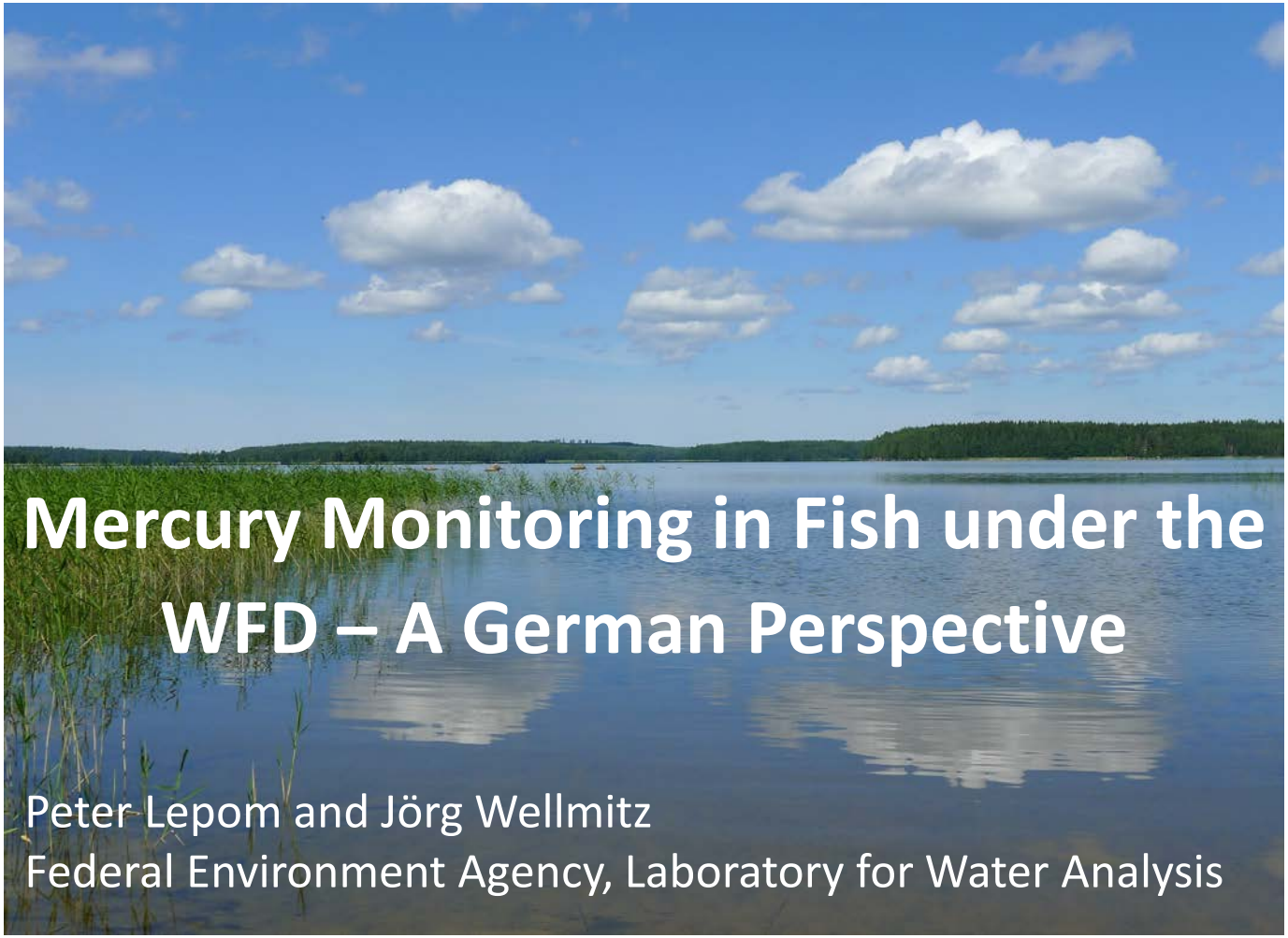

Mercury Monitoring in Fish under the WFD – A German Perspective

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Background

- **Directive 2008/105/EC amended by Directive 2013/39/EU**
  - EQS for 45 priority substances, usually expressed as water concentrations
  - EQS_{biota} for 11 substances, which usually apply to concentrations in fish
- **EQS for mercury in fish: 20 µg/kg wet weight**
  - Protection of top predators from secondary poisoning
- **A survey among 18 EU Member States indicated that the EQS has been exceeded in most water bodies in Europe, even in those nearly unaffected by human activity**

What is the situation in Germany?

