Challenges in Implementing Biota EQSs for Priority Substances

Peter Lepom

Laboratory for Water Analysis, Federal Environment Agency, Berlin, Germany

Can we afford not to monitor priority pollutants, 24/25 November 2015,
Royal Society of Edinburgh

Background

- Directive 2008/105/EC revised by Directive 2013/39/EU
  - *EQSs for 45 priority substances; mostly water*
  - *Biota-EQSs – 11 substances*
  - *Biota-EQSs normally apply to fish*
  - *Exemptions*
    - PAHs: crustaceans, molluscs
    - Dioxins and dl-PCB: fish, crustaceans, molluscs

- Basically, two different biota standards were derived and and the lower of the two adopted as overall standard

- The protection goals for biota-EQSs were not indicated in the Directive

Biota EQSs – Protection goals

- Human health (consumption of fish and seafood)
  - *PBDE, fluoranthene, HCB, PAHs, PFOS, dioxins/dl- PCBs, heptachlor/heptachlor-epoxide*
- Protection of top predators from secondary poisoning
  - *HCBD, mercury, dicofol, HBCDD*

Different protection goals may require different monitoring strategies!

Challenges

- Protection goal
  - *Where to sample*
  - *Fish species to be sampled*
  - *Age (size) of the fish*
  - *Tissue to be analysed*
- Individual fish or pooled samples?
  - *Quantity of fish tissue required*
- Normalisation
  - *Standard lipid content 5%*
  - *Standard trophic level of 4*
- Extremely low EQSs
- Conflict with food legislation

Protection of top predators

- Protection of populations
- Identification of the relevant fish-eating top predator
  - *Customised regional monitoring strategy*
- Examining the diet of the top predator
  - *Composition and size (length) range*
  - *Predators are mostly opportunistic feeders*
  - *They prey on species of a certain size/length range according to their abundance and accessibility*

Protection of top predators

- The fish species and size range to be sampled should be selected according to the diet of the targeted predator
  - *“Prey basket” approach*
  - *Composite samples of the relevant species and size range*
- Predators normally gorge the whole fish
  - *Analysis of whole fish sample*
- Where to collect samples?
  - *Locations where the predators occur*

Protection of human health

- Protection of individuals
- Sampling of consumption-relevant wild fish species
  - *Size (length) of the fish to be monitored should conform to the average length of the catch and to consumer habits*
  - *Fish eaten by humans are often larger and higher in trophic level than those consumed by top predators*
- Mostly, only fillet is consumed
  - *Analysis of fillet/muscle tissue*
- Where to collect samples?
  - *Focus on waters in which commercial fishing takes place*
  - *Areas with recreational fishery, where appropriate*

Individual Fish or Pooled Samples?

- Individual fish samples are recommended
  - *Advantages*
    - Information on the variability of contaminant concentrations
    - Statistical methods may be applied in compliance checking
  - *Drawbacks*
    - Cost for chemical analyses very high
    - Often, available sample quantity does not allow analysing all priority substances at the required low level

Individual Fish or Pooled Samples?

- Pooled samples
  - *The measured concentration corresponds to the weighted arithmetic mean of the concentrations of the individual fish*
  - *Advantages*
    - Cost-efficient
    - Sufficient tissue for analyses can easily be provided (> 100 g)
  - *Drawbacks*
    - No information on variability in concentrations between individuals
    - Limited possibilities to apply statistical methods in compliance assessment

What tissue should be analysed?

