Determination of Nanoparticles and Elements in Blue Mussels (*Mytilus edulis*) along the Norwegian Coastline

Are Sæle Bruvold,* Stig Valdersnes, André Marcel Bienfait, Monica Sanden, and Katrin Loeschner

Cite This: *J. Agric. Food Chem.* 2024, 72, 25481−25489

Read Online

Part of ***Marine nanoparticles:***
Method development, validation and environmental monitoring

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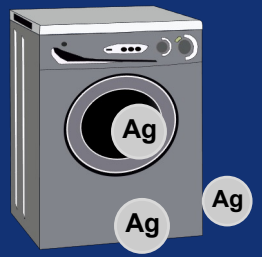
Original project motivation (2017)



INCIDENTAL NPs

Thousands to millions of tons of mining waste per year in NO(?)

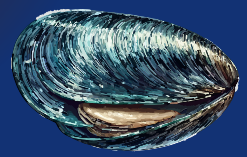
ENGINEERED NPs

Qualitative production data: tens of millions tons/year worldwide?

TiO2

TiO2

Accumulation of NPs in biota



Impact on seafood safety/quality and ecosystem

INCIDENTAL

INEERED NPs

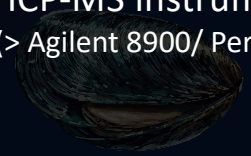
Thousands to mil

tative production data

tons per year in

Routine ICP-MS instrumentation with µs dwell time

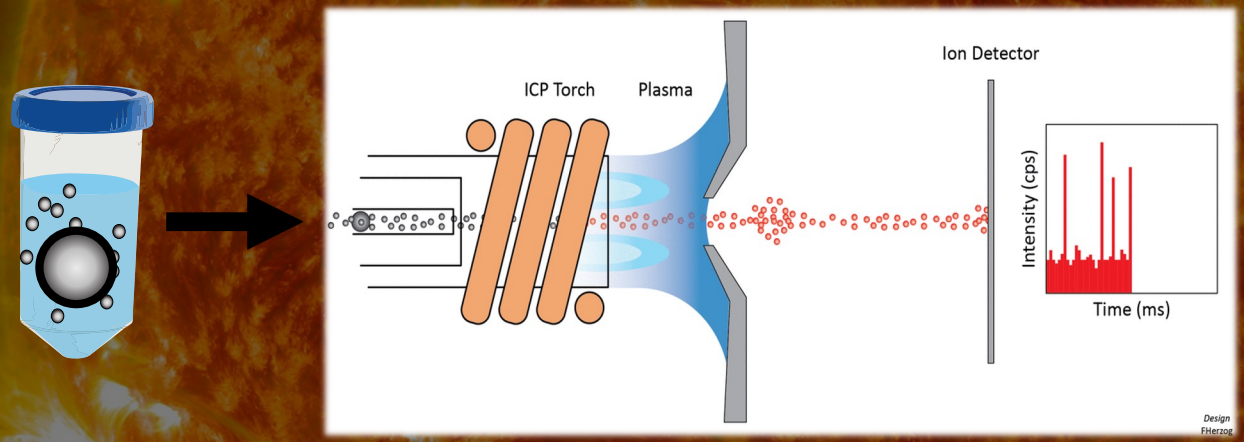
(> Agilent 8900/ Perkin Elmer NexION 300 etc)



Accumulation of NPs in biota

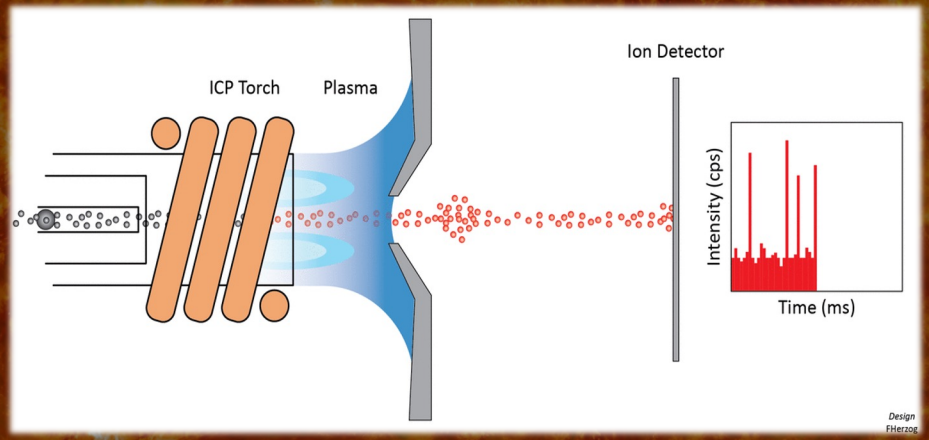
Impact on seafood safety/quality and ecosystem

Single Particle Inductively Coupled Plasma Mass Spectrometry (SP-ICP-MS)