Mercury in fish from German surface waters 2008 – 2015

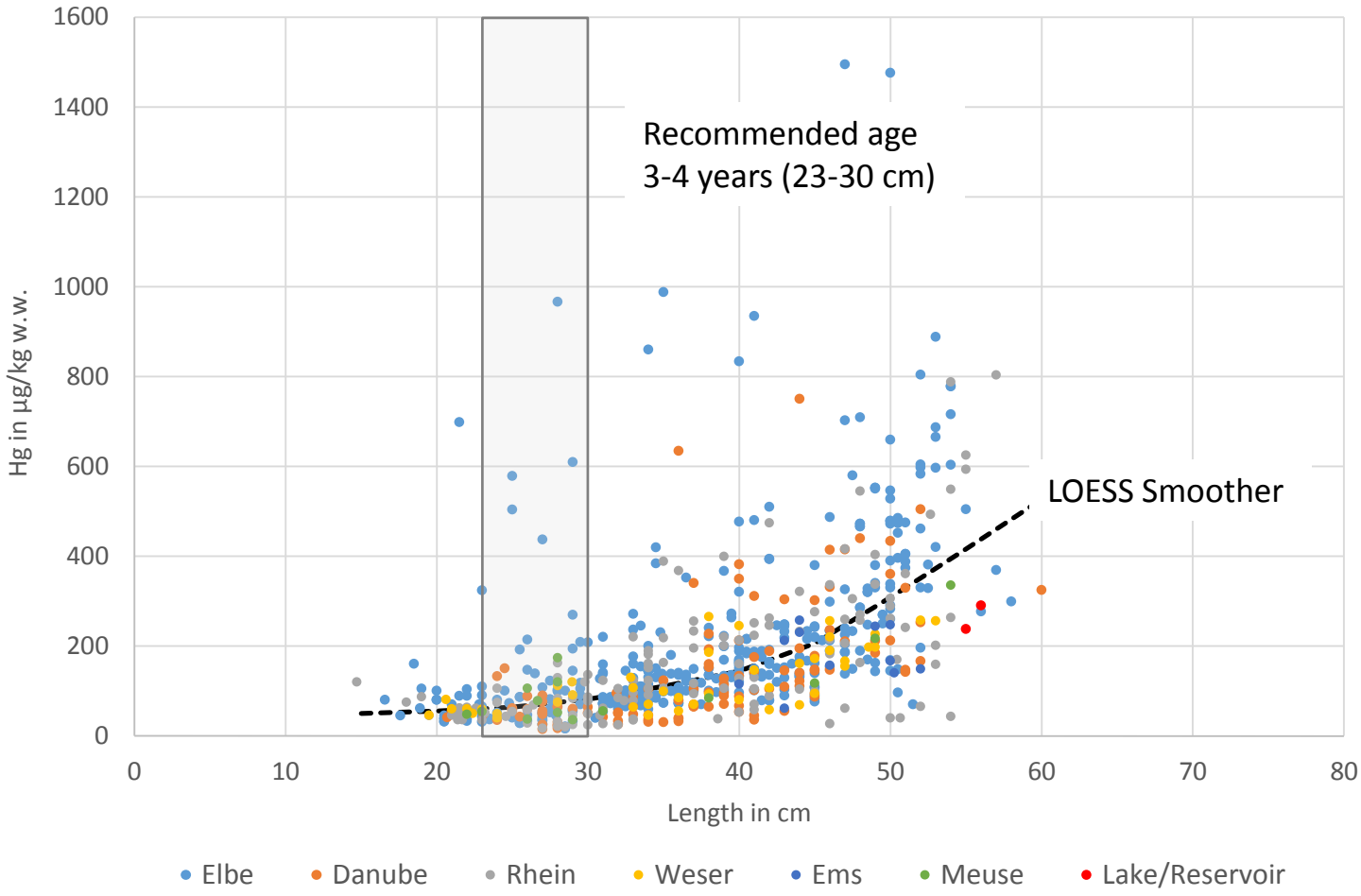
- **Survey on mercury levels in fish among Federal States Authorities**
  - Information from 12 Federal States and the Federal Environment Agency
  - 3060 data sets
- **Issues to be considered in the evaluation of the data**
  - What species?
  - What age/size?
  - What trophic level?
  - What tissue?
  - Are there any hot spots?
  - Are there any differences in Hg concentrations between river basin districts?