- Whole body – Secondary poisoning
- Muscle tissue – Human health
- Lipophilic contaminants
  - *Concentrations in whole body > muscle tissue*
- Mercury
  - *Concentrations in muscle tissue > whole body*
- Calculation of whole body concentrations from muscle concentrations and *vice versa*
  - *Reliable equations available for mercury and PCBs*
    - PCB: whole body/muscle ratio: 1.5 to 2
    - Mercury: whole body/muscle ratio: 0.6 to 0.8

Normalisation of Concentrations

- Normalisation to standard lipid content of 5%
  - *Appropriateness of normalisation depends on the contaminant under consideration and the objective of the monitoring programme*
    - Only for contaminants which accumulate in lipids
    - YES: Benchmarking, identification of pressures and comparison of concentrations at different locations
    - NO: If human fish consumers or wildlife predators are concerned

> *"...It is generally not suitable to lipid normalise concentrations if the objective is to evaluate concern to human sport fish consumers or wildlife predators because the consumers eat the entire fillet or organism and not just the lipid fraction."*
>
> Gewurtz et al. Environ. Rev. 19: 162–184 (2011)

Normalisation of Concentrations

- Contaminant levels depend on the trophic level (TL) of the fish species sampled
- Select trophic level according to the protection goal
  - *Humans often eat fish of trophic level 4 or higher*
  - *Predators feed on fish of trophic levels 3 to 4.4*
- Normalisation to standard trophic level of 4
  - *Calculation of normalised contaminant concentrations*
    - Local TL or TL available from *www.fishbase.org*
    - Suitable trophic magnification factor
  - *Local trophic level*
    - Analysis of stable isotopes $^{15}N/^{14}N$ in the fish and a reference of known trophic level, e.g. mussels (TL = 2)

Normalisation to Trophic Level 4

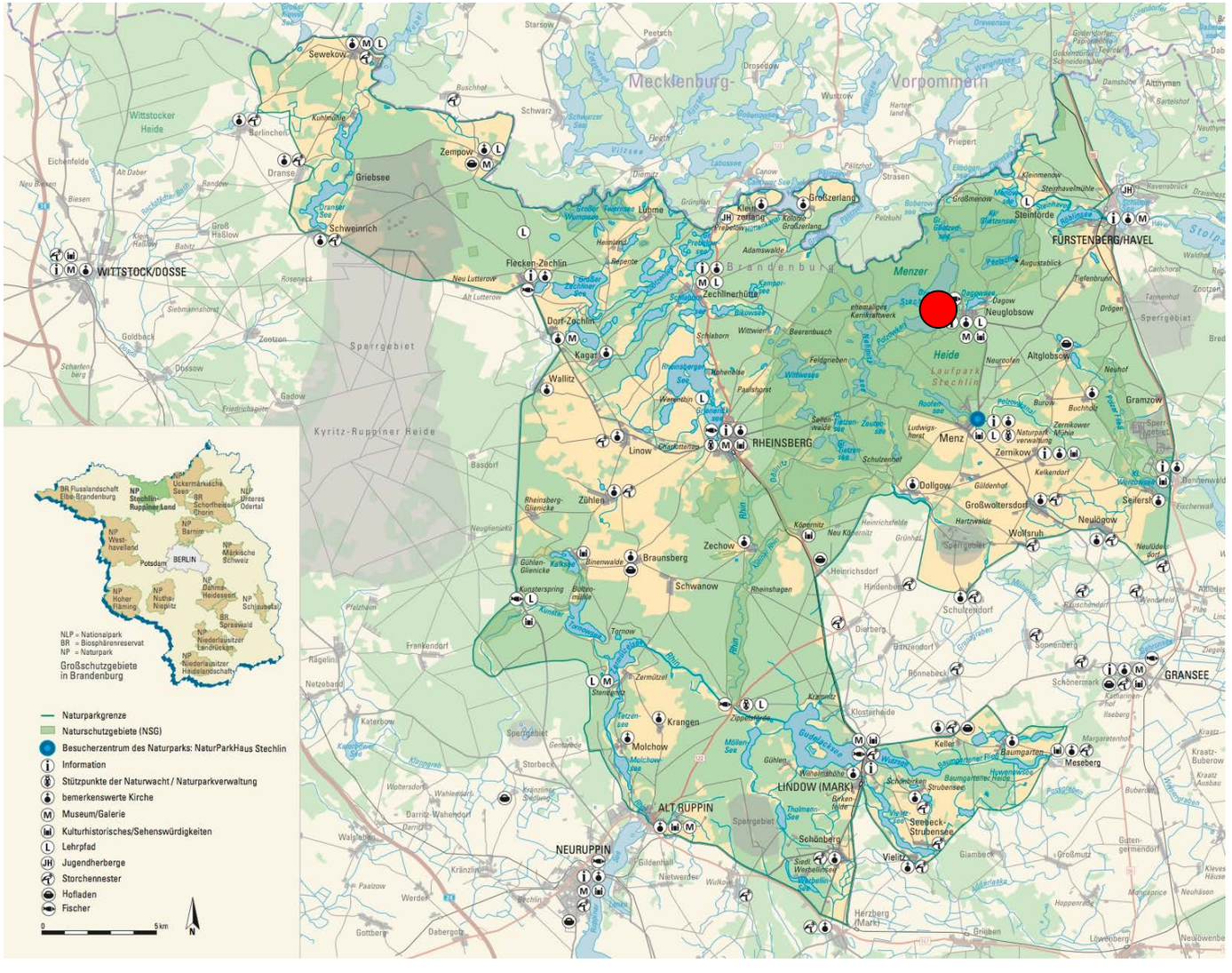
- Example: roach and perch from Lake Stechlin
  - *Input data:*
    - Roach TL = 3.0; Hg = 34 µg/kg w.w.
    - Perch TL = 4.4; Hg = 58 µg/kg w.w.
    - TMF_{Hg} – Freshwater: 4.3 ± 4.8; 101 studies (Lavoie et al. EST 2013)

