Marine snow enhances the adverse effects of oil on benthic invertebrates

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GoMRI C-IMAGE project (#SA 12-10/GoMRI-007) - Wageningen UR – IPOP TripleP@Sea (KB-14-007)

Background

- Deepwater Horizon explosion
- Marine snow; MOSSFA (Marine Oil Snow Sedimentation and Flocculent Accumulation)
- Estimates vary, but as much as 14% of total oil on sediment *(Daly et al., 2016)*
- What about the consequences for the benthic community?

MOSSFA
MARINE OIL SNOW SEDIMENTATION & FLOCCULENT ACCUMULATION

Daly et al. 2016 *Anthropocene* 13 "Assessing the impacts of oil-associated marine snow formation and sedimentation during and after the Deepwater Horizon oil spill"

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Objective

- Question: what does MOSSFA mean for the benthic ecosystem?
- Aquarium Experiment with benthic macro-invertebrates to assess:
  - Organism behavior
  - In vivo toxicity
  - Oil biodegradation

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Setup of Aquarium Experiment

- Natural sediment and organisms from intertidal area in Waddensea, The Netherlands
- Temperature and light controlled room
- 5 treatments in triplicate:
  - "Control": sediment, no addition
  - "Clay": sediment and kaolin clay
  - "Snow": sediment and marine snow
  - "Clay+Oil": sediment and clay with oil
  - "Snow+Oil": sediment and marine snow with oil
- Oil: same amounts in each aquarium (10 g/m^2)
- Oil-degrading bacteria added

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Setup of Aquarium Experiment

- Organisms

Corophium volutator (amphipod)

Hydrobia ulvae (gastropod)

Macoma balthica (bivalve)

Foraminifera

- Samples
  - t=16 benthic invertebrates; t=42 oil biodegradation samples (separate aquaria)

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Marine snow

- Marine snow in the lab: EPS, alginate-like polysaccharides excreted after exposure to oil spill dispersants *(van Eenennaam et al. 2016)*

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(van Eenennaam et al. 2016 *Marine Pollution Bulletin* 104(1-2), "Oil spill dispersants induce formation of marine snow by phytoplankton-associated bacteria")

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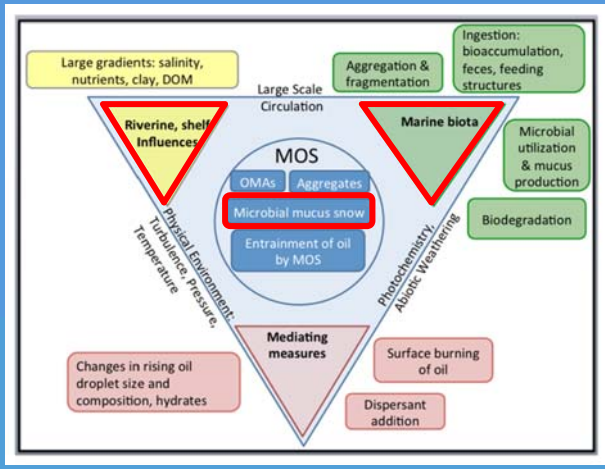
Marine snow

- Ingredients of marine snow



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Daly et al. 2016 *Anthropocene* 13 "Assessing the impacts of oil-associated marine snow formation and sedimentation during and after the Deepwater Horizon oil spill"

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Artificial marine snow

- Created with alginate, algae biomass, kaolin clay with or without oil (slightly weathered BP surrogate oil)

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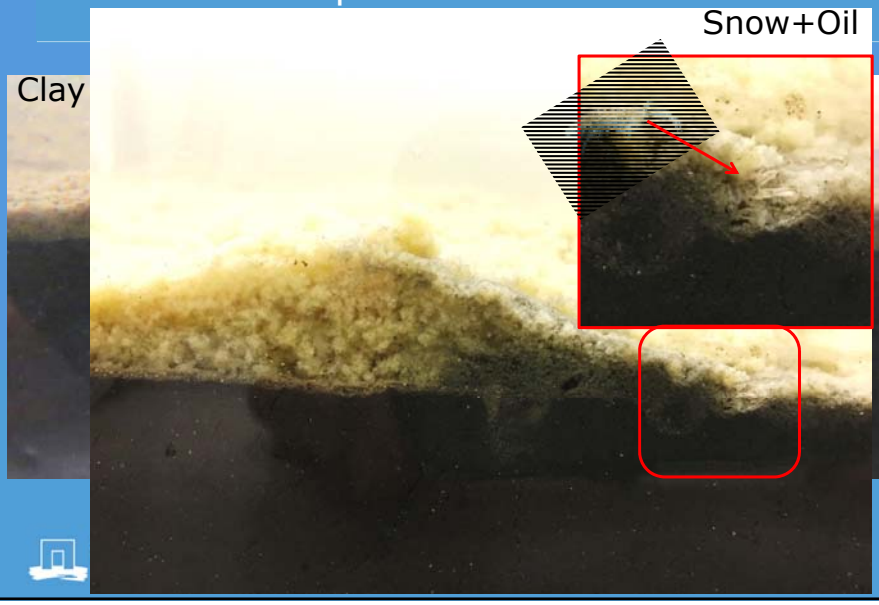
Behavior observations: burrows immediately after start of experiment



