Exposure to chemically dispersed oil is more harmful to early stages of the Northern shrimp *Pandalus borealis* than mechanically dispersed oil.

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ITAC MEETING 2019 – 4 OCTOBER 2019

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NORCE

Create new knowledge about the petroleum resources in the Arctic and to provide essential knowledge and methodology for eco-safe exploration

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TROMS fylkeskommune
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Objectives

Obtain new data on the sensitivity of key species to petroleum discharges within **northern ecosystems**

1. Assess potential impacts of oil spill response (OSR) options

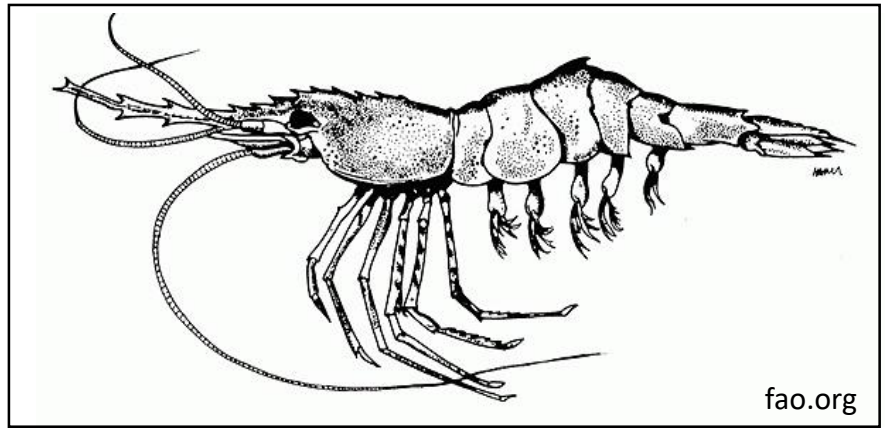
   → dispersant application

2. Provide data for risk assessment / contingency planning / NEBA

   → OSR in cold waters with best net environmental benefit

Risk of oil spills in the High North/Arctic

Pandalus borealis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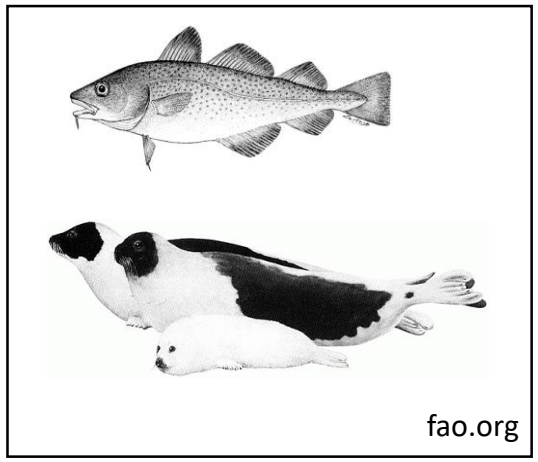
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Oil exposure set-up

- Based on protocol developed by CEDRE, France

Troll field crude oil

(Density of 0.845 kg L^{-1}, API gravity 35.9, Total sulphur 0.19 % wt)

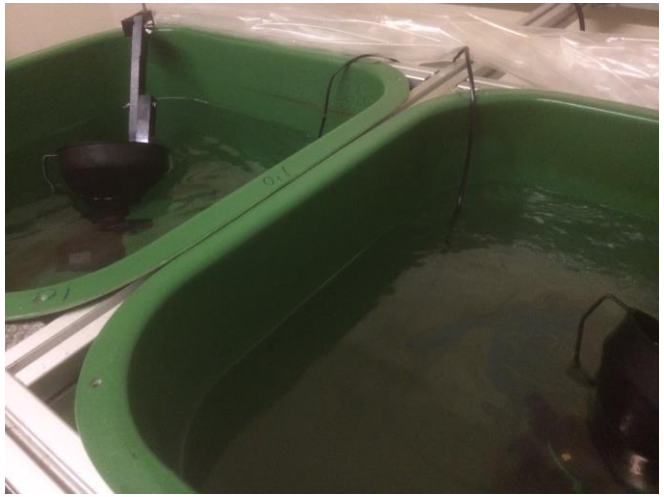
Dasic Slickgone NS (Dasic International Ltd)

(Type 3 concentrate dispersant used worldwide, largest national stockpile in Norway, effective dispersant for Troll oil)

- 1: 25 dispersant to oil ratio (4% w/w)