Perch: $c_{TL4} = c_{measured} * TMF^{(4-TL)}$ = **58 µg/kg** * $4{,}3^{(4-4{,}4)}$ = **32 µg/kg**

Roach: $c_{TL4} = c_{measured} * TMF^{(4-TL)}$ = **34 µg/kg** * $4{,}3^{(4-3{,}0)}$ = **146 µg/kg**

Uncertainties associated with the determination of TL and TMF are high and not sufficiently understood to apply TL normalisation in a regulatory framework

Pilot Study Lake Stechlin



Sampling site:
- Lake Stechlin
- September 2013

Top predator:
- Osprey

Fish species
- Roach: n=30
- Perch: n=17
- Bream: n=23

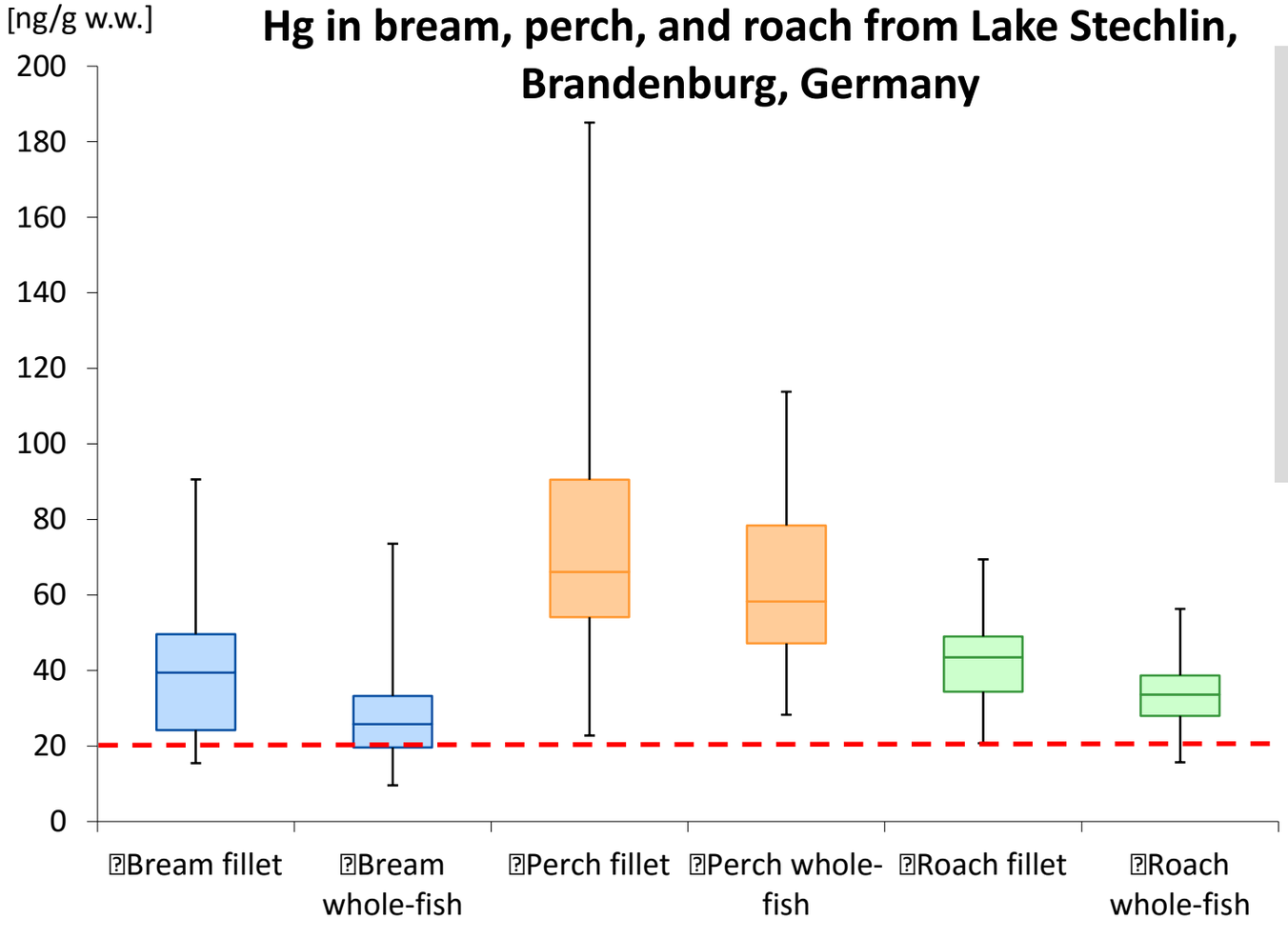
Individual fish:
- Muscle/remaining fish
- Mercury

Three pooled samples:
- Muscle/remaining fish
- Organics

Objectives of the Pilot Study

- How does the **trophic level** of the selected fish species affect the measured contaminant concentrations?
- How does the **size/length (age)** of the fish affect the measured contaminant concentrations?
- How does the choice of the **tissue for analysis** affect the measured contaminant concentrations?