Mercury in fish in German surface waters 2008 – 2015

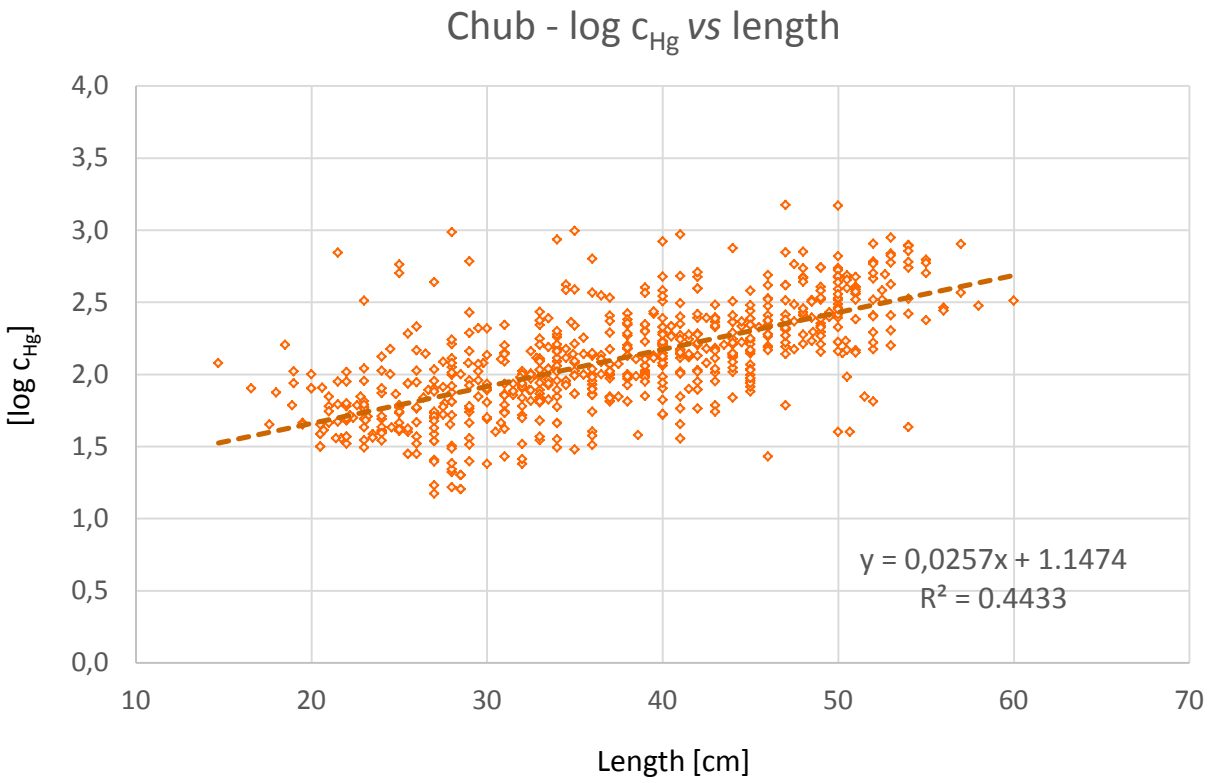
- **Mercury was usually measured in muscle tissue**
- **87% of the data were from individual fish samples**
- **The evaluation was limited to**
  - Six fish species recommended in the national guidance on biota monitoring
    - Chub, bream, roach, perch, trout, pike
    - 150 to 700 results for each species
  - A total of 2123 data sets (72%) was evaluated
    - Size of the fish was used as surrogate for age
    - 20% of the fish were within the recommended species specific size (age) range

Mercury in chub (all sampling sites)

The size range of the fish should be typical for the diet of the predators to be protected!



