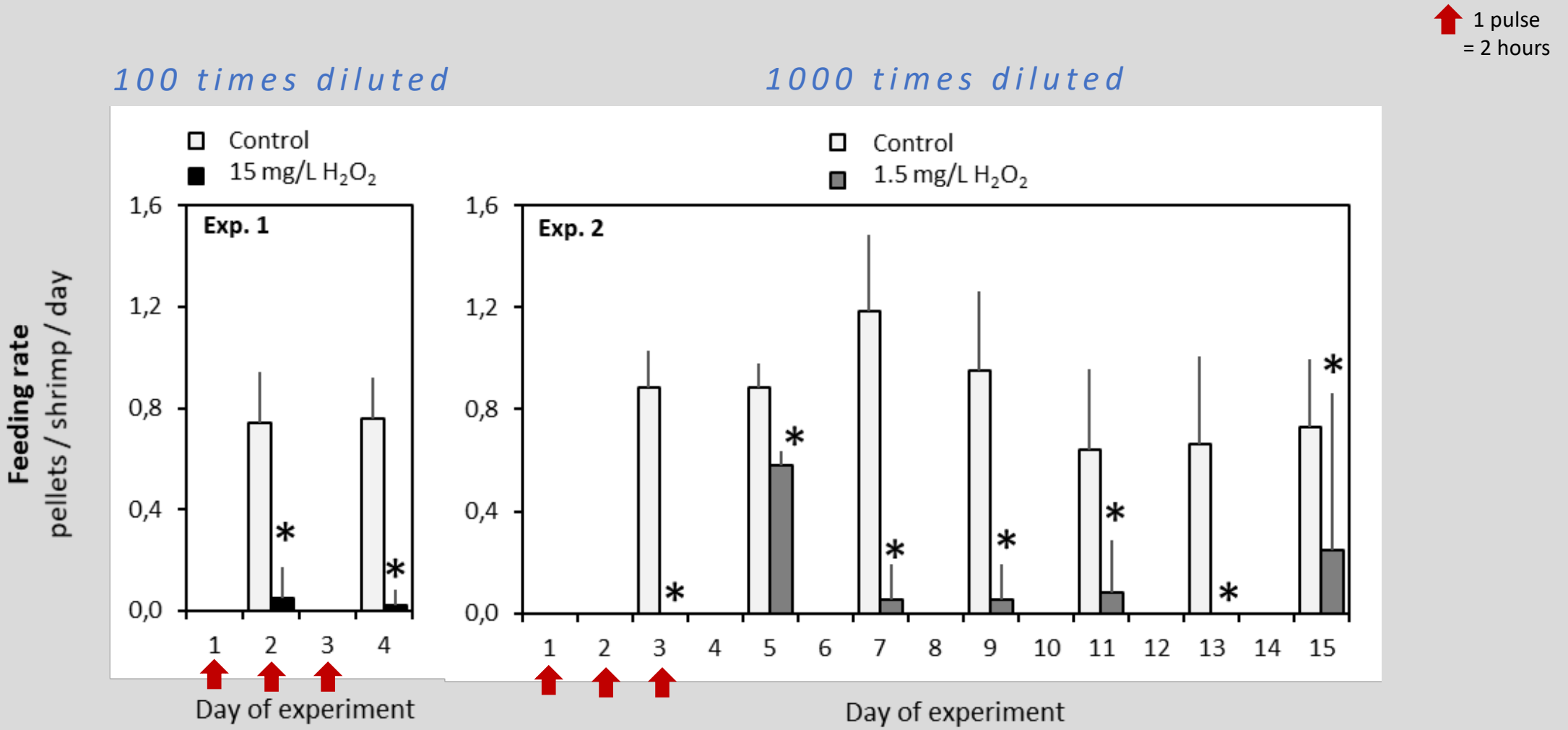
Mortality also increased 3 days after 1 pulse exposure:

Delayed effects!

