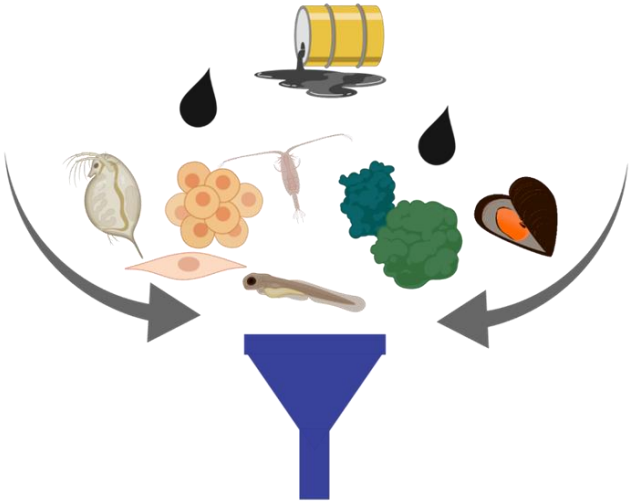
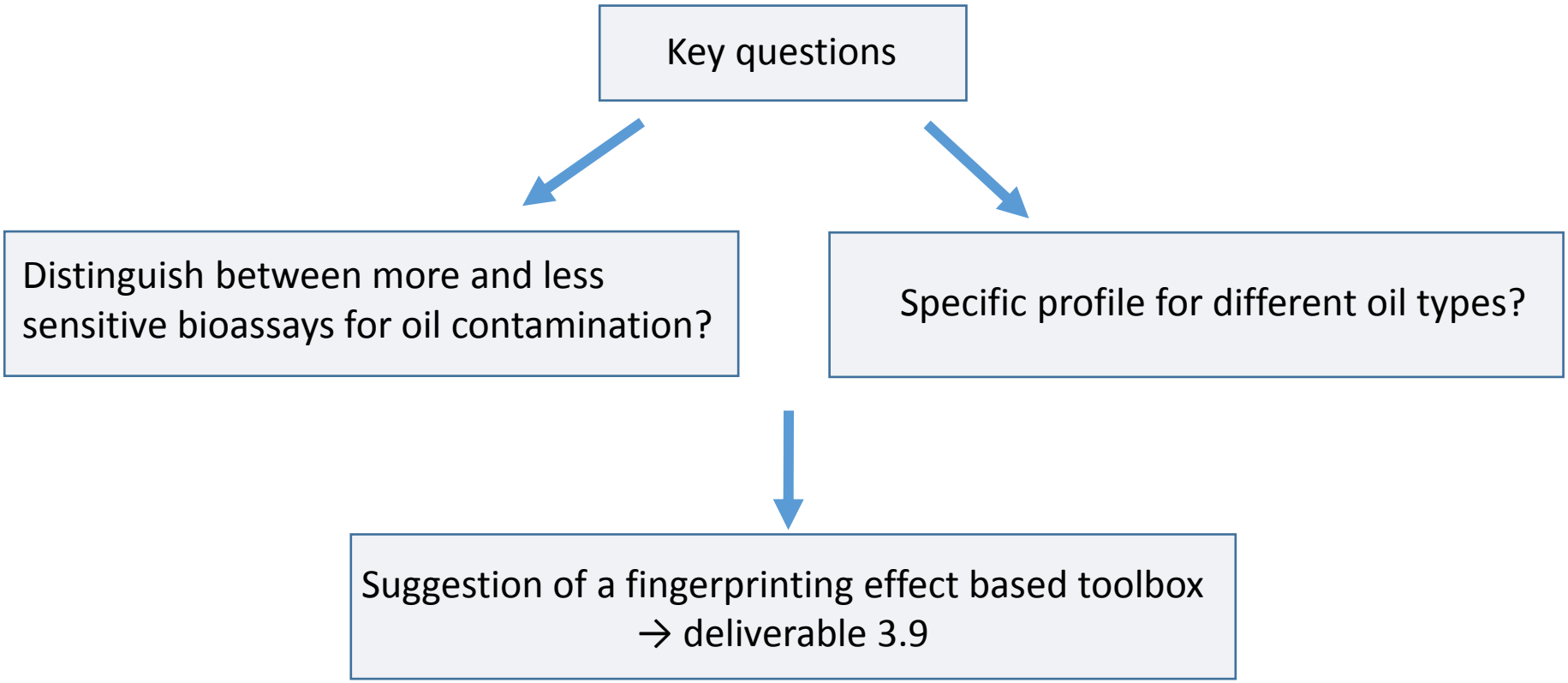
An effect-based toolbox for the rapid and cost-effective investigation and fingerprinting of oil contamination