By F. Herzog, kevinjwilkinson.openum.ca/

Single Particle Inductively Coupled Plasma Mass Spectrometry (SP-ICP-MS)



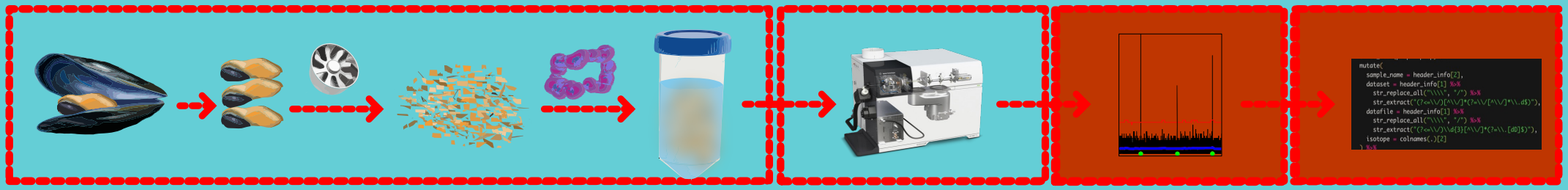
By F. Herzog, kevinjwilkinson.openum.ca/

- **Mass per NP**
  - ↳ size
- C_{number}
- C_{mass}

Potential for:

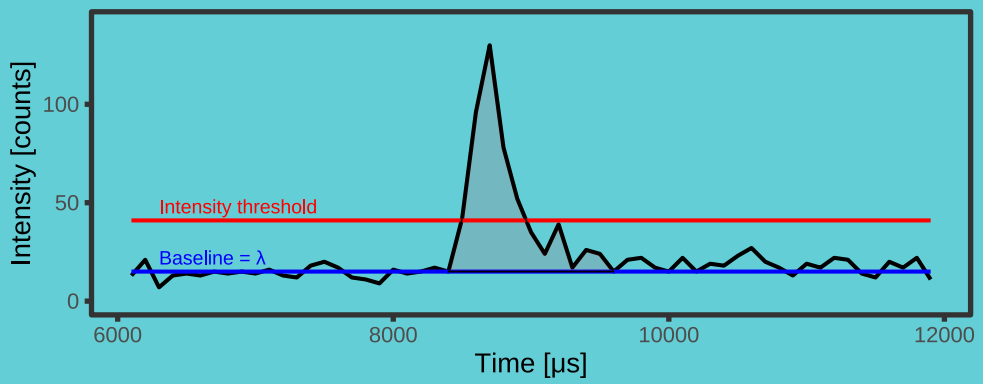
High sensitivity and selectivity
High throughput
Reproducible quantitative data

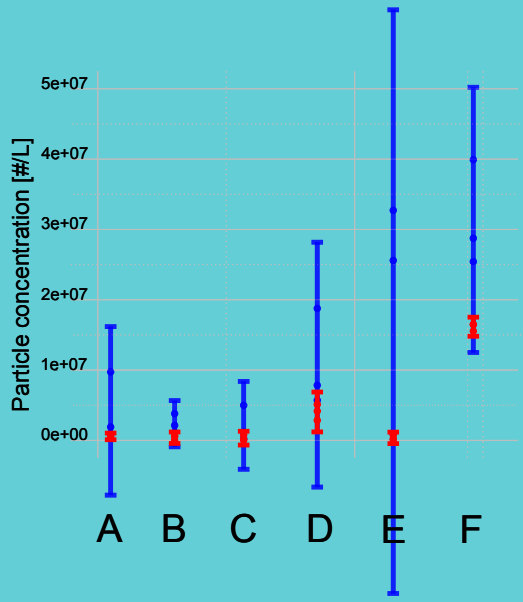
Method development for SP-ICP-MS



Sample treatment | Instrumentation | Signal processing | Data treatment

Signal processing





- **4-fold decrease in variation = 16-fold decrease in sample size**
- Data analysis in **minutes** instead of **days**
- Scientifically reproducible data
- (Now 4+ alternatives: **SPCal**, SPTool, TOF-SPI)

Bruvold, A., Bienfait, A.M., Ervik, T.K., Loeschner, K., & Valdersnes, S. (2023) *Marine Environmental Research* **188**, 105975. doi:10.1016/j.marenvres.2023.105975
Bruvold, A., Valdersnes, S., Loeschner, K., & Bienfait, A.M. (2024) *Journal of AOAC International* qsae024. doi:10.1093/jaoacint/qsae024

The blue mussel

- Efficient accumulator of pollutants
- Sedentary
- Tolerant
- Long lifespan
- Wide geographical distribution
- Common in coastal monitoring
- Most studied in (nanoparticle) ecotoxicology