IRIS

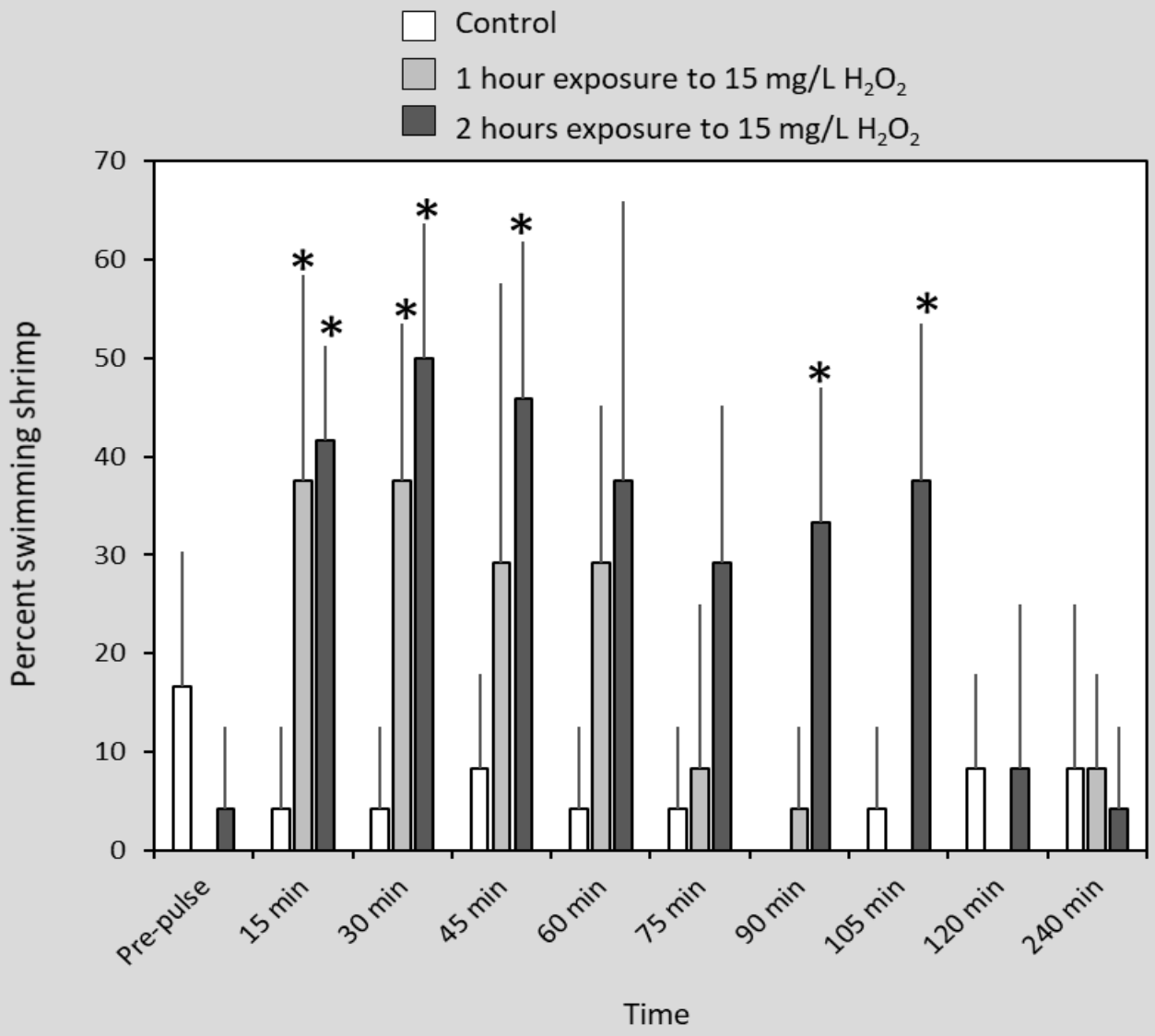
Significantly reduced feeding rate for shrimp during and after exposure to 3 pulses of 15 mg/L and 1.5 mg/L H_2O_2