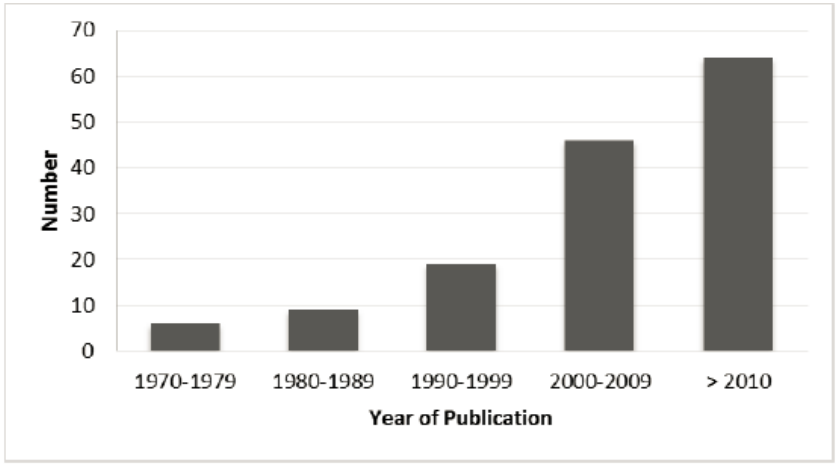
Sarah Johann, Mira Goßen, Henner Hollert, Leonie Nüßer, Richard Ottermanns, Xabier Lecube, Ionan Marigómez, Laura de Miguel Jiménez, Alberto Katsumiti, Aino Ahvo, Kari Lehtonen, Tomasz Maciej Ciesielski, Björn Munro Jensen and Thomas-Benjamin Seiler