Effect of length on Hg concentration in chub



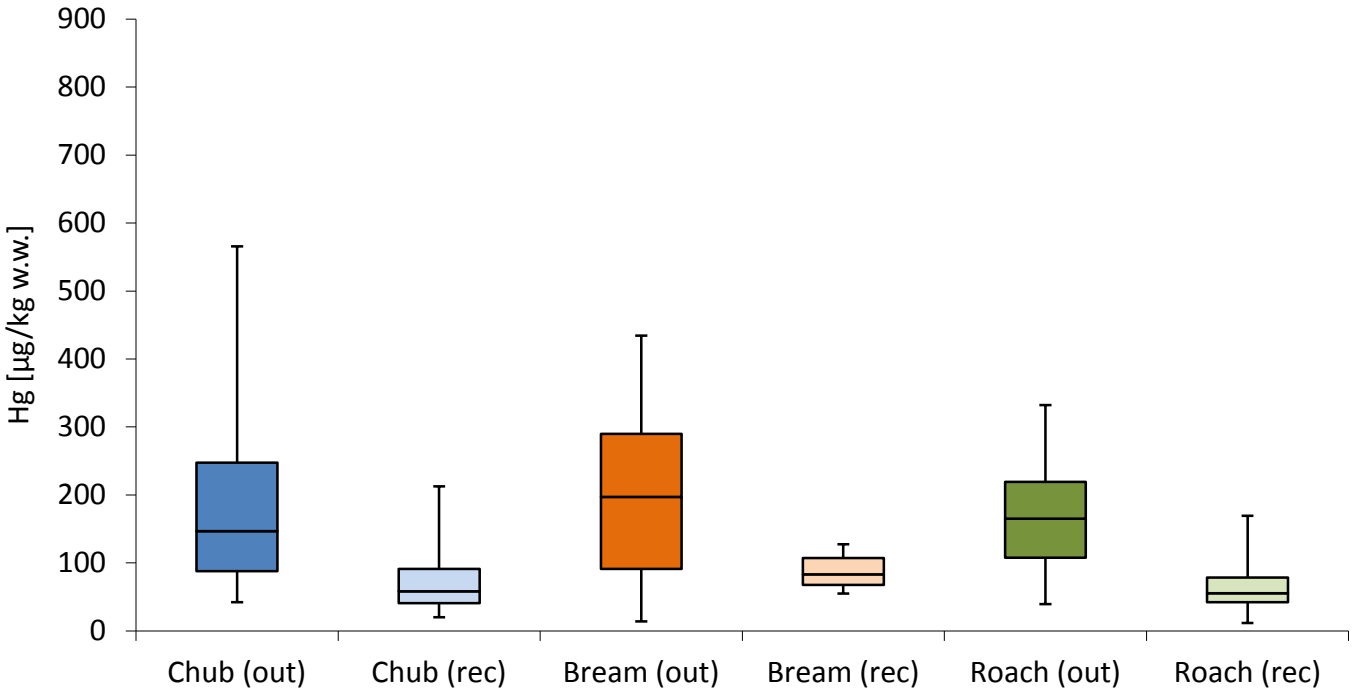
Multiple Regression

Predictors:

- Length
- Sampling site
- Year
- River basin

- Length explains 44% of the variability in mercury concentration, $R^2 = 0.4433$
- If sampling site was included in the regression, R^2 would change to 0.449

Mercury in fish from all river basins (1)