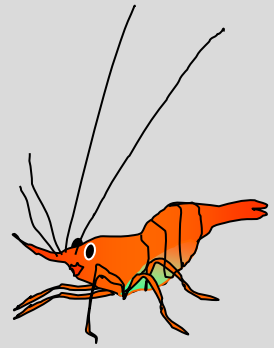




Increased swimming activity during exposure to 15 mg/L H_2O_2

100 times diluted salmon treatment concentration of Paramove

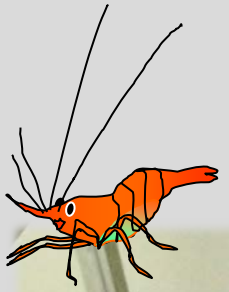




IRIS

Indications of increased swimming activity for adult shrimp also after exposure to

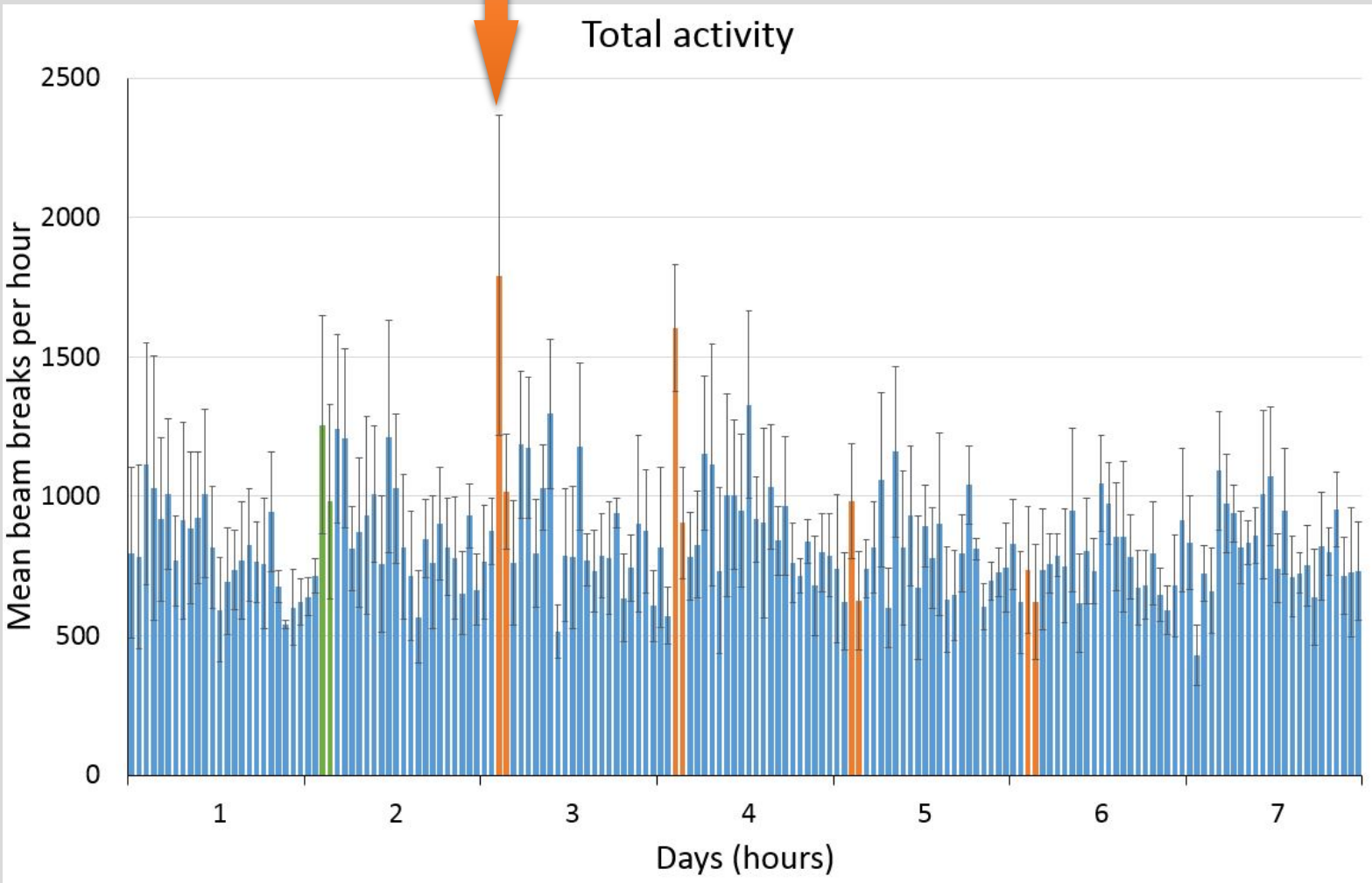
1000 times diluted treatment concentrationof Paramove



