# Key considerations in assessing Environmental impacts of essential elements

*F. Van Assche*, M. Cook* and A. Green***

**International Zinc Association, 168, Avenue de Tervuren, B-1150 Brussels, Belgium*

*** International Lead and Zinc Research Organisation, Research Triangle Park, NC, USA*

# Natural, essential elements

- Essential Elements (EE's) e.g. zinc, copper, iron,…are present in natural (background) concentrations in all environmental compartments
- EE's are used by biota for essential functions in cellular metabolism
- Environmental toxicity has been a major issue in the LCIA of metals
- The EU Risk assessment has identified key issues in which EE's require a specific methodological approach

# Natural zinc background

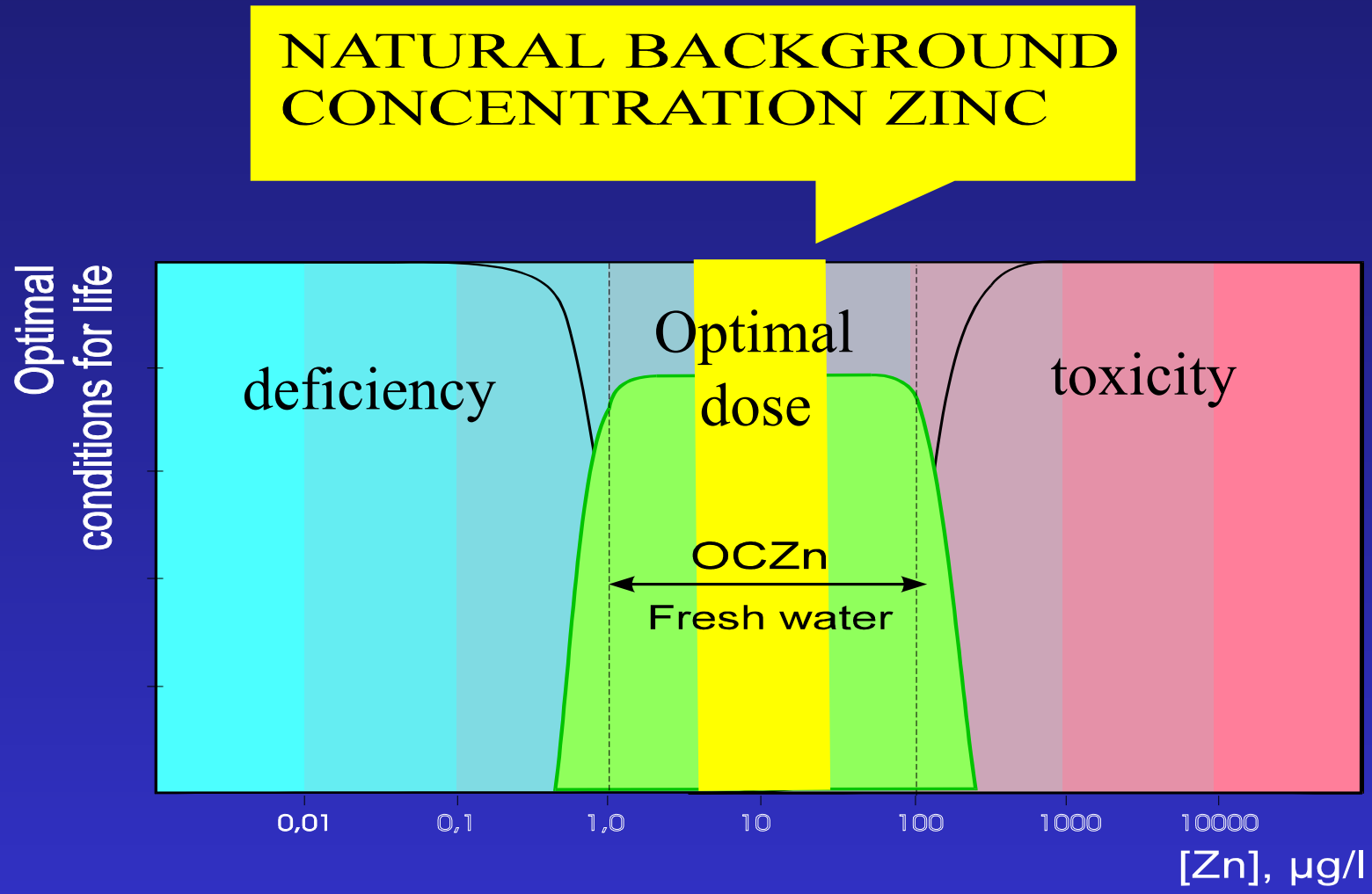
Biota take their required dose of EE's from their environment