Task 3.5: toxicity profile of oil pollution

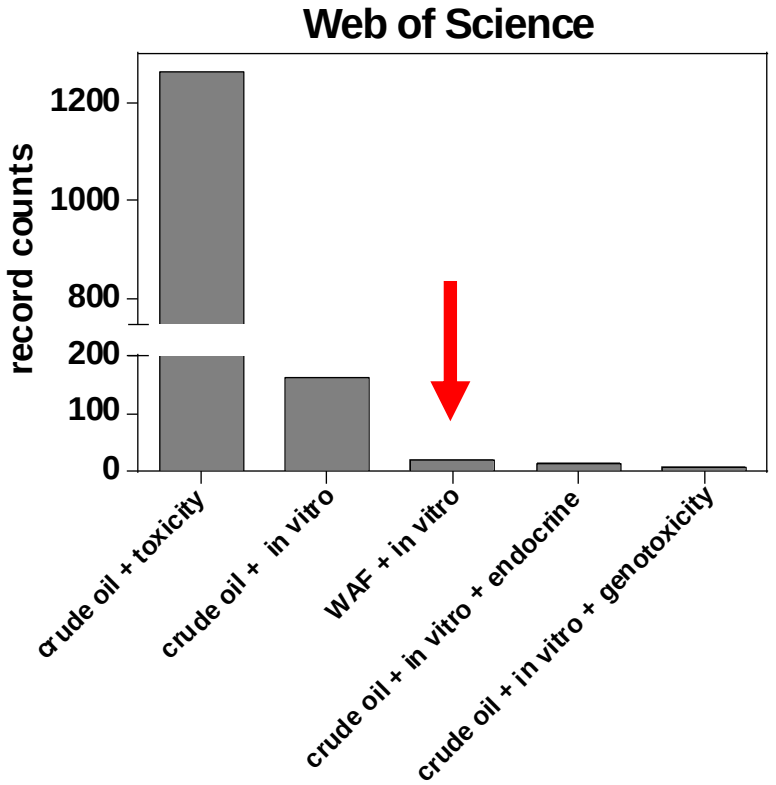


Background and Motivation

- small-scale mechanism-specific (*in vitro* based) bioassay battery



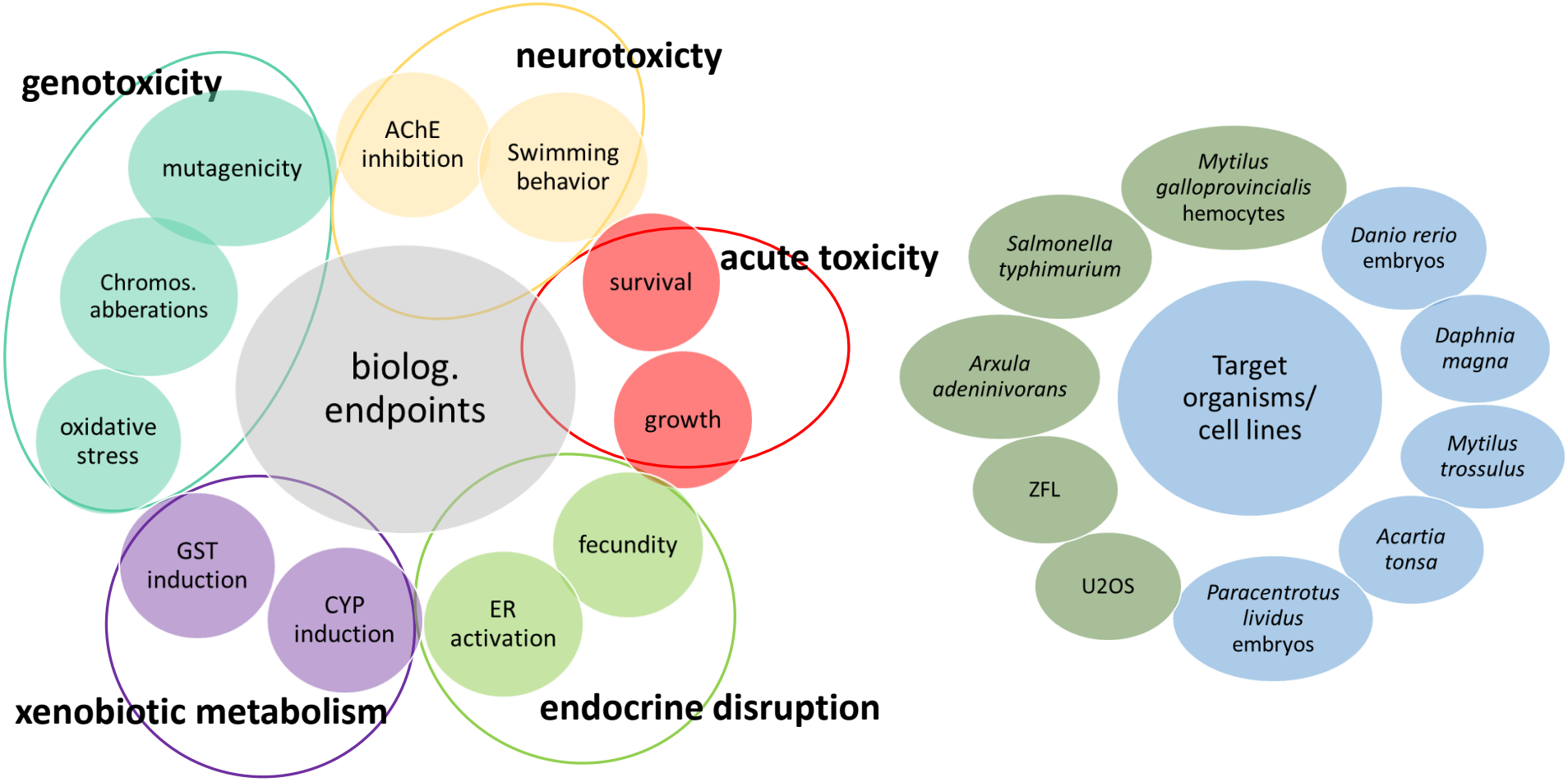
Adams et al. 2017 [1]



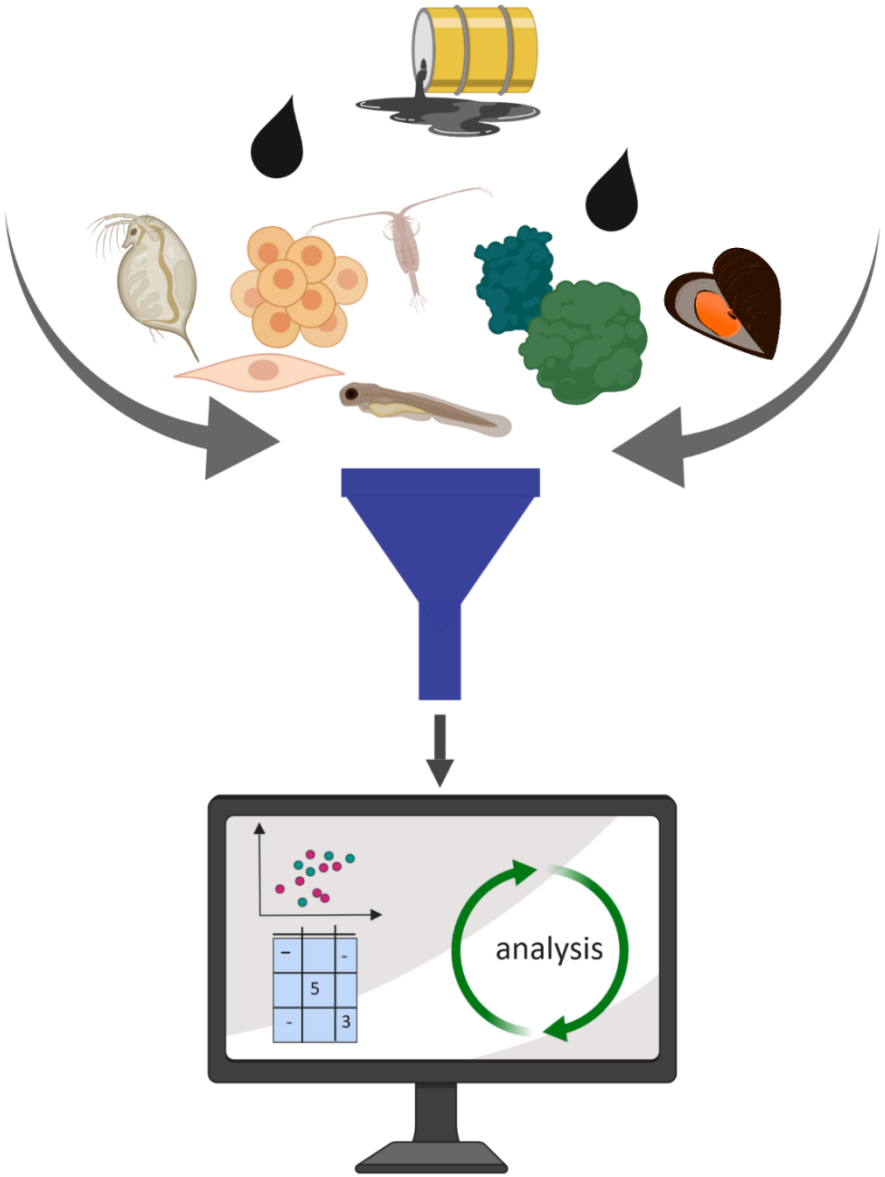
→ lack of small scale *in vitro* studies (focus WAF approach)