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Burrowing *Corophium volutator* in Snow+Oil (at start): bioturbation in progress

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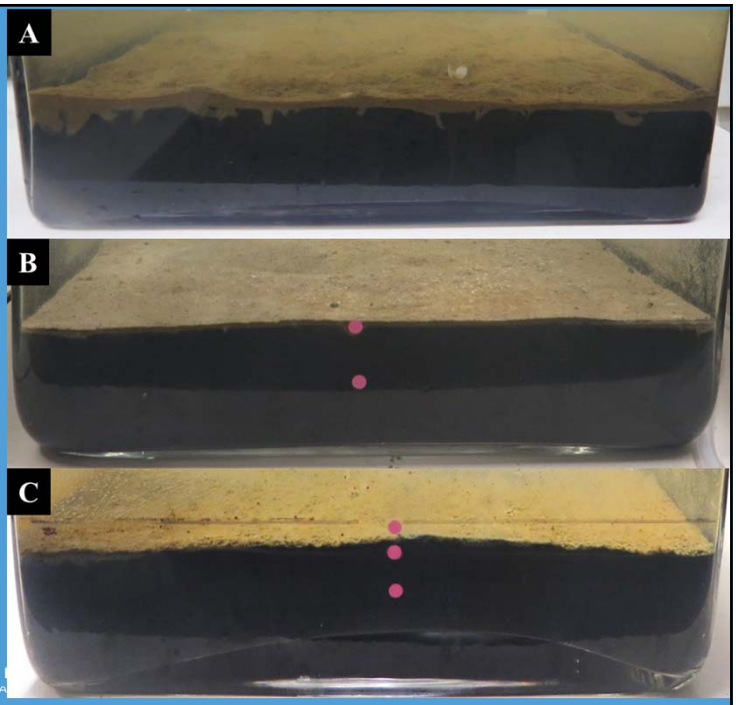
After 16 days

Control: normal oxidized layer (5 mm), with burrowing activity

Clay+Oil: thin layer (2 mm), no burrows

Snow+Oil: no layer, no burrows



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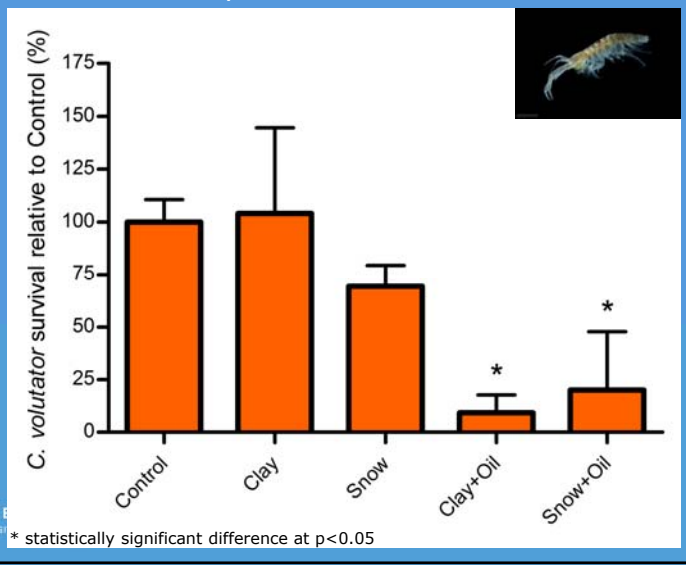
In vivo toxicity: *Corophium volutator*