Internal EE levels are actively regulated (within boundaries by homeostasis

⇨ *background variability??*

⇨ *relationship organism sensitivity-background??*

# The Optimal Concentration range for Essential Elements



# The variable environment e.g. freshwaters

| Freshwater | Great Lakes | EU lowland rivers | Nordic waters |
|---|---|---|---|
| Natural Zn background (dissolved, µg/l) | 0,09-0,3 | 1-10 | <1-3 |
| pH | 7.5-8.2 | 7.5-8.2 | 5-8 |
| Mean hardness | 50 | 200 | 10 - ? |
| Typical DOC | No data | 2-5 | 5-10 |

# Conditioning of organisms to pre-test zinc concentration

- **Sensitivity of the unicellular alga *Raphidocelis subcapitata***
  - Standard laboratory organism
  - OECD 201 prescribes 1,4 µg/l (dissolved) zinc in test medium
  - often cultivated under the same (zinc) conditions; sometimes however conditions are deviating

# Ecotoxicity of zinc to *Raphidocelis subcapitata*

- *Raphidocelis subcapitata* was originally cultured for a lo time at very low (<EU natural background) zinc concentration (0.3 µg/l)
- subsequently, the algae were cultured for 4 weeks at 3 different Zinc levels:
  - OECD 201 medium + 0.3 µg Zn/l
  - OECD 201 medium + 1.4 µg Zn/l
  - OECD 201 medium + 18 µg Zn/l
- Results: Table

# Changing zinc sensitivity of *Raphidocelis subcapitata* as a function of culture conditions

| Toxicity endpoint | 0.3 µg/l zinc | 1.4 µg/l zinc | 18 µg/l zinc |
|---|---|---|---|
| EC50 Growth rate | 37 | > 200 | 1100 |
| NOEC Growth rate | < 4 | 101 | / |

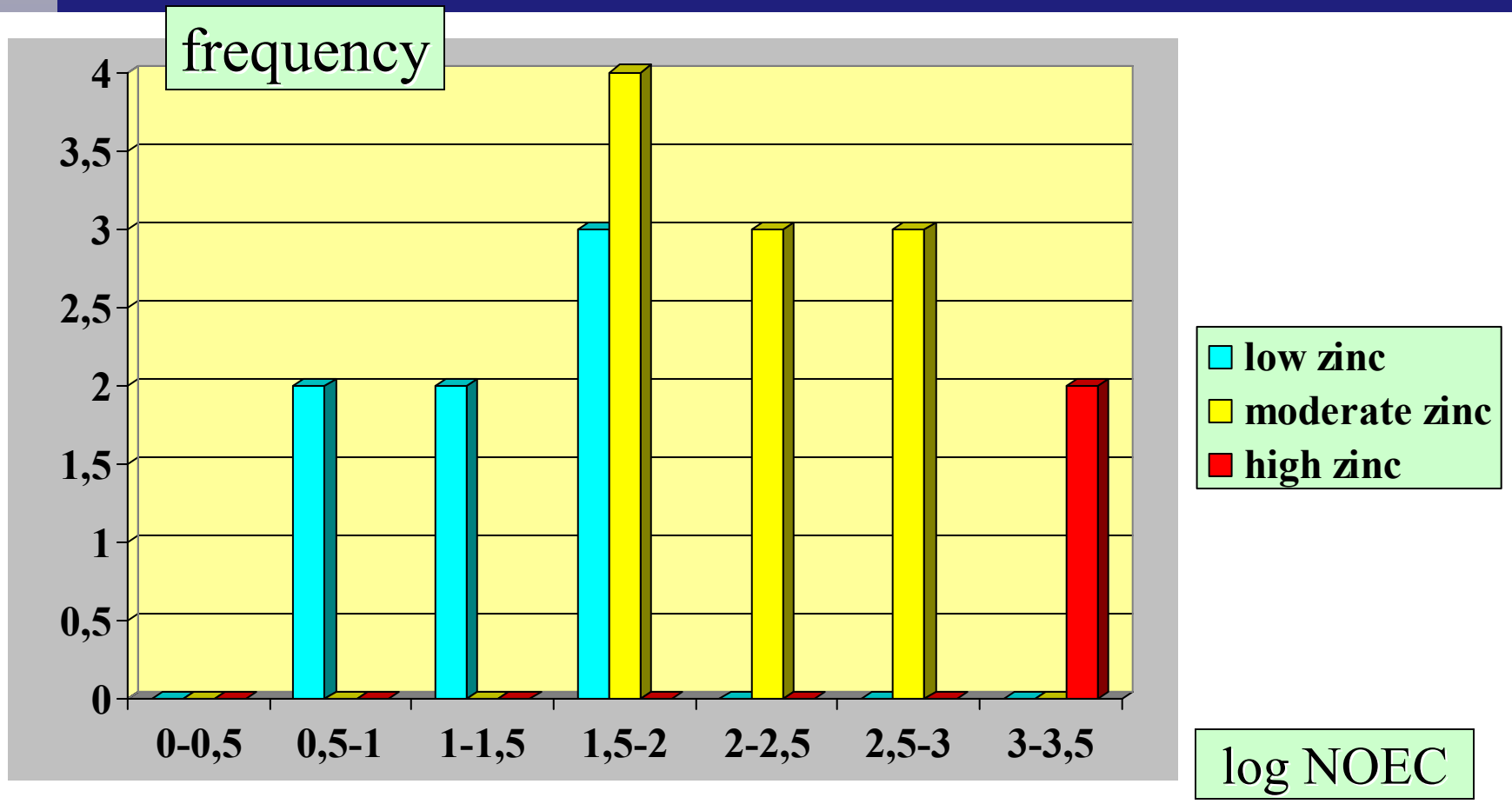
# Zinc (NOEC) data of the RAR groupe according to pre-test conditions