Overview toxicity profiling

naphthenic North Sea crude oil : water-accommodated fractions



Overview toxicity profiling - workflow



biological effect data

→ naphthenic North Sea crude oil (NNA)

→ n = 171 in >20 different endpoints

data transformation

→ classification (1 – 5)

→ common scale for different assays

biological interpretation with statistical fundament

→ recommendation of sensitive, time, cost efficient bioassay battery

Classification system

- individual for each biological endpoint

- based on expert knowledge

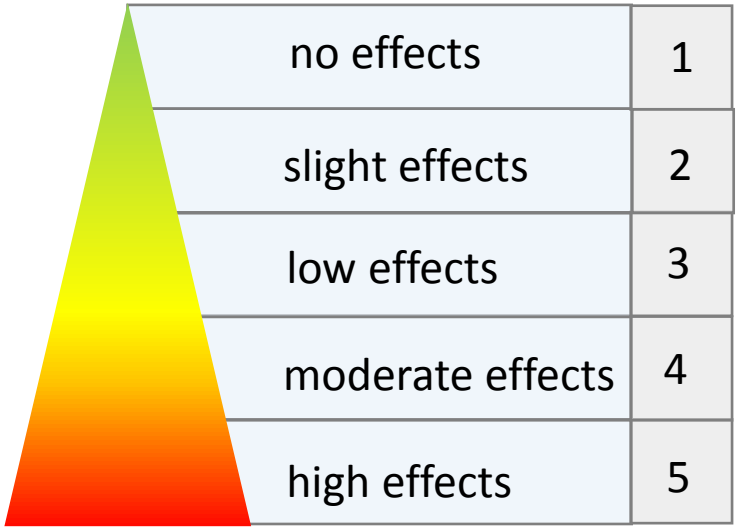
  → limits of detection or quatification?

  → baseline activity?

  → other petroleum products?

  → extrapolation to higher biolog. organisation levels?

- to be discussed….!