Oil exposure set-up

High energy mixing



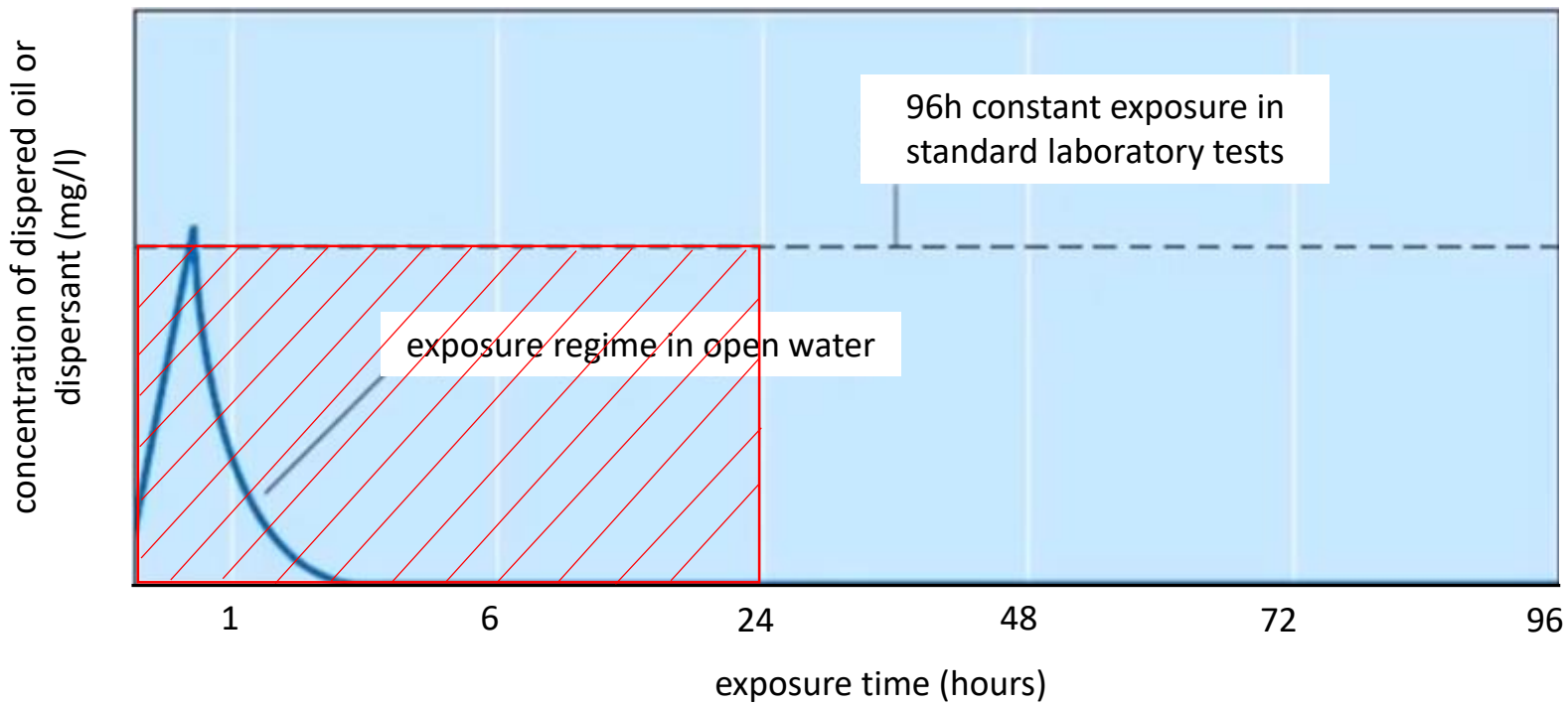
24h later

10x

Static exposure in open bottles

- at 5°C
- salinity (34 ppt)
- artifical light conditions (10h low intensity light : 14h darkness)

Experimental design



Study 1 24h

Study 2 6h

1h

Experimental design

Four treatments: clean seawater (**control**)

dispersant only (**D**)

mechanically dispersed oil (**MDO**)

chemically dispersed oil (**CDO**)

Study 1 24h → 6 days

Dilution series: High (**H**), 10x Medium (**M**), 100x Low (**L**)

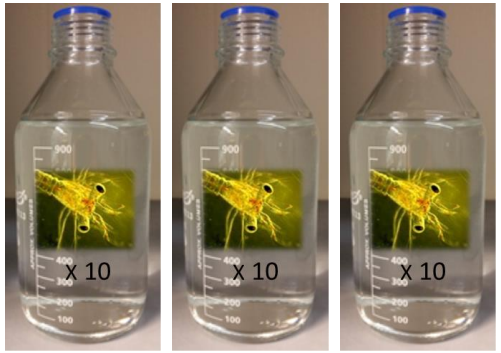
Study 2 6/1h → 30 days

High concentration

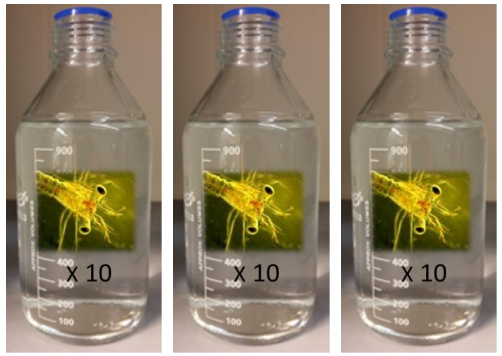
- **Survival**
- **Feeding rate**
- **Growth**
- **Developmental time**

Experimental design

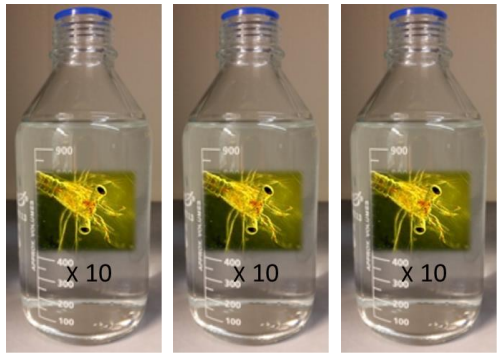
Exp. 1



Exp. 2



Exp. 3



3 exposure bottles/ treatment/ concentration

3 consecutive replicate experiments -> increase data robustness

Working hypotheses

Dispersant application increases adverse effects on shrimp larvae after 24 h exposure to oil.

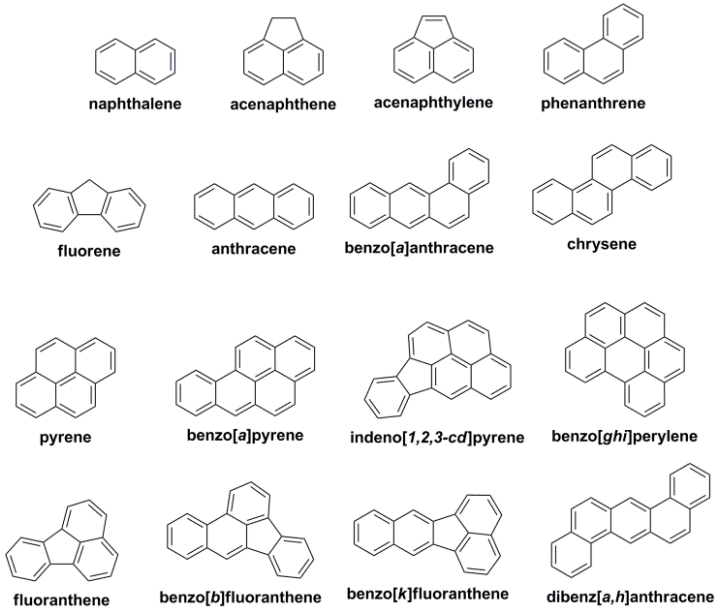
After 6h exposure or less there will be no effect of oil exposure.