Add refs

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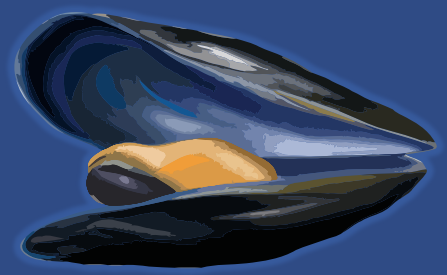
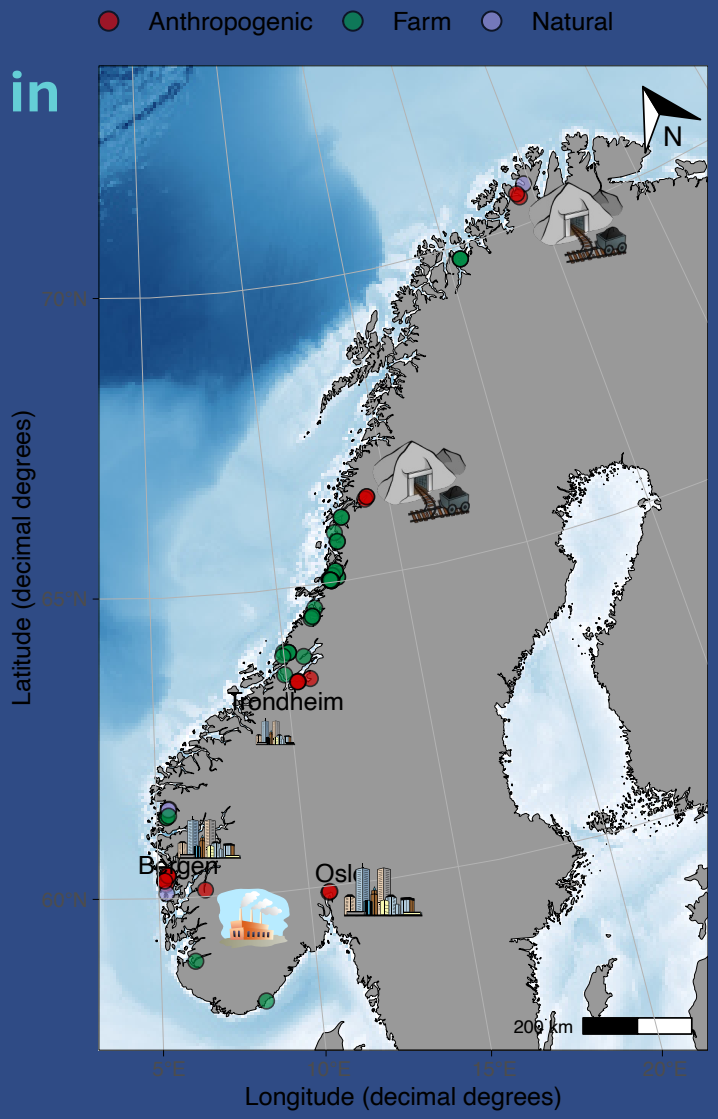
H: Levels of NPs are higher in anthropogenically impacted than in pristine natural and farmed sites.

→ Survey data needed.