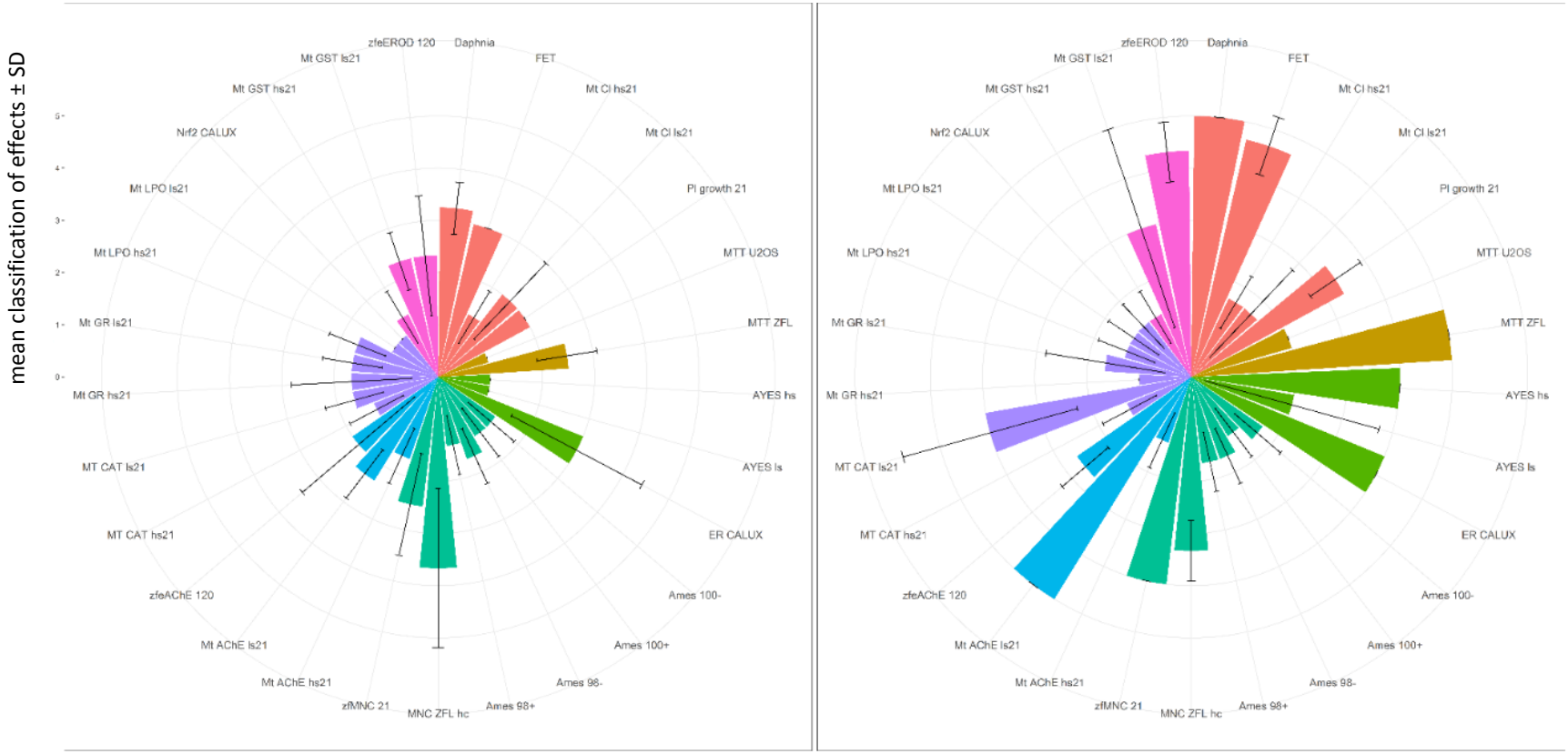


NNA – classified biological effect data

INSTITUTE FOR ENVIRONMENTAL RESEARCH | RWTH AACHEN UNIVERSITY

crude oil exposure (LEWAF)

dispersed crude oil exposure (CEWAF / LEWAF+D)