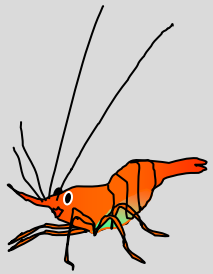
Activity of shrimp monitored continuously over seven days

H_2O_2

Mean for 4 shrimp



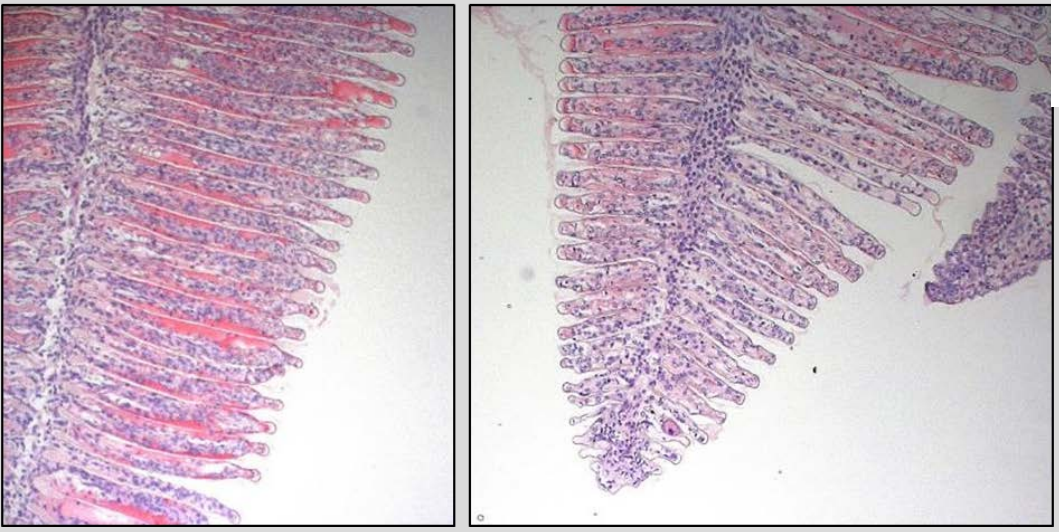
One hour exposure to 1.5 mg/L and 15 mg/L H_2O_2 caused gill damage in adult shrimp