- <1 µg/l Zn dissolved
  - Ephydatia (3,3)
  - Daphnia (55)
  - Selenastrum (8)
  - Corbicula (25)
  - Ceriodaphnia (31)
  - Jordanella (51)
  - Pimephales (78)

- ≥ 50 µg/l dissolved
  - Hormidium (1000)
  - Scenedesmus (1400)

- ≥ 1 µg/l Zn dissolved
  - Chroococcus (200)
  - Selenastrum (37)
  - Synecoccus (390)
  - Dreissenia (400)
  - Potamopyrgus (75)
  - Daphnia (224)
  - Hyallella (42)
  - Phoxinus (50)
  - Salmo (210)
  - Salvenilus (530)

# Frequency of chronic NOECs as function of zinc background



# Ecological relevancy of ecotoxicity data: the regional approach

- Organisms are conditioned to the background range of EEs in their environment (in nature, in the lab).
- Background levels of metals in the natural environment show great variety
- The sensitivity to EEs of test organisms from environments with different pre-test EE level will be different in laboratory tests
- ⇨ region-specific approach required

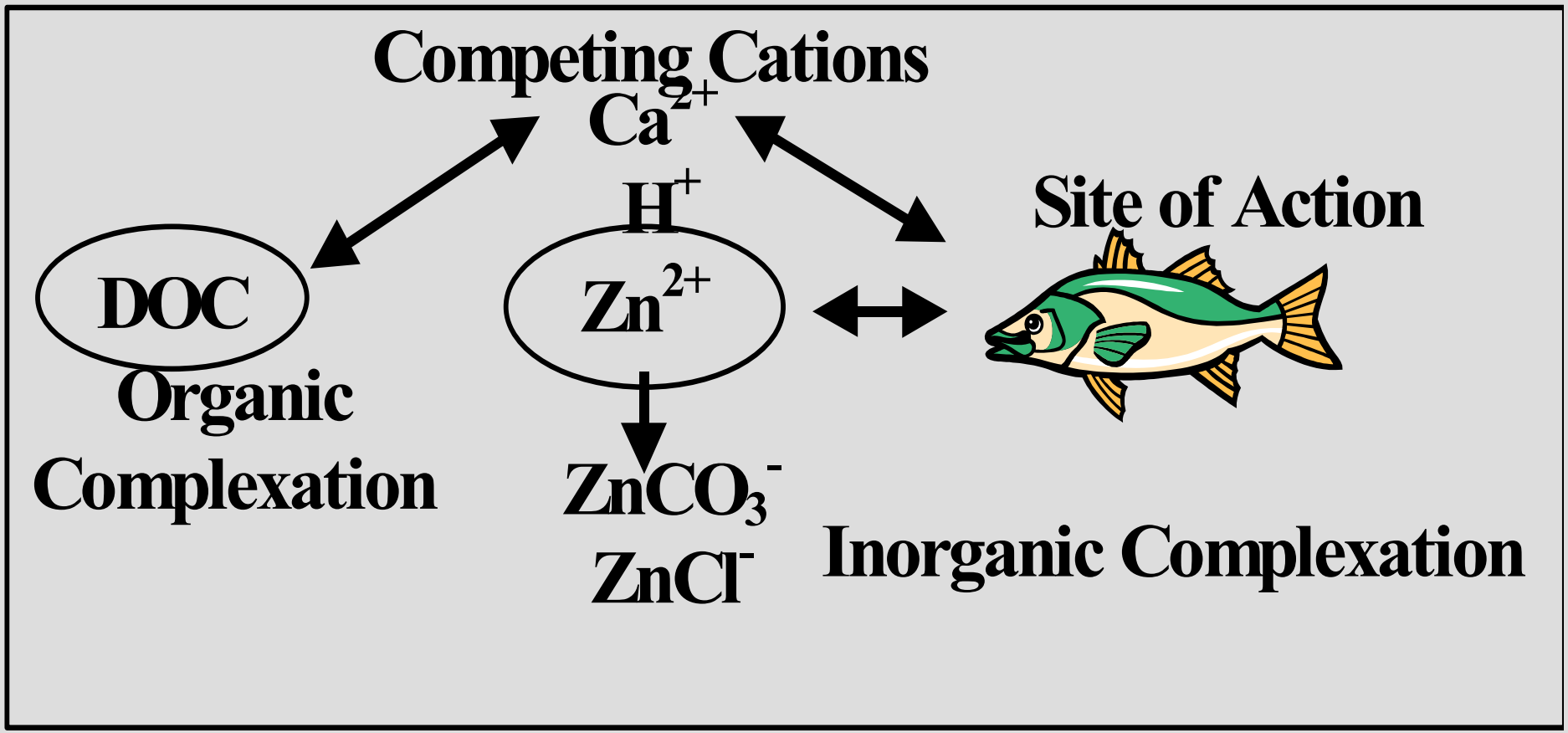
# Summary statistics/extrapolations for different zinc-metalloregions

| Zinc metalloregion in µg zinc dissolved/l in culture (N) | Mean +/- Standard Deviation | PNEC (µg Zn/l) |
|---|---|---|
| < 1 (7) | 36 +/- 27 | 3.1 |
| > 1, < 50 (10) | 216 +/- 174 | 26 |

# Bioavailability

- In the natural environment, organisms are conditioned to the available EE concentration
- the combination of factors defines bioavailability
  - water: pH, DOC, hardness
  - soil: OC, CEC
  - sediment: AVS, OC
- The EU has recognised that bioavailability must be factored in the RA
- Research is ongoing to develop the quantifiers for bioavailability in water, sediment, soils

# Modelling bioavailability



# Bioavailability makes the difference

| Scenario | PEC/PNEC without bioavailability | PEC/PNEC with integration of availability factor |
|---|---|---|
| Regional waters e.g. region Rhin-Meuse (F) | 2.8 | 0.5-0.8 |
| Roadside waters NL worst case scenario | 4.0 | 0.5 |

# Relevancy of ecotoxicity data

- EE background and physicochemical factors determine the availability of EE's to biota
- ⇨ conditions to be documented and to be conform with the environment to be assessed:
  - metal background
  - physico-chemistry (pH, hardness, DOC/CEC…)
- To be relevant for use in the risk assessment of a given environment, an ecotox result should be obtained under the conditions of that environment (culture and test)

# Conclusions

- Due to the close relationship between the environmental conditions (EE background, physicochemistry) and the sensitivity of organisms towards EE's, the potential risks of EE's must be assessed on a region-specific, not a general-environment basis