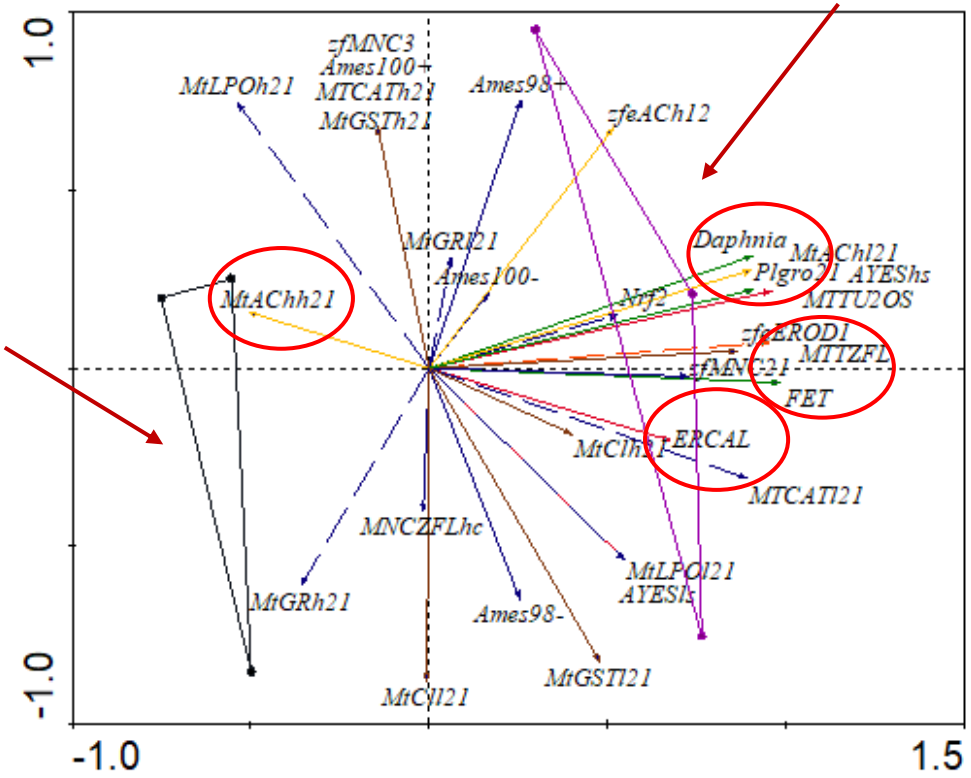


NNA – multivariate statistical analysis

- Principal component analysis (PCA) with classified data (treatments: n=3)
- treatments to compare:
  - → crude oil (LEWAF)
  - → dispersed crude oil (CEWAF)

dispersed crude oil exposure

crude oil exposure

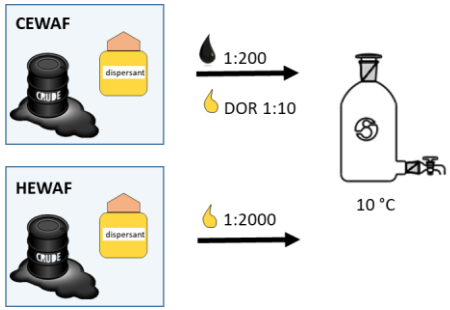


	[%] of variance cumulativ
1. axis	54.2
2. axis	73.0
3. axis	85.5
4. axis	93.4

- genotoxicity
- endocrine disruption
- acute toxicity
- cytotoxicity
- xenobiotic metabolism
- oxidative stress
- neurotoxicity

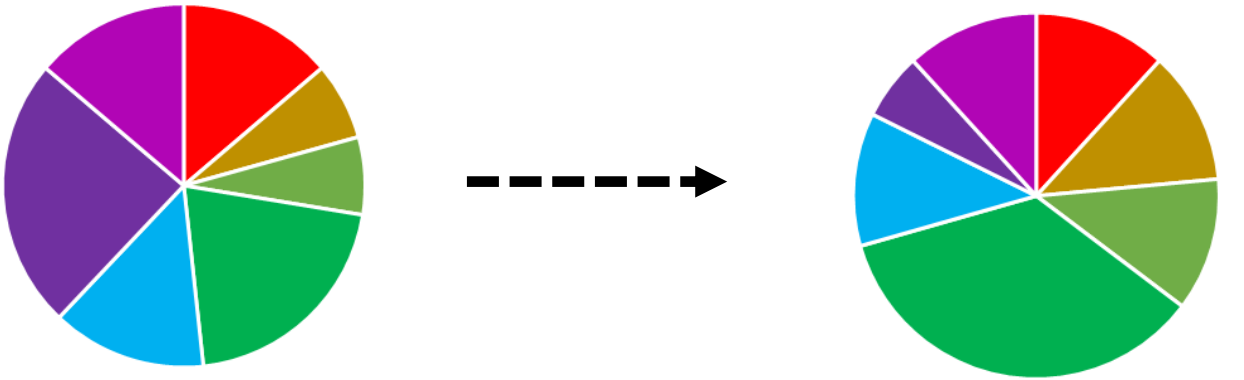
Contribution of dispersant to CEWAF toxicity

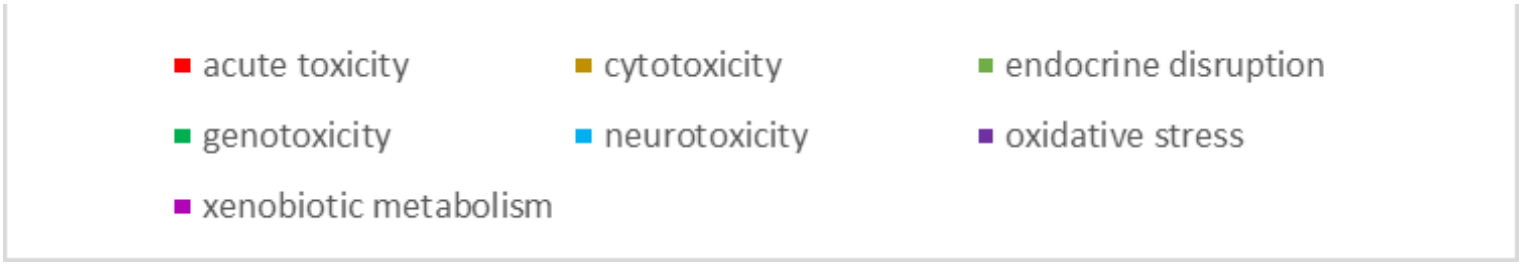
- direct comparison to dispersed crude oil
  → comparable „WAF“ preparation method