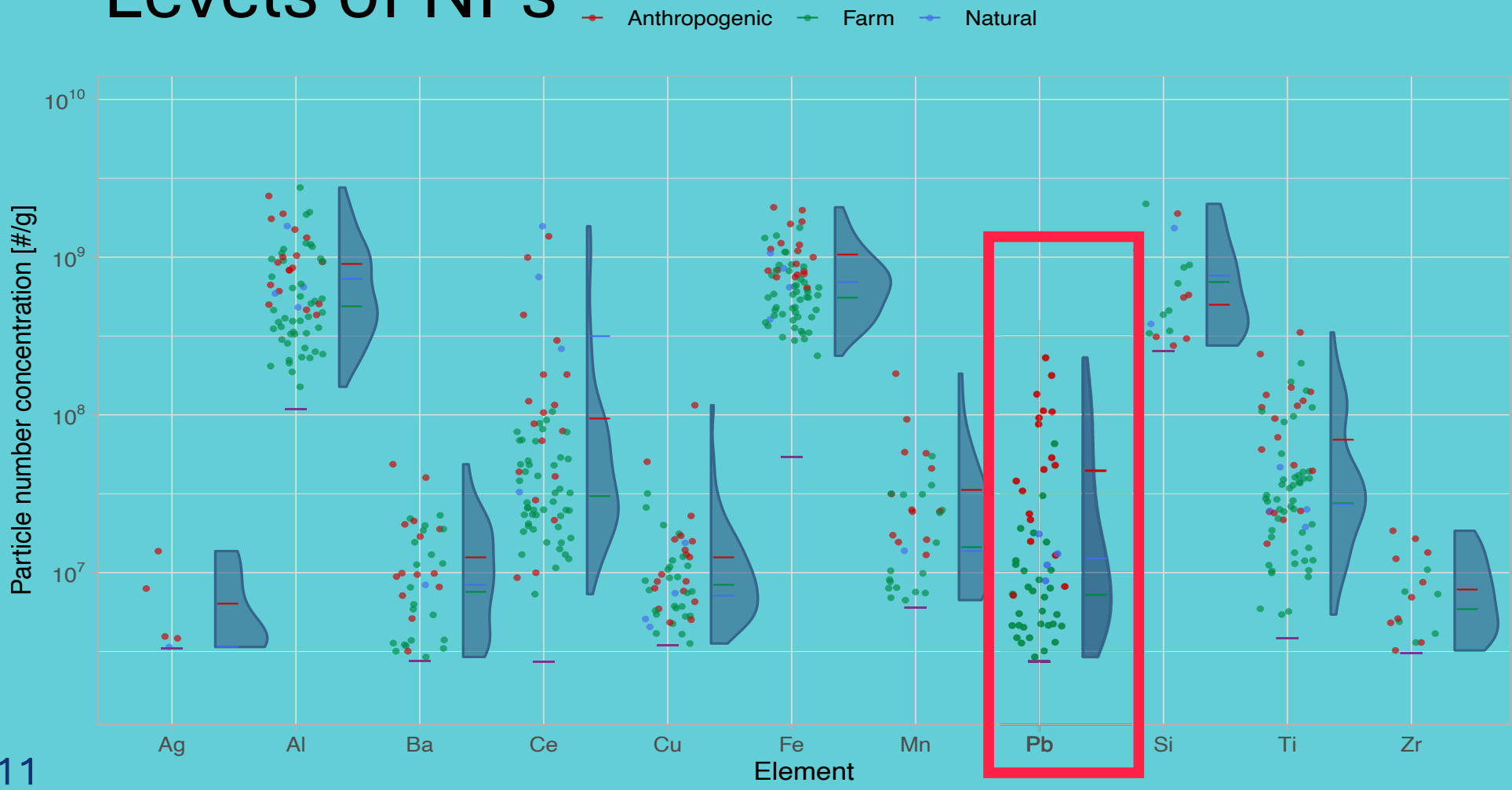
69 pooled samples

11 elements

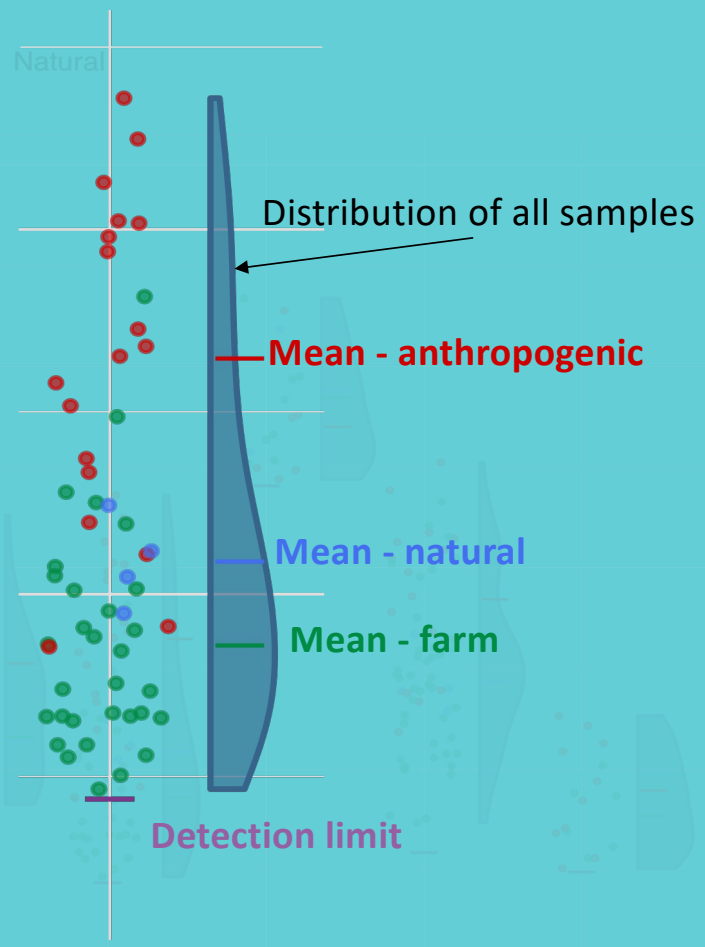


Bruvold, A.S., Valdersnes, S., Bienfait, A.M. Sanden, M, Loeschner, K. (2024) *Journal of Agricultural and Food Chemistry* doi:10.1021/acs.jafc.4c04721