Pilot Study Lake Stechlin



Trophic Level

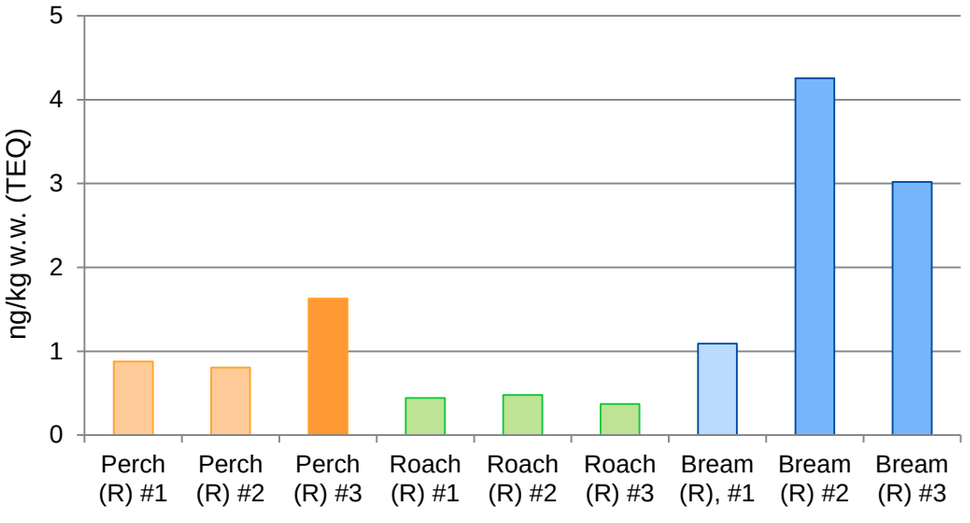
Bream	3.1
Perch	4.4
Roach	3.0

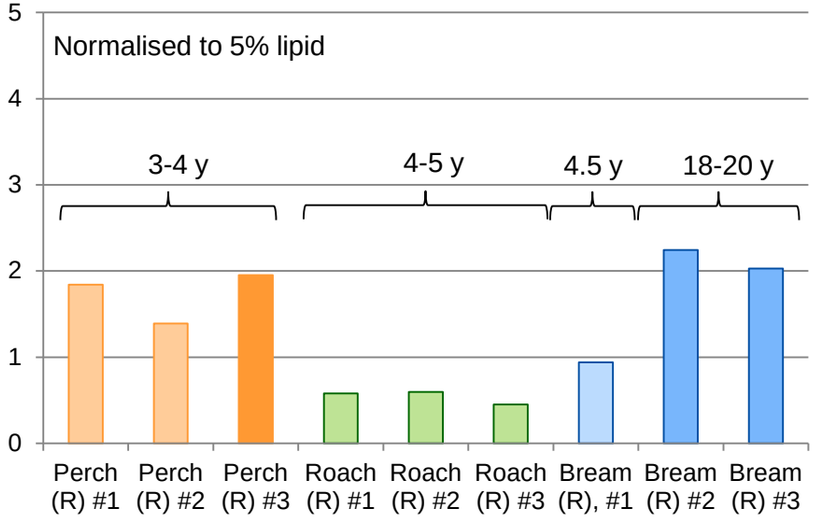
Hg concentrations depend on the trophic level of fish

EQS = 20 µg/kg w.w.