endpoints with LEWAF, CEWAF
n= 29

endpoints with LEWAF, CEWAF, HEWAF
n= 18



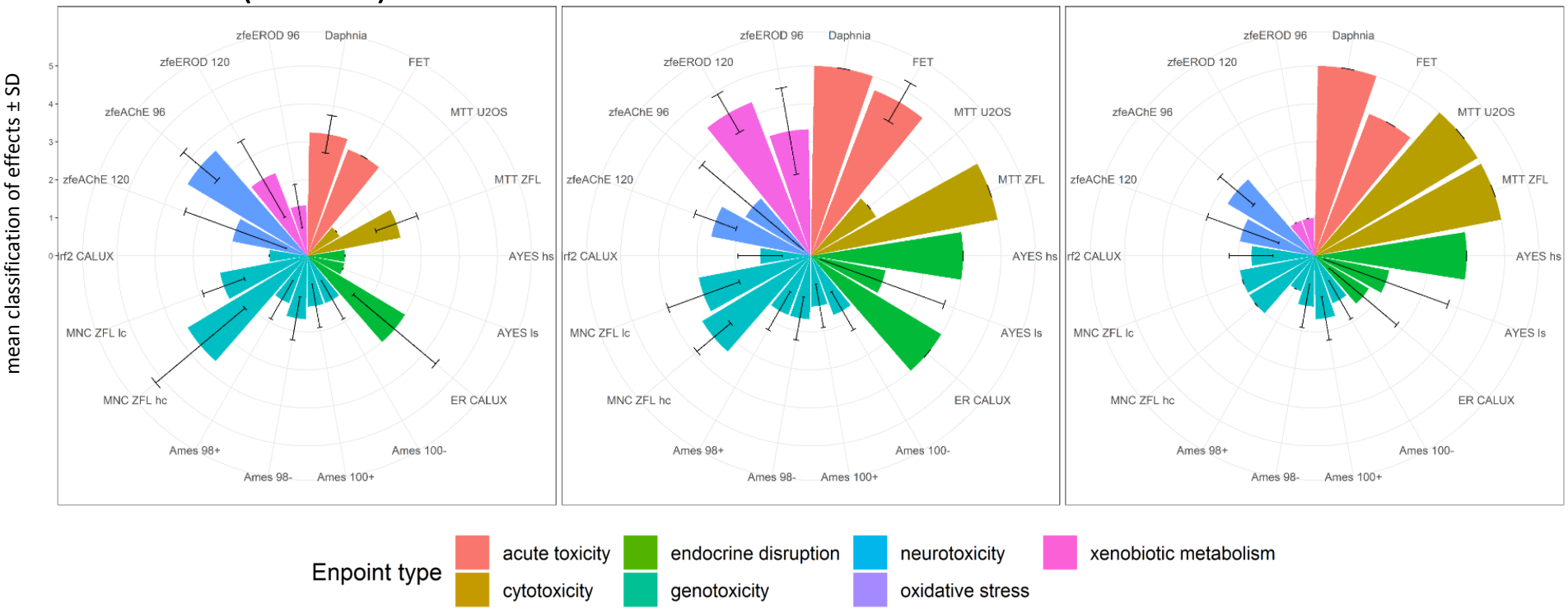


NNA – classified biological effect data

crude oil exposure (LEWAF)

dispersed crude oil exposure (CEWAF)

dispersant exposure (HEWAF)



dispersant increases toxicity

→ higher bioavailabilty of crude oil compounds

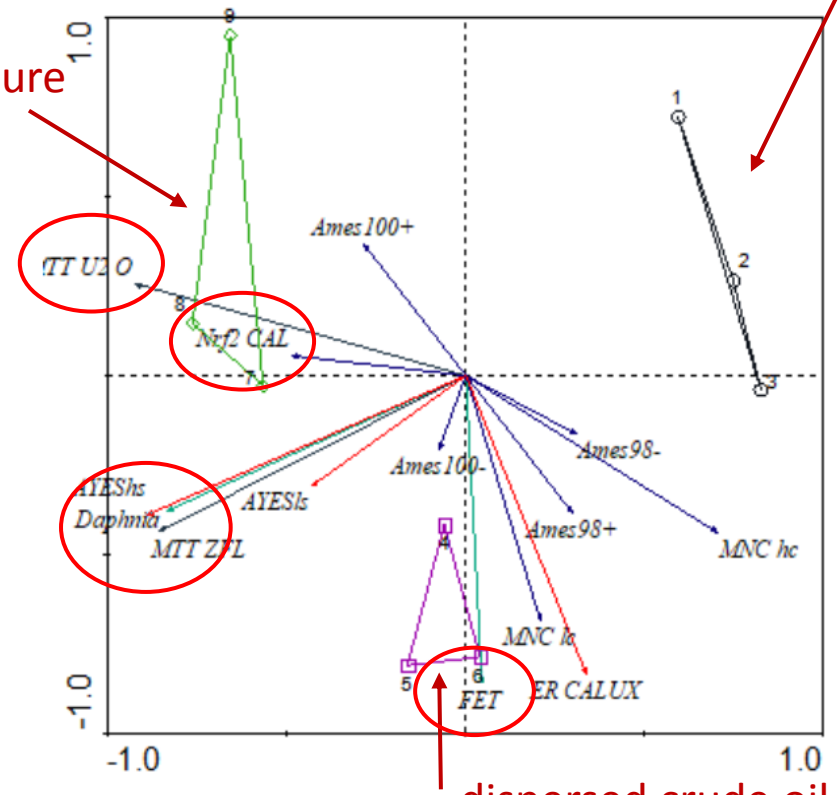
→ dispersant toxicity (general cellular stress)