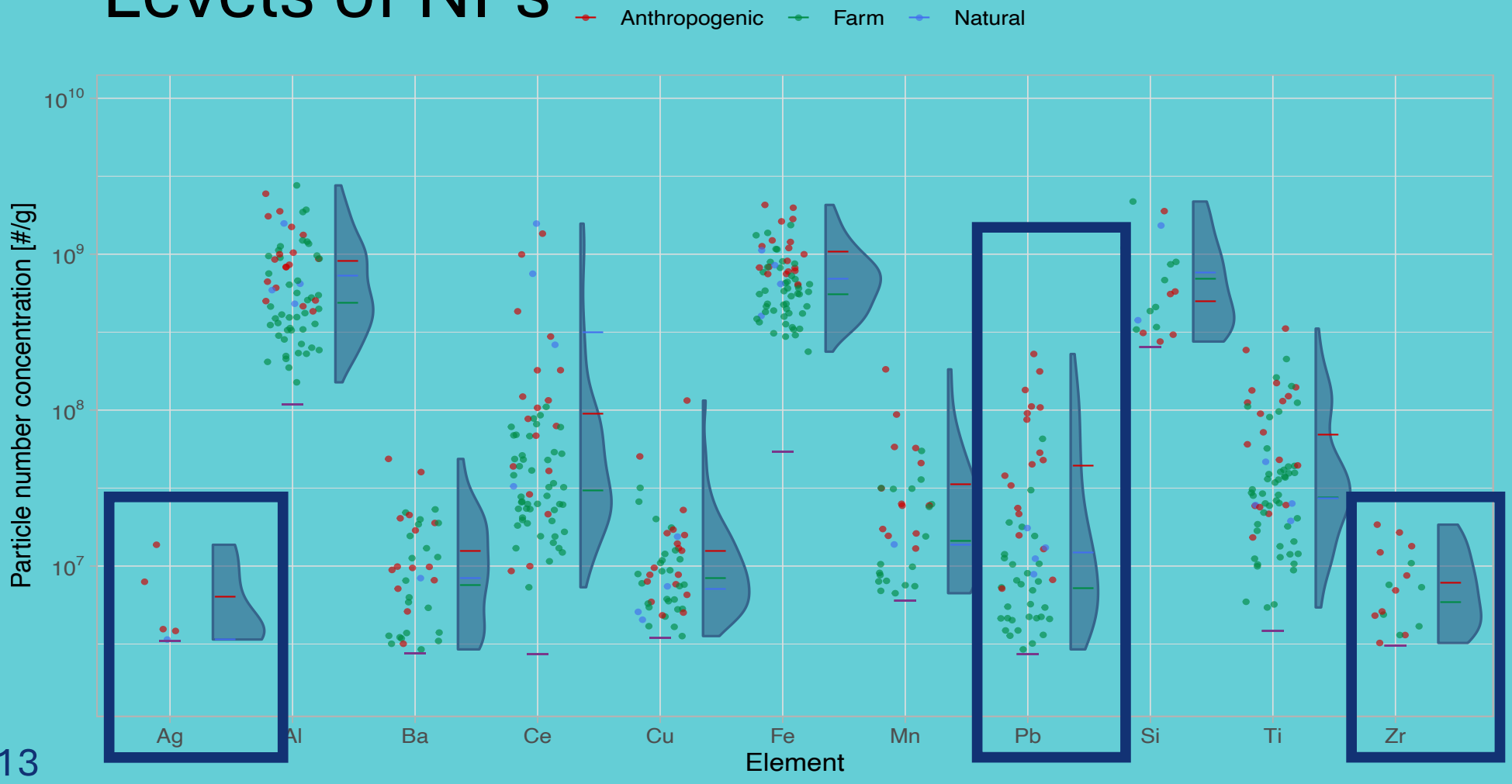
Levels of NPs



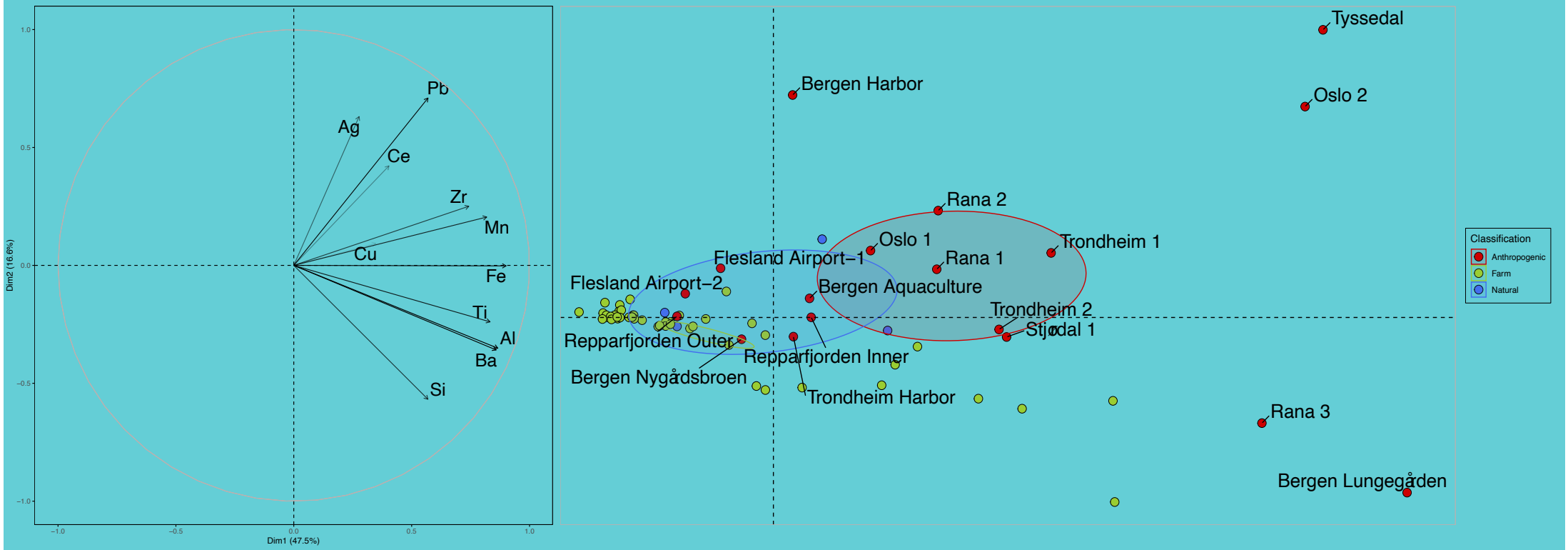