Exposure Metric

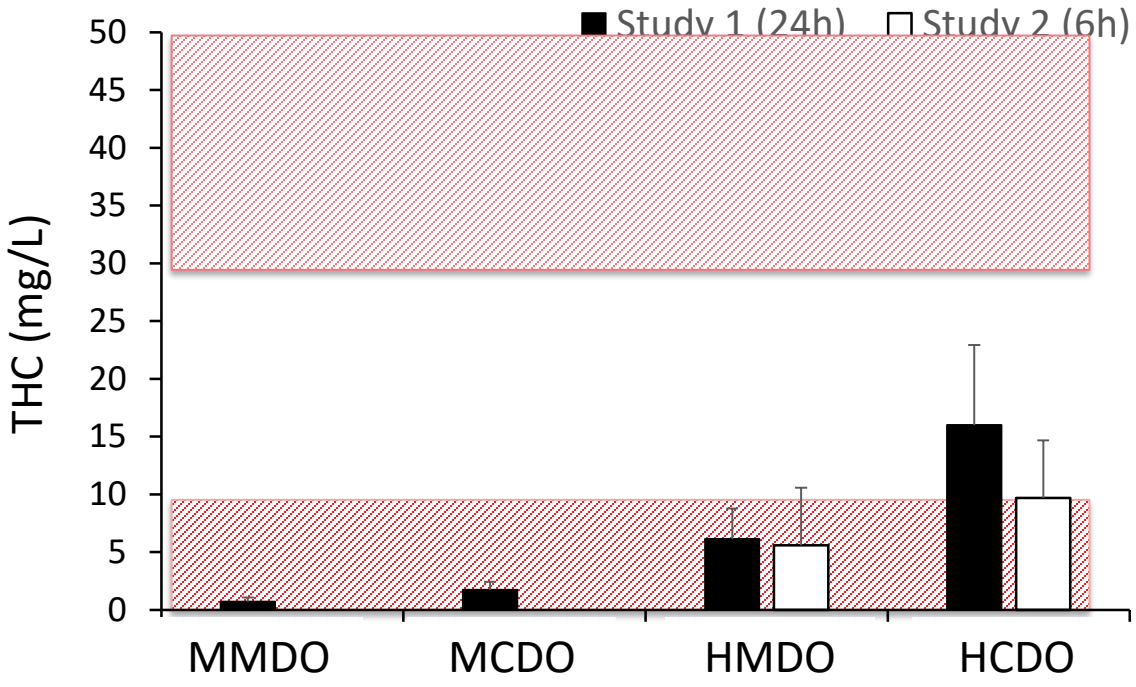
- Total hydrocarbon content (THC)

- 16 EPA PAHs and C1-C3 naphthalenes, C1-C3 phenanthrenes and C0-C3 dibenzothiophenes (NPD)

  adding up to 26 PAHs in total



THC concentrations



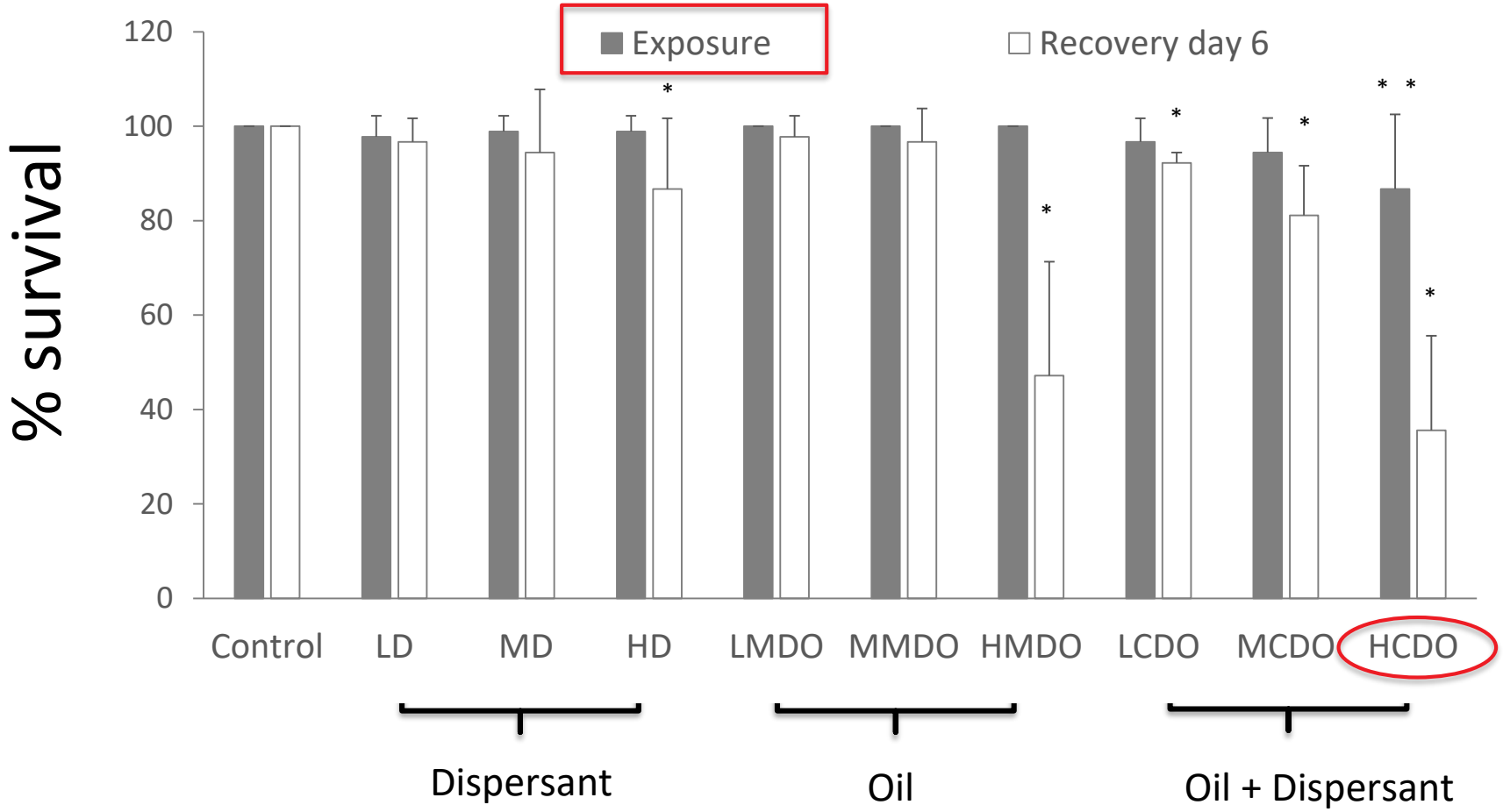
Real spill concentrations
short time after treatment