- Lowest survival in aquaria with oil



* statistically significant difference at p<0.05

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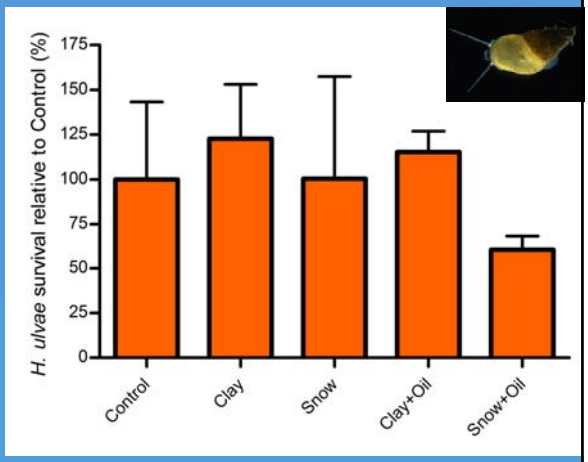
In vivo toxicity: *Hydrobia ulvae*

- Indication of reduced survival in Snow+Oil
- Avoid the oil?
- (Oiled) snow as food?



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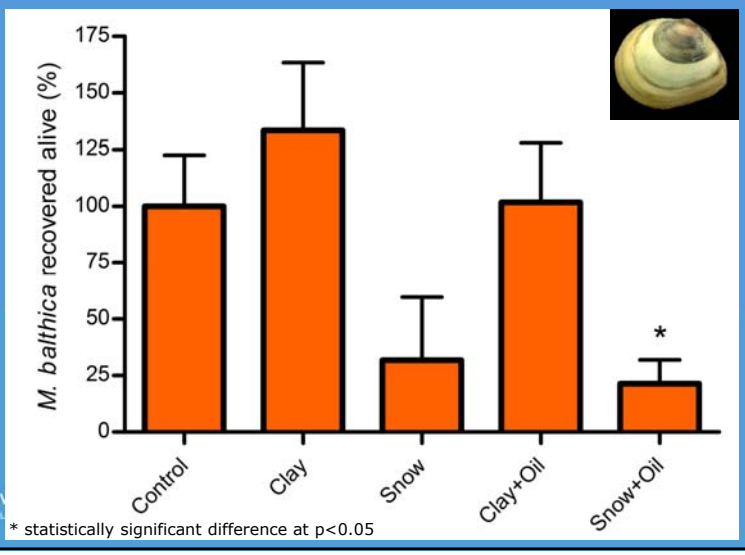
In vivo toxicity: *Macoma balthica*

- Lowest survival in Snow and Snow+Oil



* statistically significant difference at p<0.05

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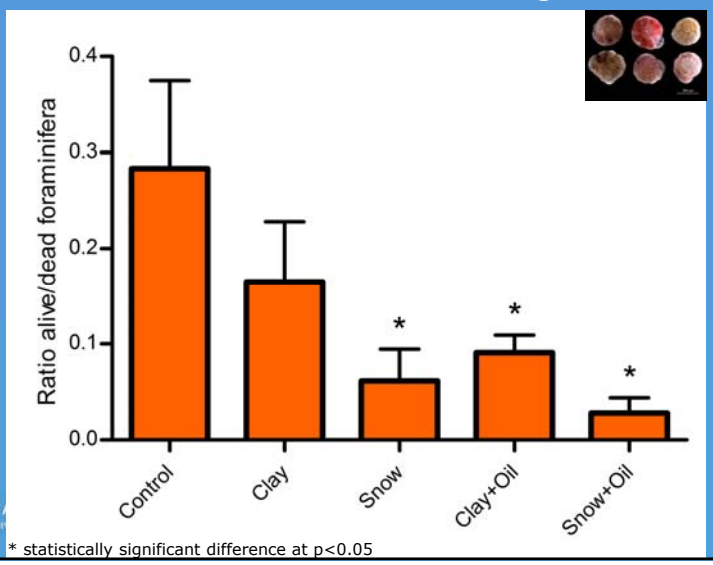
Foraminifera