Levels of NPs



Levels of NPs

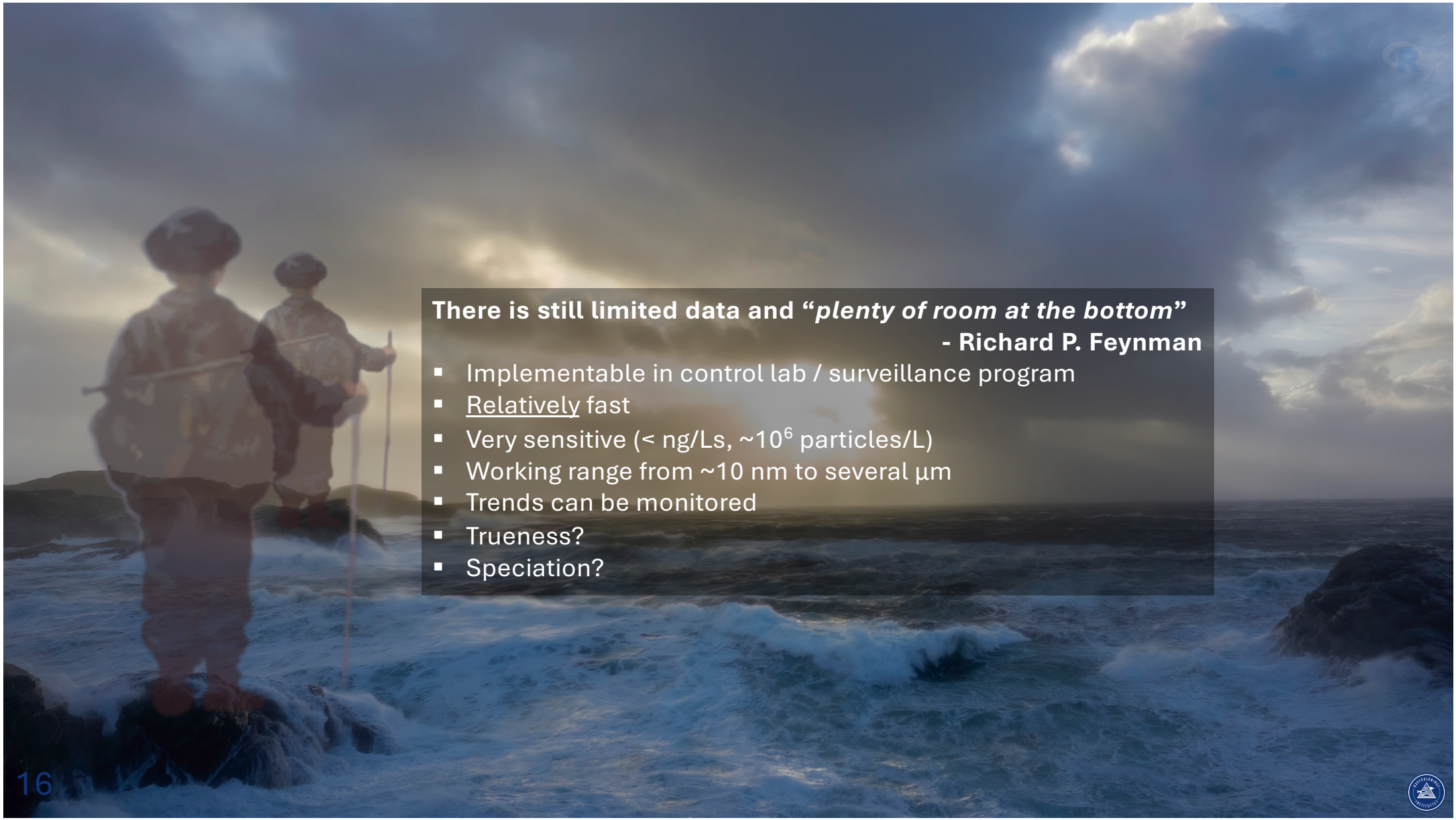


Principal component analysis (PCA)