Real spill concentrations
few hours after treatment

LMDO and LCDO below LOQ (<0.04 mg/L)

Study 1

24h → 6 days

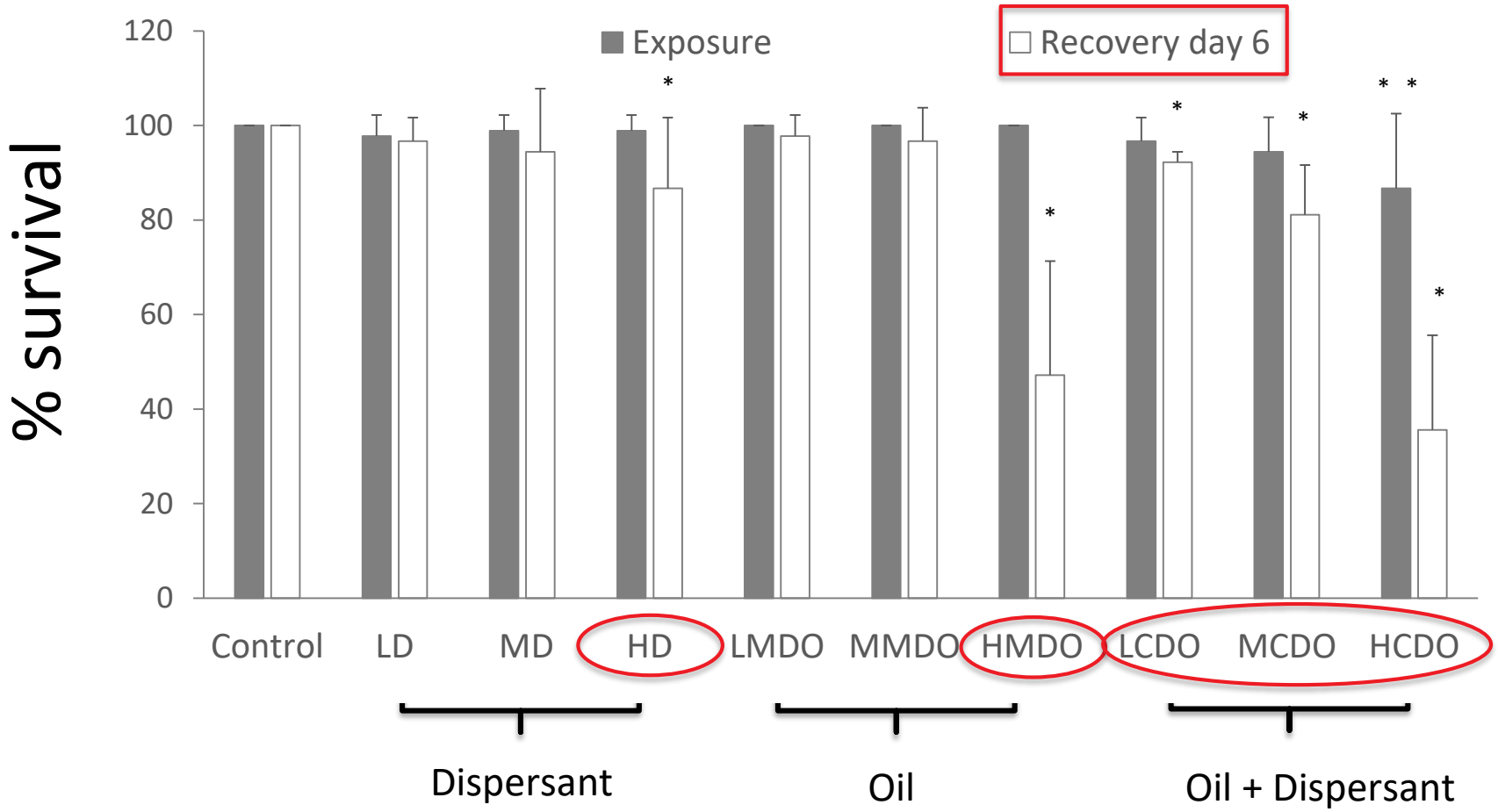


L: low
M: medium