- Ratio alive/dead decreases -> less living foraminifera



* statistically significant difference at p<0.05

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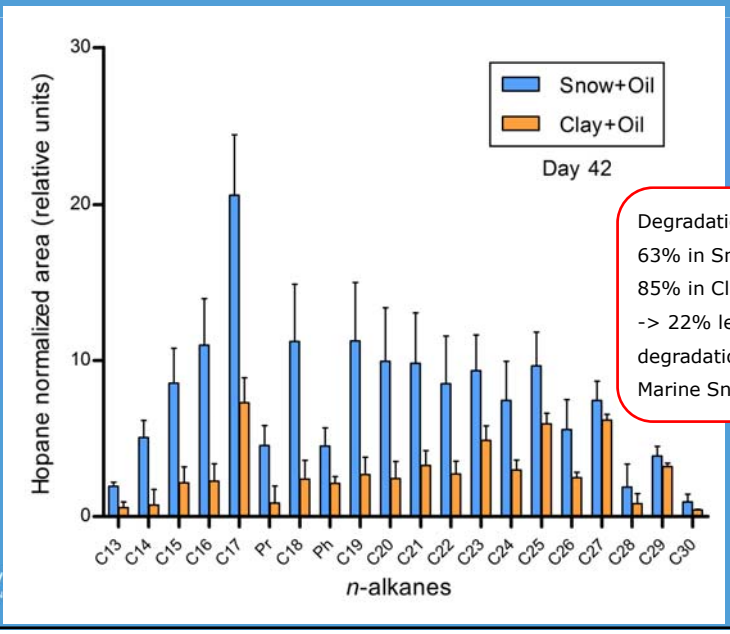
Biodegradation: Fingerprint of *n*-alkanes



Degradation:
63% in Snow+Oil
85% in Clay+Oil
-> 22% less oil degradation with Marine Snow

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Conclusions

- *Oil-contaminated marine snow negatively impacts benthic invertebrates*
- *Marine snow by itself also affects benthic invertebrates, but to a lesser extent*
- *Presence of marine snow inhibits oil biodegradation: longer residence time of oil in benthic system*

Benthic community can be affected by impacts of oil spill responses, like MOSSFA

- Healthy benthic ecosystem is crucial for other organisms in the food chain, like fish
- Paper in preparation: van Eenennaam et al., "*Marine snow enhances the adverse effects of oil in benthic invertebrates*"

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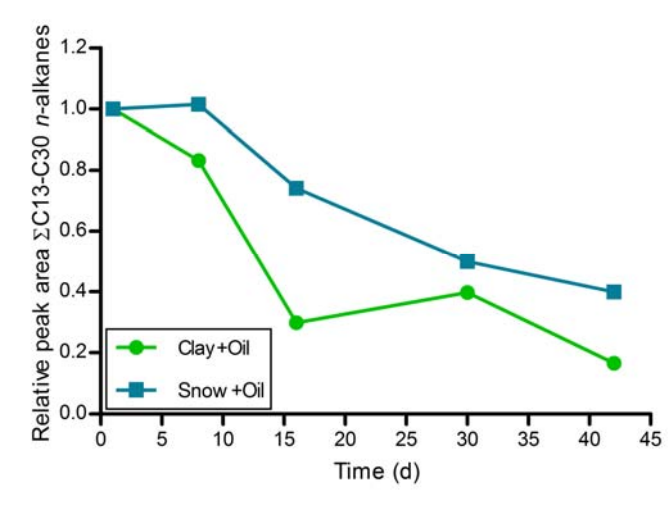
Biodegradation over time



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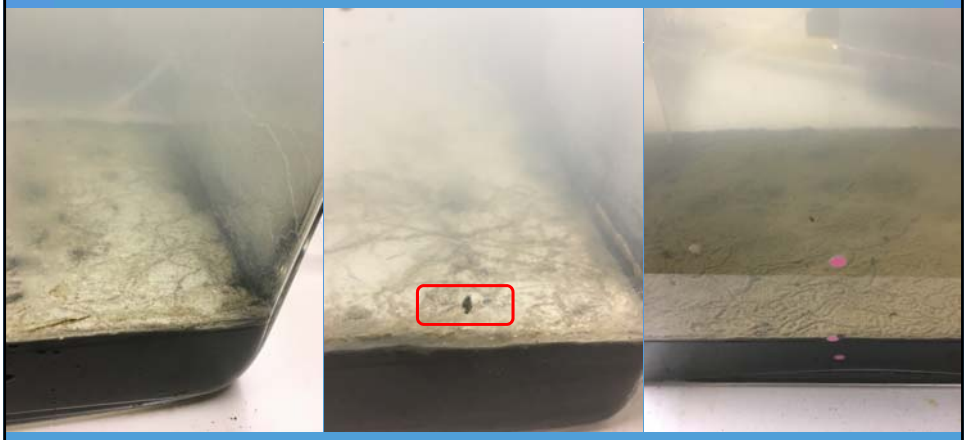
Behavior observations: tracks on top sediment



Clay | Clay | Control

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