Control

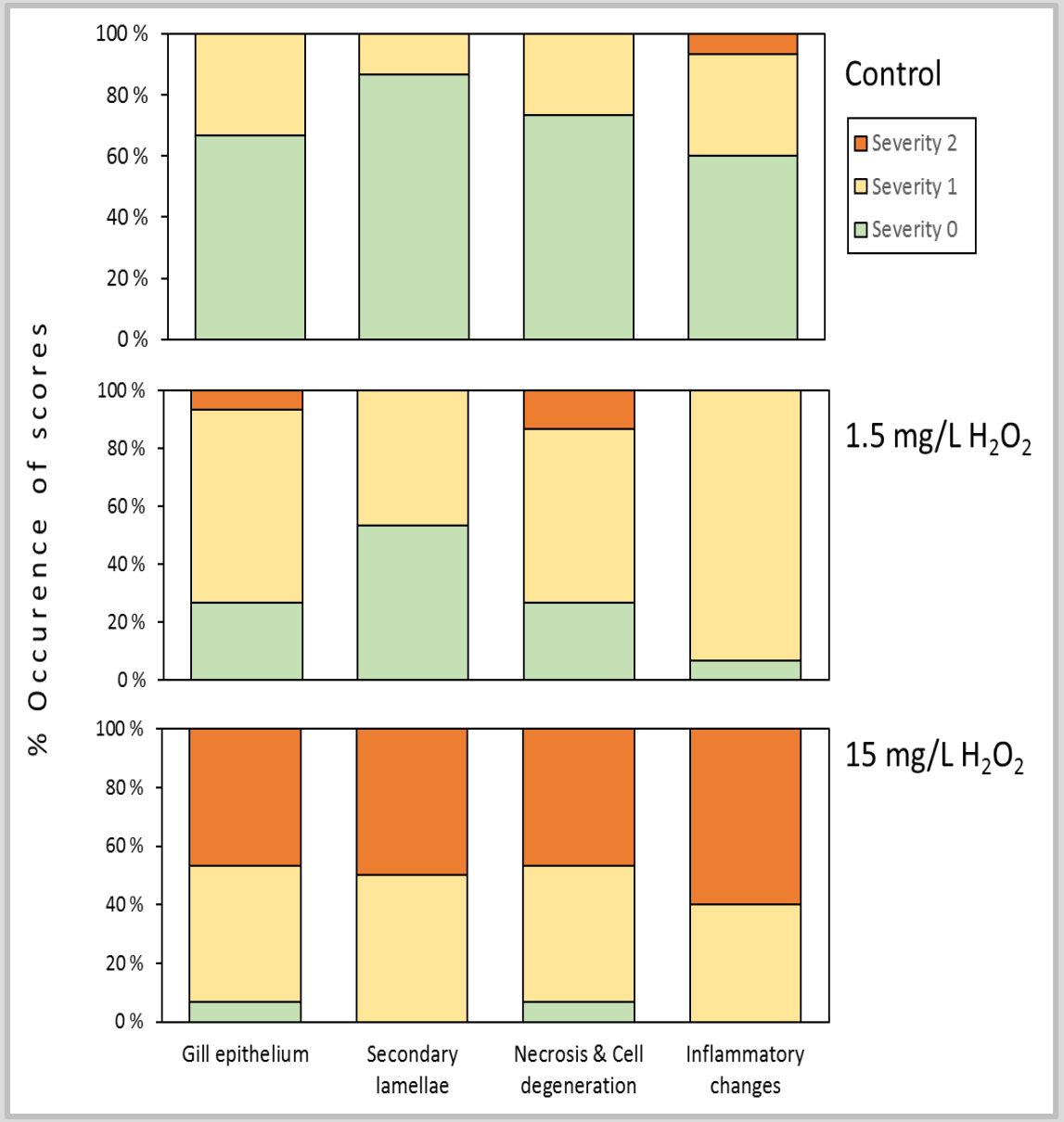
1000 times diluted
treatment solution for salmon