H: high

1-way ANOVA *p<0.05 difference to control

Study 1

24h → 6 days



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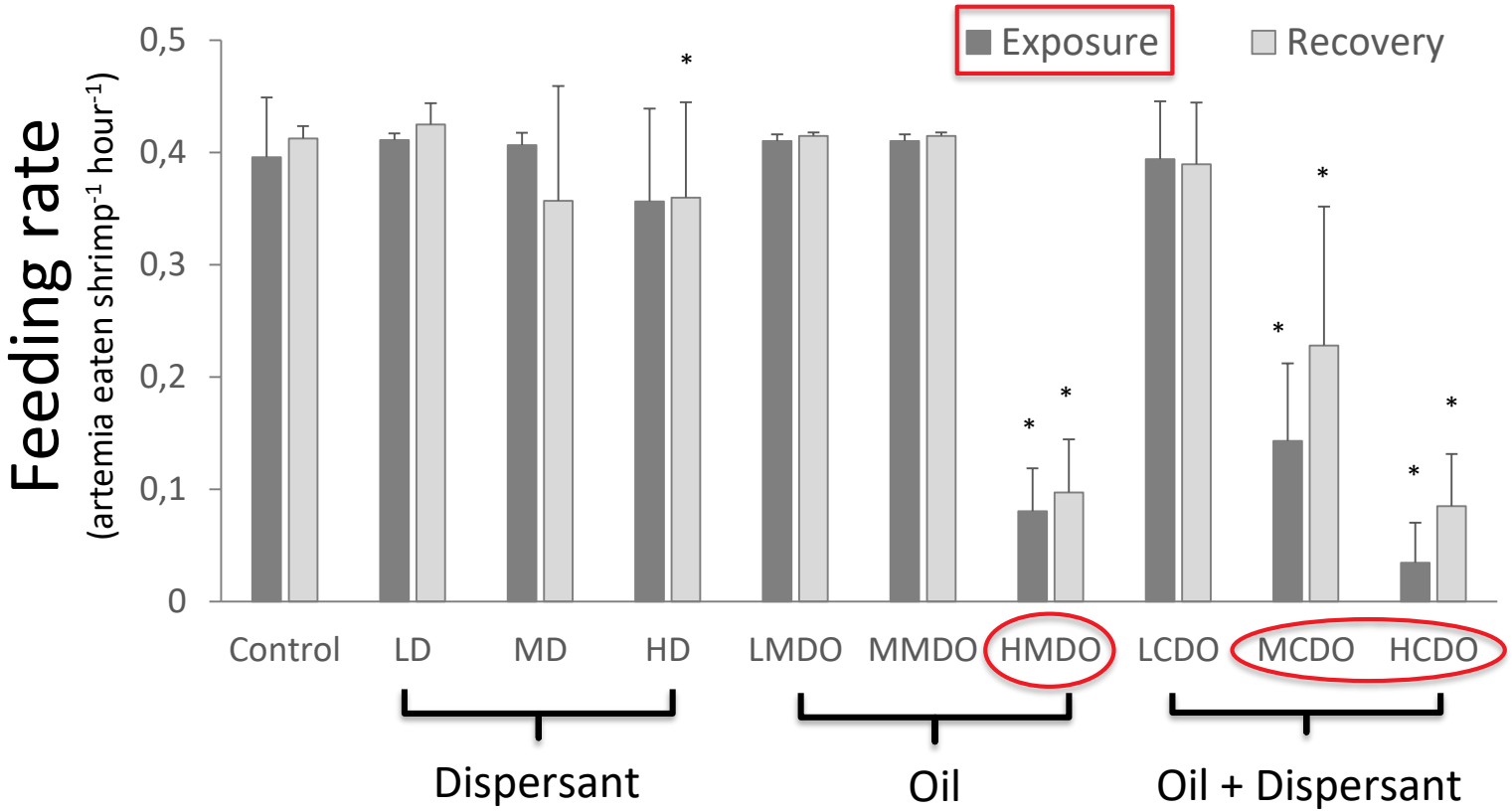
Study 1