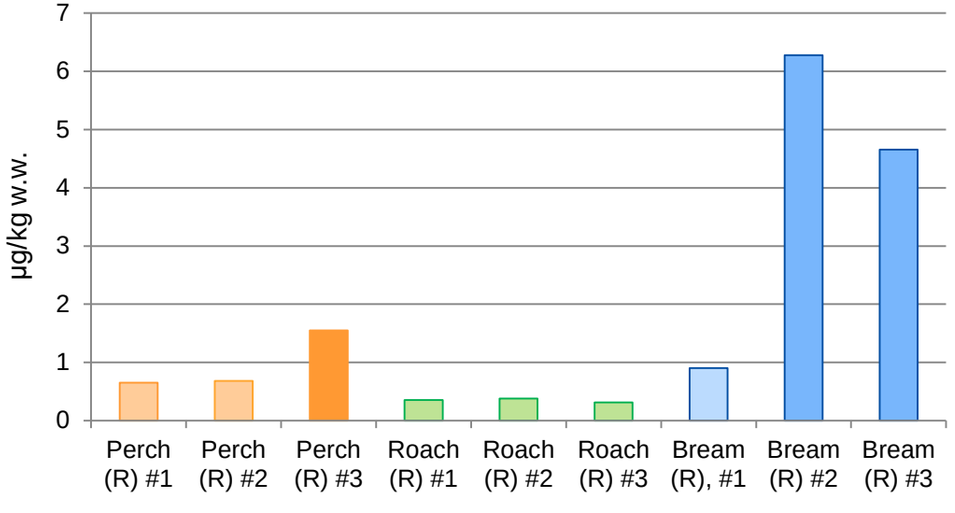
Organics in Fish from Lake Stechlin

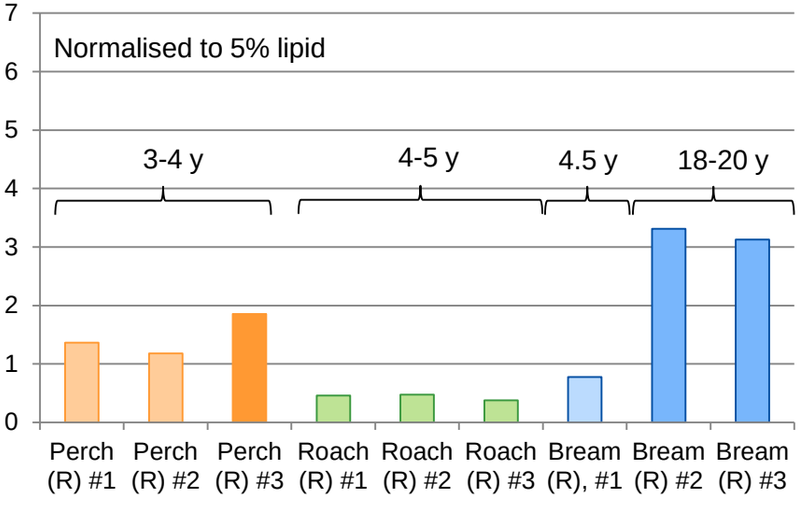
PCDD/F + dl-PCBs





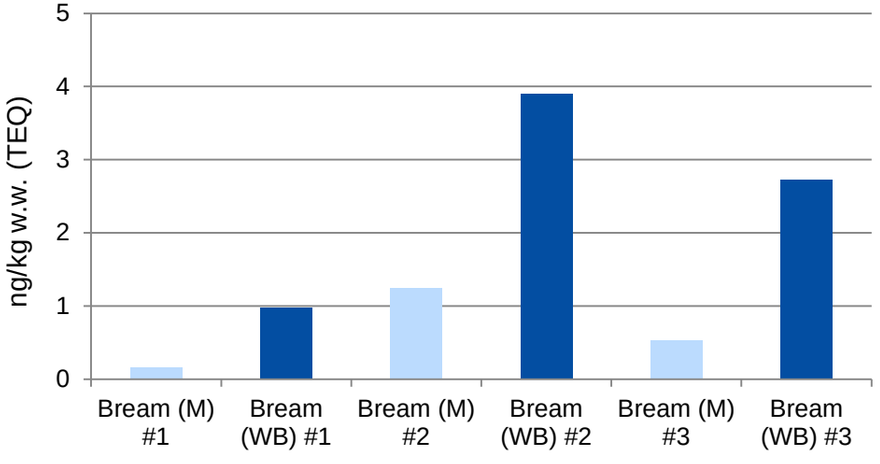
Sum of 6 BDE congeners

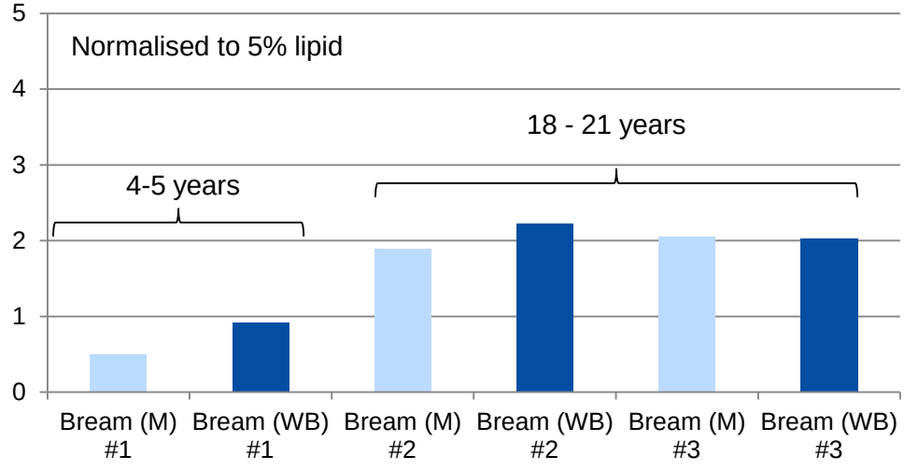




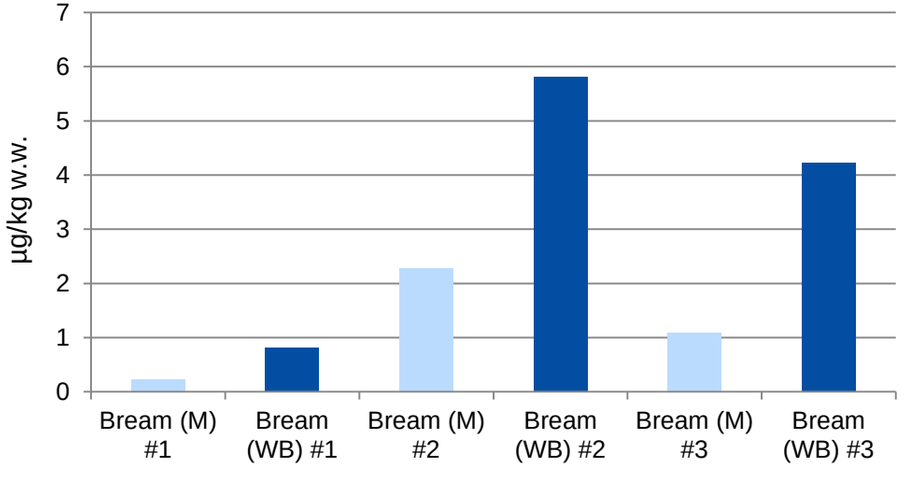
Organics in Bream from Lake Stechlin

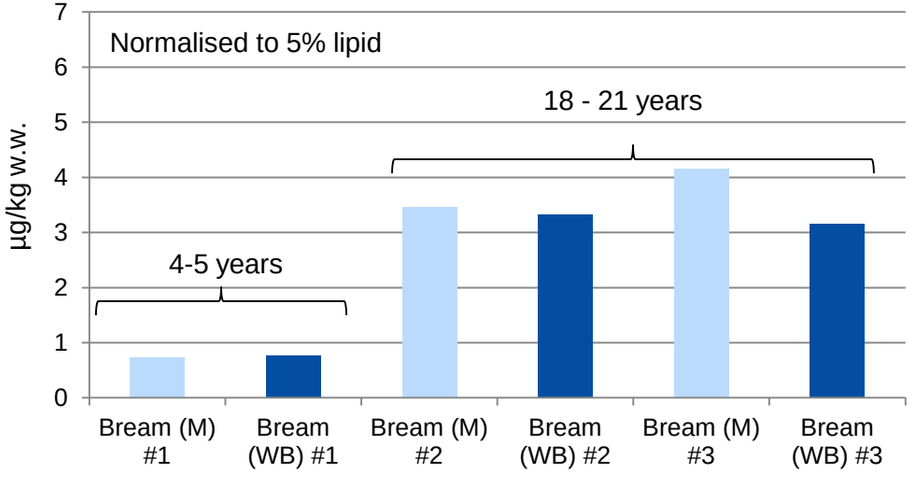
PCDD/F + dl-PCBs



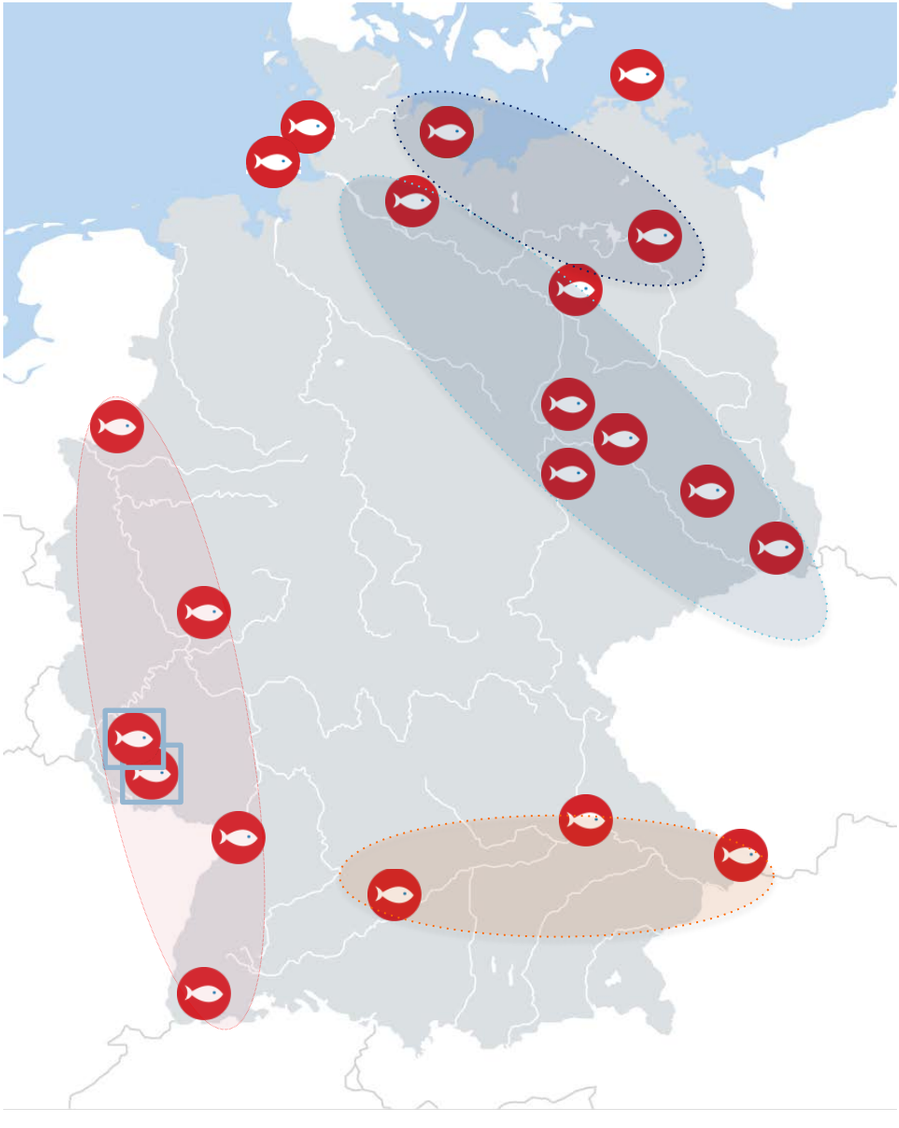


Sum of 6 BDE congeners





Other Challenges



- Sum of 6 BDE; EQS = 8.5 ng/kg w.w.
- Exceedance at all sampling sites even at reference sites
- No routine method allowing measuring concentrations at EQS level
- Derivation of EQS was questioned by various Member States
- Conflict with food legislation
  - *No maximum level in food*
- EFSA used the same toxicological data for assessment but drew a different conclusion
  - *"No concern", except possible concern as regards BDE99 for children (1-3 y)*

Conclusions

- The protection goal of the EQS is the key factor in establishing the monitoring strategy
  - *Sampling site, fish species, size of the fish, tissue to be analysed*
- Pooled samples – acceptable option
  - *Required sample amount, costs for analyses*
- Normalisation of concentration to 5% lipid where required for benchmarking but not for local risk assessment
- Normalisation to TL of 4 involves too much uncertainties to be applied in compliance assessment routinely
- Sampling two fish species of different trophic level desirable

Acknowledgements