1.5 mg/L
H_2O_2



100 times diluted

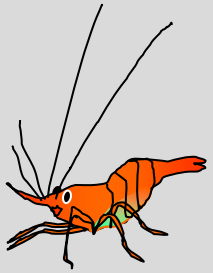
15 mg/L
H_2O_2

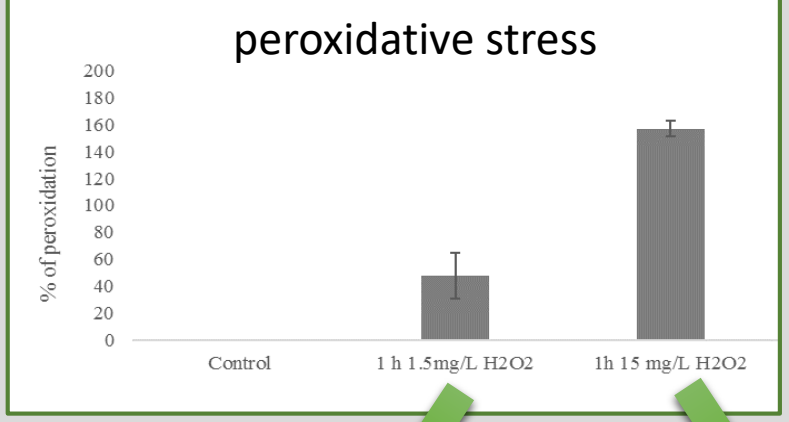


Significant **tissue damage**

in the digestive glad of adult shrimp

exposed to 1.5 mg/L and 15 mg/L H_2O_2

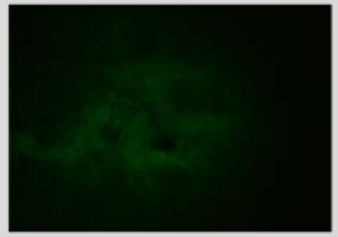


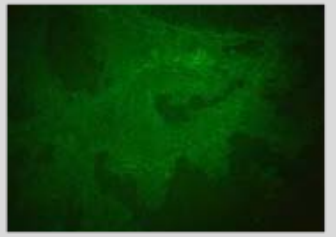


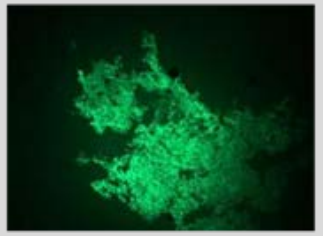
Control

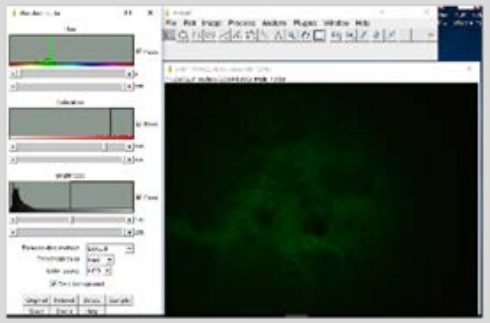
One pulse
+ one week recovery
1.5 mg/L H_2O_2

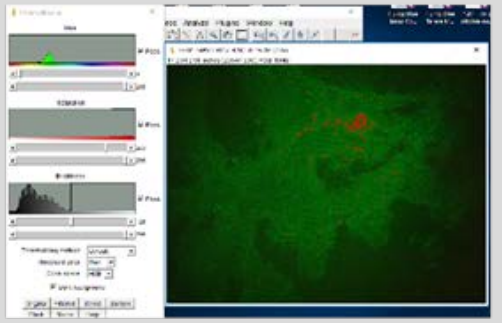
One pulse
+ one week recovery
15 mg/L H_2O_2

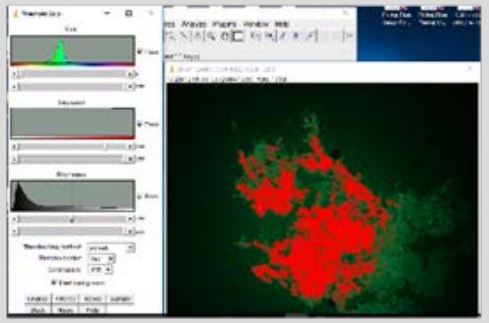












Calculated OD (entire frame):

2436

36543

IRIS

1000 times diluted treatment water of AlphaMax & Paramove, or a few pellets of Releeze medicine feed can kill shrimp

- Is dilution the solution when pesticides are used as medicine?