24h → 6 days



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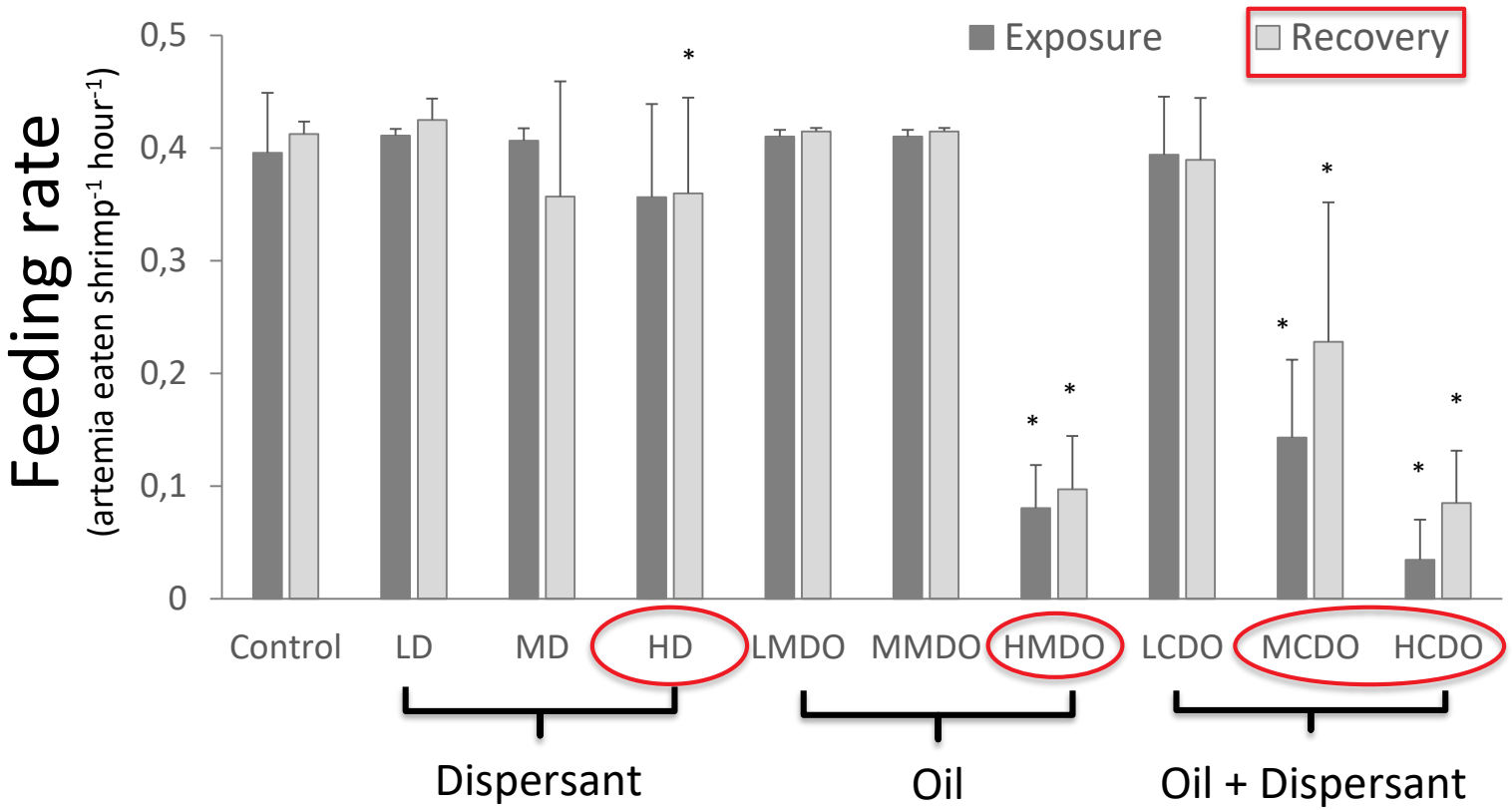
Study 1