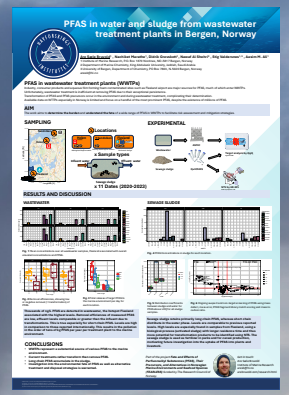


Concluding remarks

- **NPs - especially Ag, Pb and Zr - linked to anthropogenic sites**
- Safe? Low NP-levels in mussels for human consumption
- Mussels depurate NPs, providing an environmental snapshot


There is still limited data and “*plenty of room at the bottom*”
- Richard P. Feynman
Implementable in control lab / surveillance program
Relatively fast
Very sensitive (< ng/Ls, ~10^6 particles/L)
Working range from ~10 nm to several µm
Trends can be monitored
Trueness?
Speciation?

Poster on target PFAS and NTS in WWTPs in Bergen:



Thanks

especially to Stig Valdersnes, Katrin Löschner, Monica Sanden

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Future topics of interest: method

- Peak tail:
  - Sampling depth
  - Sensitivity
  - Different elements
  - Gas flow
  - False detections: JRCNM100 NP?
    - Separation?
    - SEM?
- Comparison of algorithms
- Automated parameter optimization
- Particle signals from adsorbed ionic elements

Future topics of interest: application

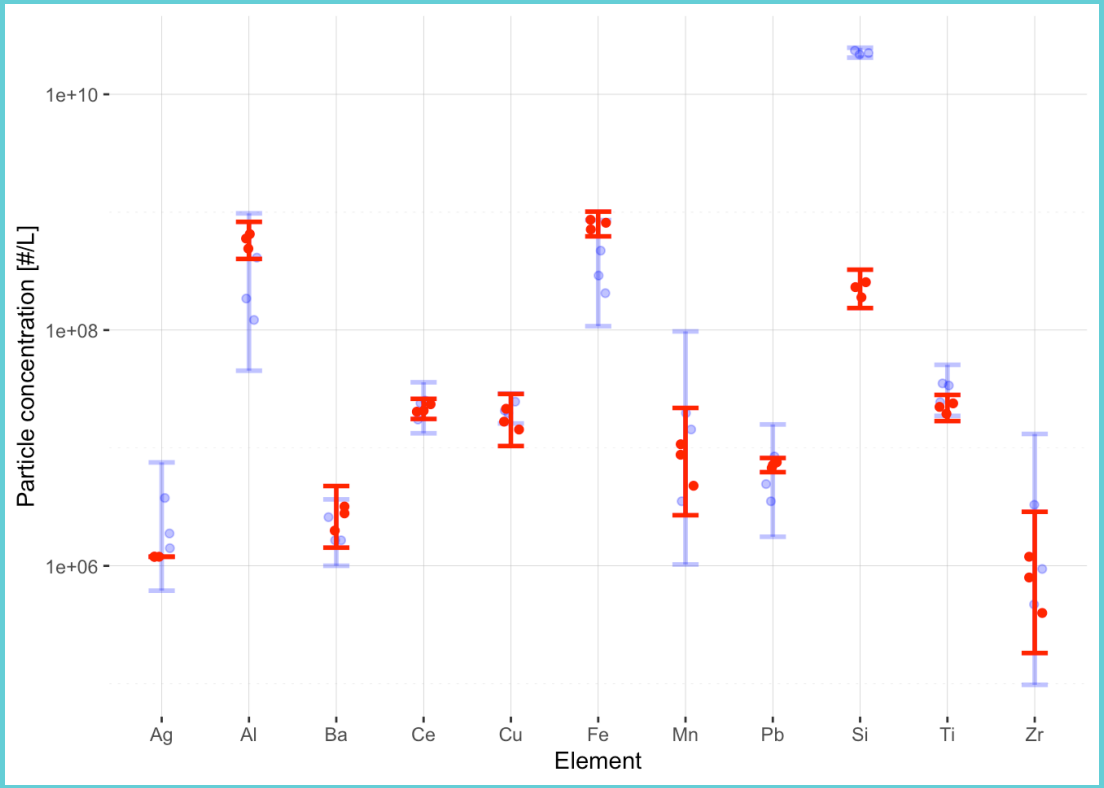
- NPs in a mining impacted fjord:
  - Ranfjorden. Hustadmarmor (Ca)
- Deep sea mining(?)
- **Characterization of mining waste**
  - Ranfjorden. Ba, Ti?
- Mussels:
  - Site-specific study / caged mussels
  - Electron microscopy
  - Effects
- SP greater sensitivity and selectivity vs total metals