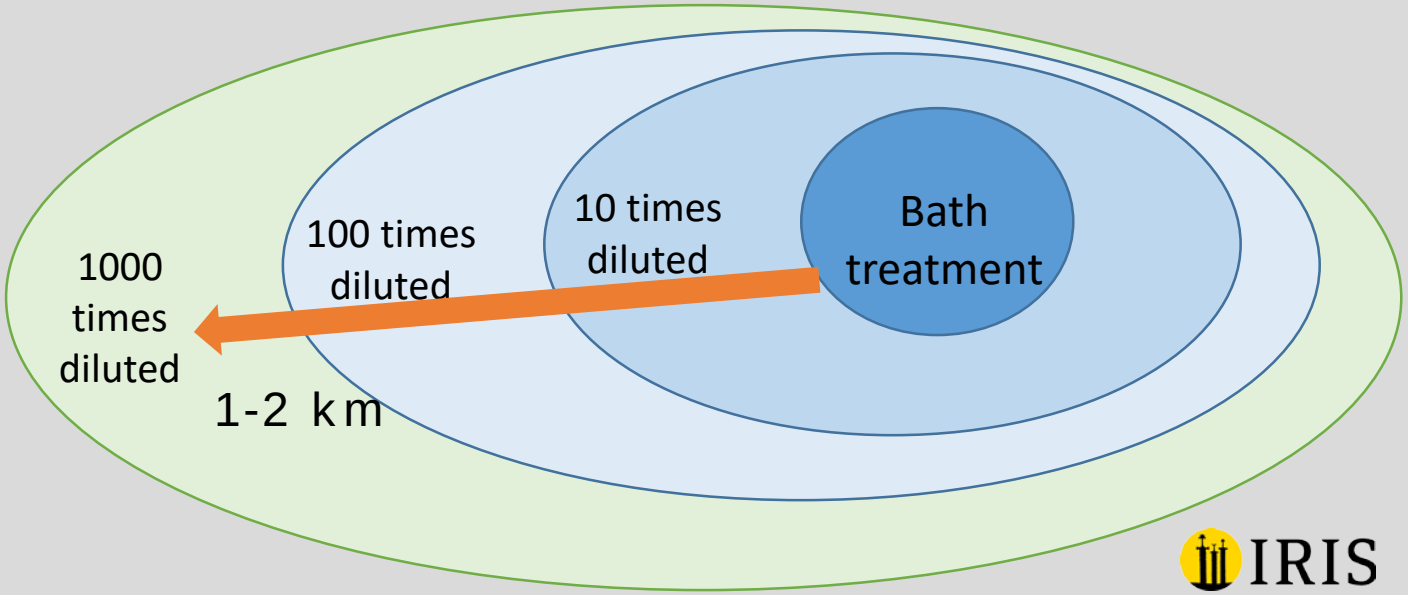
- Maybe not?

Page et al. (2014), Fisheries and Oceans Canada:

Within a couple of hours after release, bath chemicals may be advected up to 1-2 kilometers, and the concentration is estimated to be 100 – 1000 times diluted

Samuelsen et al. 2015, IMR:

Particles of medicine feed and feces from fish eating medicine can be transported more than 1 km away from the farm



IRIS

Please think about

What is acceptable?

Aquaculture is important for Norway

In 2017 we had ca. 3400 cages at 550 locations

…… x 5 in the future?

= Sustainable?

- ✓ How important is it to protect the coastal marine ecosystem? Are shrimp & co “expendable”?
- ✓ How important is it to protect wild Atlantic salmon from lice (and escaped farmed salmon)?
- ✓ Should farmed salmon be protected from lice in closed cages to stop the use of chemical treatment?

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