24h → 6 days



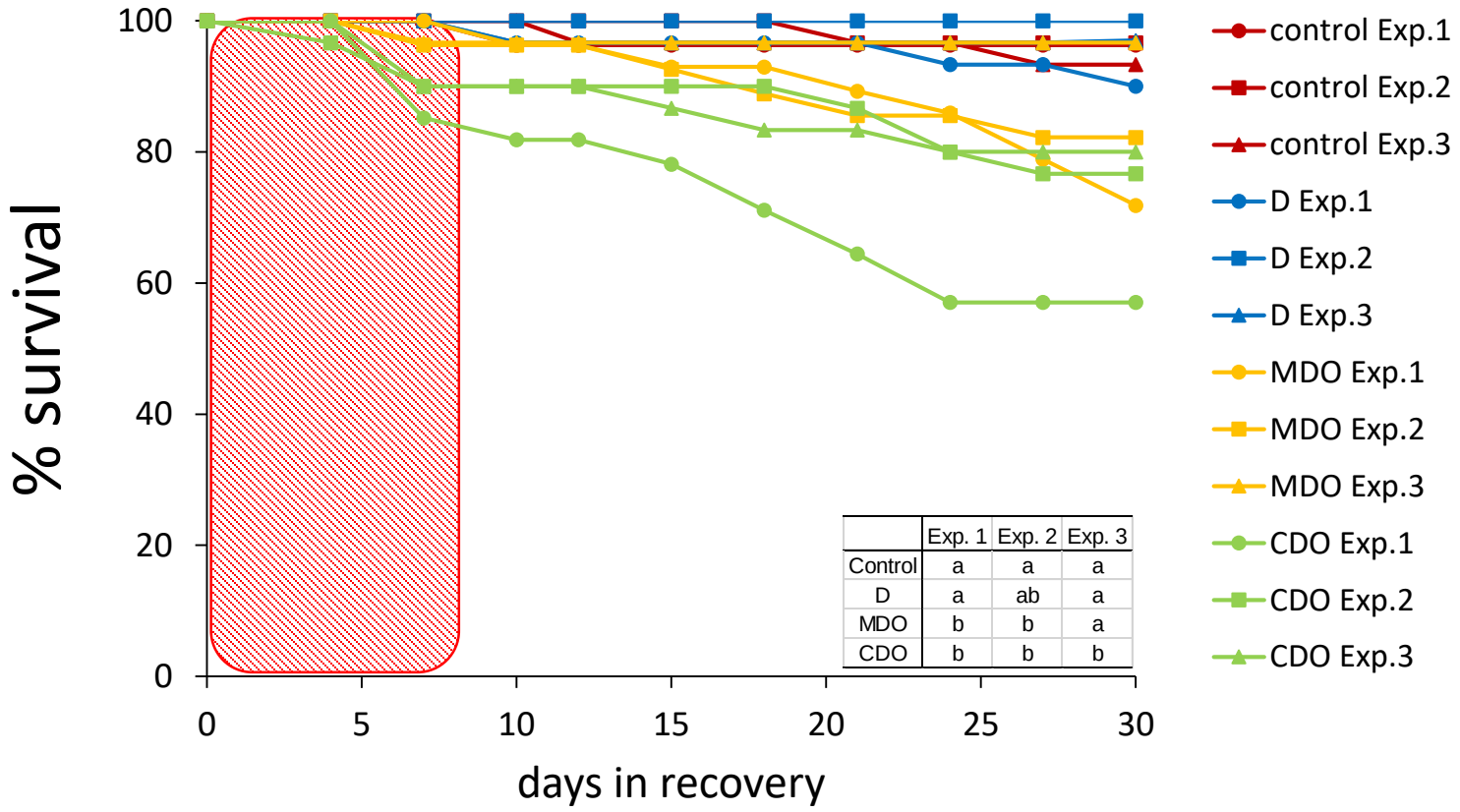
L: low
M: medium
H: high

1-way ANOVA *p<0.05 difference to control

Arnberg et al. 2019
Mar Pollut Bull 145: 409-417

Study 2

6h → 30 days



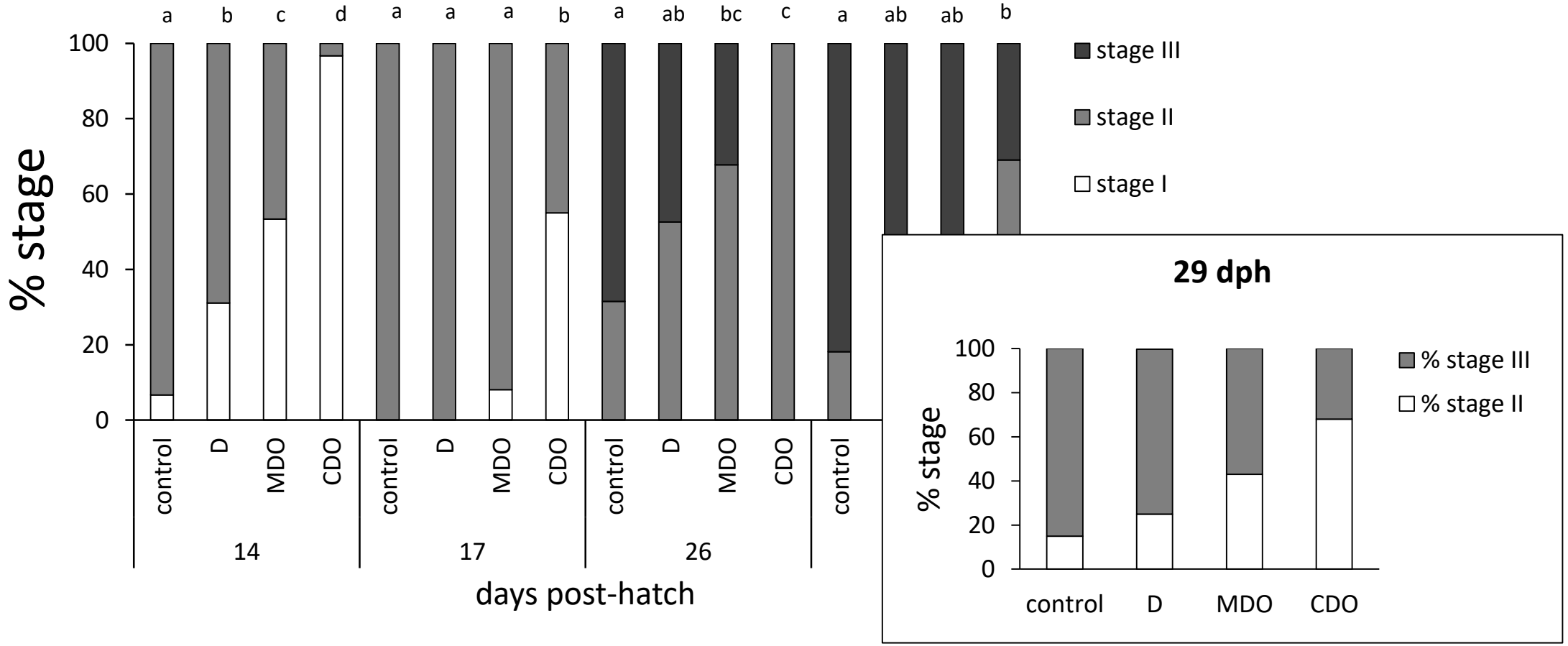
	Exp. 1	Exp. 2	Exp. 3
Control	a	a	a
D	a	ab	a
MDO	b	b	a
CDO	b	b	b

- no mortality during exposure, but within a few days in recovery

Kaplan-Meier Log Rank (Mantel Cox) test including pairwise comparison, $p<0.05$ lower case letters indicate statistcal differences between treatments within one experiment