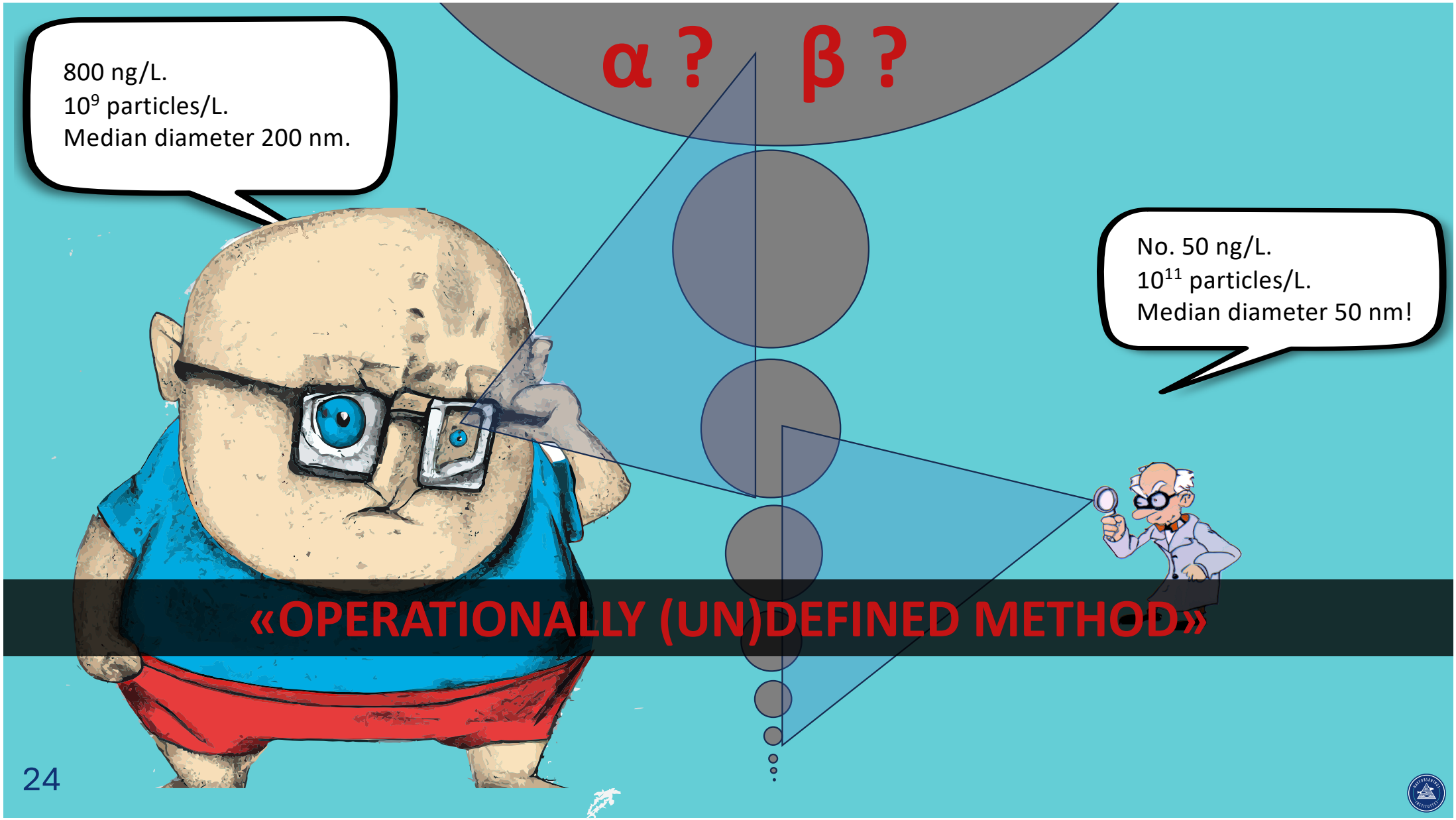
Some limitations and lessons

- More **natural** and anthropogenic locations for P3
- Survey of Ranfjorden in P1
- More extensive field sampling and analysis for P1
- Generally:
  - Working range and bias: exp. dependence of mass/# on these
  - Data and metadata sharing: FAIR & Open
  - Interlab comparison and standardization
  - False positives/ negatives

ALGORITHM: Inhouse vs MassHunter

final optimized method, blue mussels (Paper III)




α ? β ?
800 ng/L.
10^9 particles/L.
Median diameter 200 nm.
No. 50 ng/L.
10^{11} particles/L.
Median diameter 50 nm!
«OPERATIONALLY (UN)DEFINED METHOD»