NNA – multivariate statistical analysis

- Principal component analysis (PCA) with classified data
- treatments to compare:
  - → crude oil (LEWAF)
  - → dispersed crude oil (CEWAF)
  - → dispersant (HEWAF)

crude oil exposure

disperant exposure



	[%] of variance cumulativ
1. axis	45.3
2. axis	73.4
3. axis	85.2
4. axis	91.2

- genotoxicity
- endocrine disruption
- acute toxicity
- cytotoxicity

dispersed crude oil exposure

Summary / key findings

- suggested bioassay battery for NNA based on biological and statistical sensitivity of endpoints

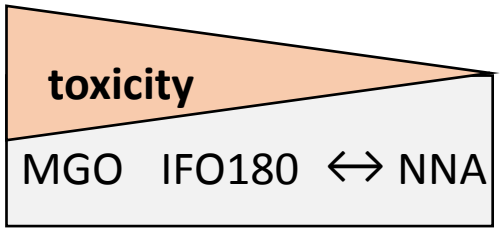
  in-vivo methods:
  → acute toxicity in invertebrate/vertebrate (early developmental stages)
  → biomarkers in mussels and zebrafish (oxidative stress, xenobiotic biotransformation,…)

  in-vitro methods:
  → cytotoxicty
  → MNC induction
  → oxidative stress

Conclusion and outlook

- limitations
  - → preliminary results (data gaps)
  - → classification system
  - → differences in experimental setups (WAF stocks, dispersants, sublethal exposure concentrations for biomarkers)

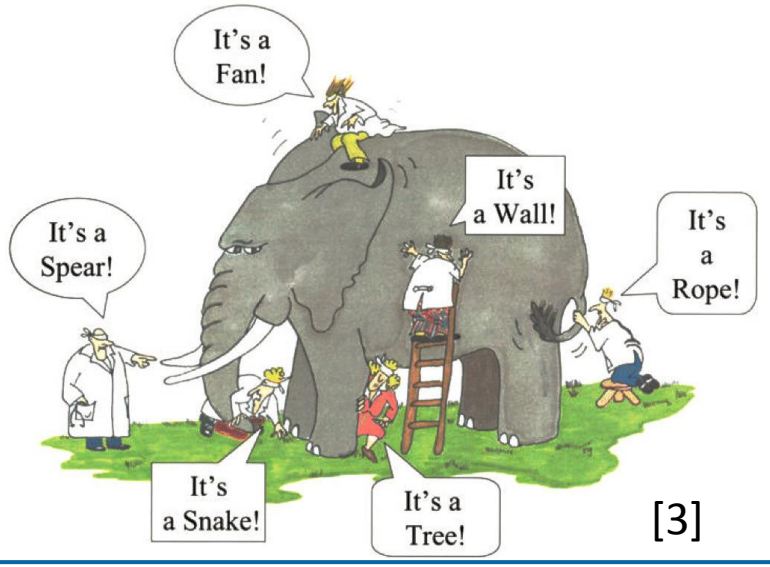
- comparison of different oil types



- additional scenarios (weathering,..)

- to be continued….!

Looking forward to „the big picture“



[3]

Thank you for your attention!

Dr. Richard Ottermanns

H2020 research and innovation programme grant agreement No 679266

References

[1] Adams, Julie Elizabeth, and Canadian Science Advisory Secretariat. Review of methods for measuring the toxicity to aquatic organisms of the water accommodated fraction (WAF) and chemically-enhanced water accommodated fraction (CEWAF) of petroleum. Fisheries and Oceans Canada, 2017.

[2] Singer, M., Aurand, D., Bragin, G., Clark, J., Coelho, G., Sowby, M. and Tjeerdema, R. (2000) Standardization of the preparation and quantitation of water-accommodated fractions of petroleum for toxicity testing. Marine Pollution Bulletin 40(11), 1007-1016.

[3] http://www.philipchircop.com/post/25783275888/seeing-the-full-elephant-its-a-tree-its-a