Study 2

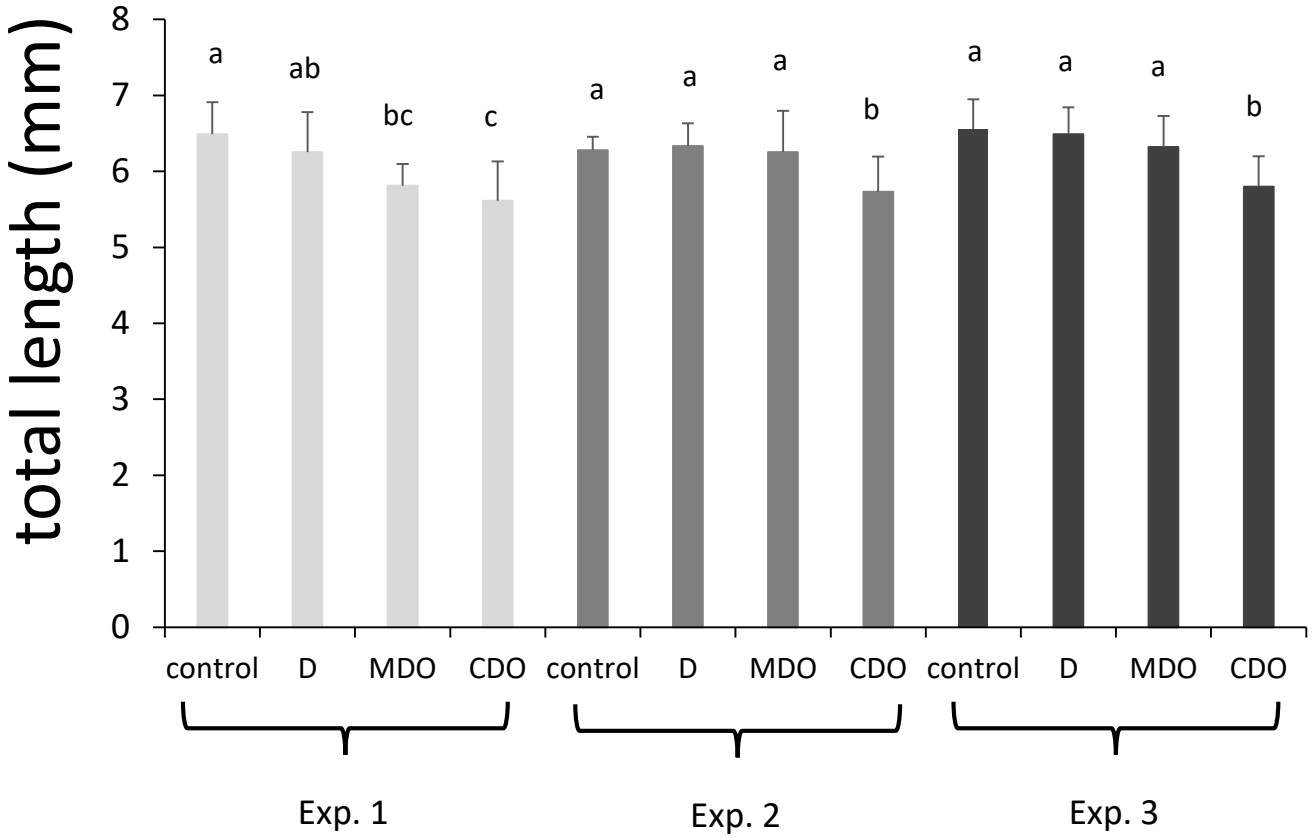
6h → 30 days



Kruskal-Wallis tests followed by Mann-Whitney-U tests. Lower case letters indicate statistically significant differences between treatments at a given timepoint, $p<0.05$

Study 2

6/1h → 30 days



No difference in total length after 1h exposure.

Kruskal-Wallis tests followed by Mann-Whitney-U tests or ANOVA followed by Tukey HSD post-hoc testing. Lower case letters indicate statistically significant differences between treatments, $p<0.05$

Study 2

6/1h → 30 days

	control 6h	D 6h	MDO 6h	CDO 6h	control 1h	D 1h	MDO 1h	CDO 1h
survival	🟢🟢🟢	🟢🟢🟢	🟡🟡🟢	🟡🟡🔴	🟢🟢🟢	🟢🟡🟢	🔴🟡🟢	🟢🟡🟢
feeding	🟢🟢🟢	🟢🟡🟢	🟡🟡🟡	🟡🟡🔴	🟢🟢🟢	🟢🟢🟢	🟡🟡🟢	🟢🟡🟢
growth	🟢🟢🟢	🟢🟢🟢	🟡🟢🟢	🟡🔴🔴	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢
development	🟢🟢🟢	🟢🟢🟢	🟡🟢🟢	🟡🟡🟡	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢	🟢🟢🟢

Lessons learnt

- Short-term oil exposure has long lasting effects on larval fitness
- Clear time component
- Greater sensitivity to CDO compared to MDO → important for NEBA

? Consequences for local shrimp population

? Underlying mechanisms of delayed effects post-exposure

What's next?

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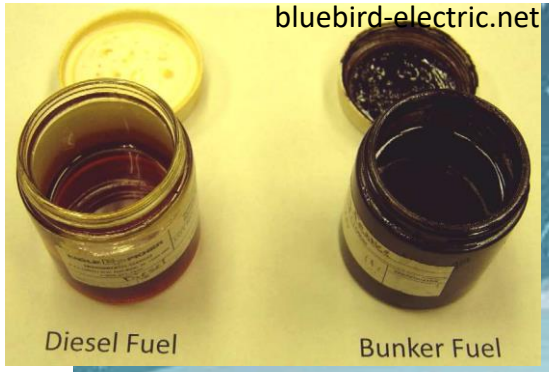
Diesel Fuel
Bunker Fuel
GOLIAT
www.arcex.no

What's next?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Diesel Fuel
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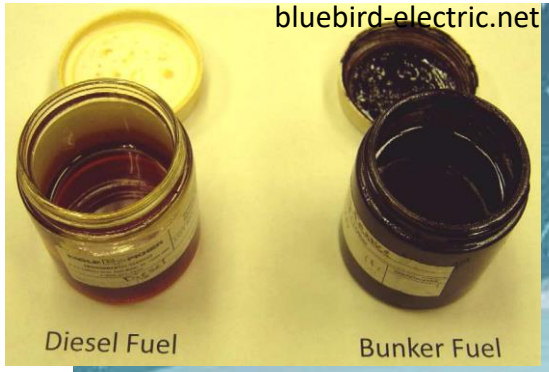
GOLIAT

What's next?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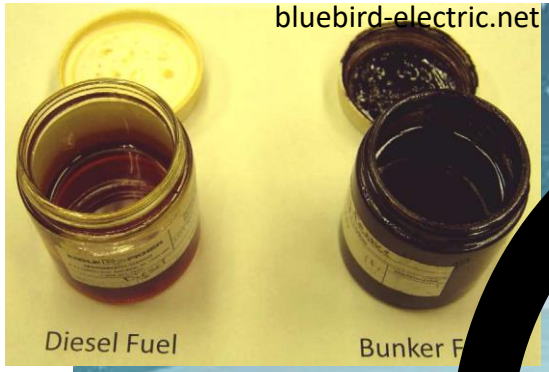
What’s next?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Thank you for your attention!

Thanks to a great team at NORCE!

AND include recovery times in your experimental design

Frederike Keitel-Gröner
Postdoctoral Researcher – NORCE
frke@norceresearch.no

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