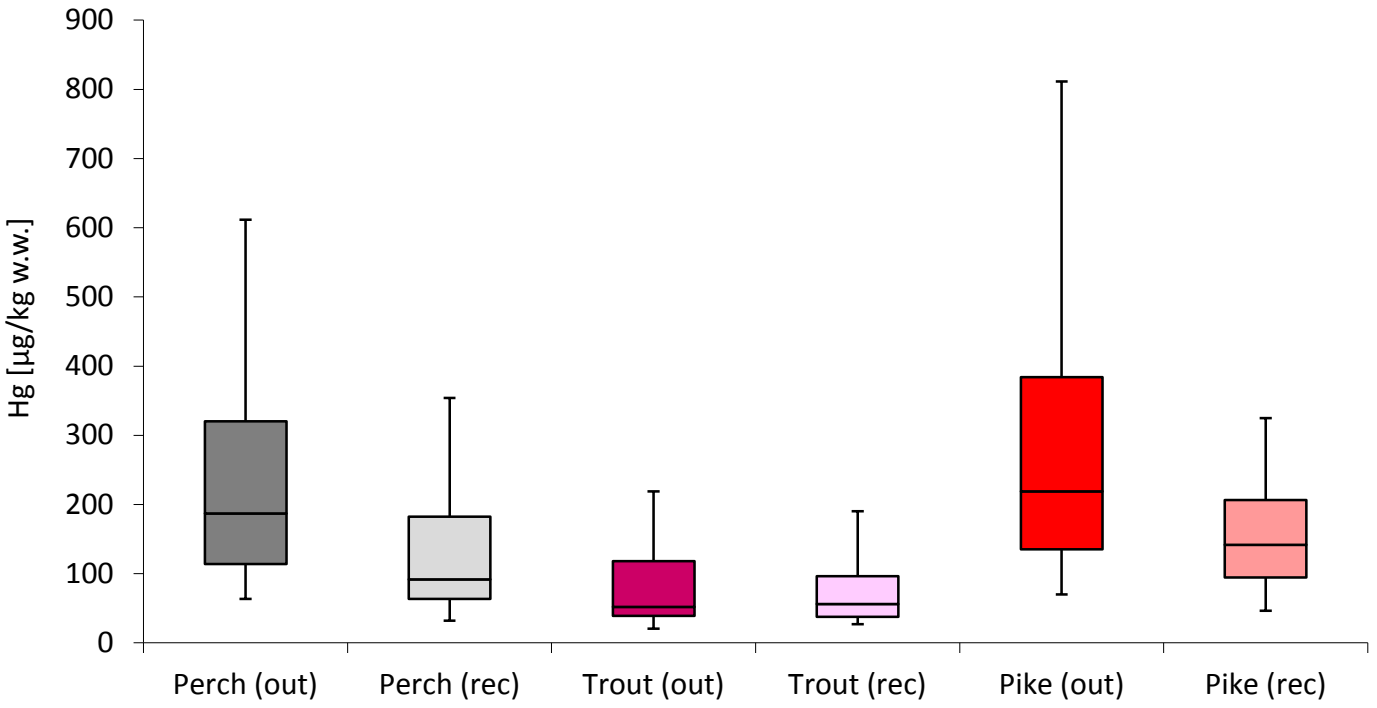


out = length of the fish outside the recommended range
rec = length of the fish within the recommended range

Mann-Whitney U-Test (out/rec)

Species	**p-value**
Chub	< 0.0001
Bream	0.024
Roach	< 0.0001

Mercury fish from all river basins (2)



out = length of the fish outside the recommended range
rec = length of the fish within the recommended range

Mann-Whitney U-Test (out /rec)

Species	**p-Wert**
Perch	< 0.0001
Trout	0,81
Pike	< 0.0001

Mercury (µg/kg w.w.) – Summary statistics

	Chub (out)	Chub (rec)	Bream (out)	Bream (rec)	Roach (out)	Roach (rec)
Number	571	146	555	7	184	75
Min	24	15	1	55	5	6
P5	42	20	14	55	39	12
P25	88	41	91	68	108	42
Median	147	58	197	83	165	55
P75	247	91	290	107	219	79
P95	566	213	435	128	332	169
Max	1495	966	1185	130	517	230

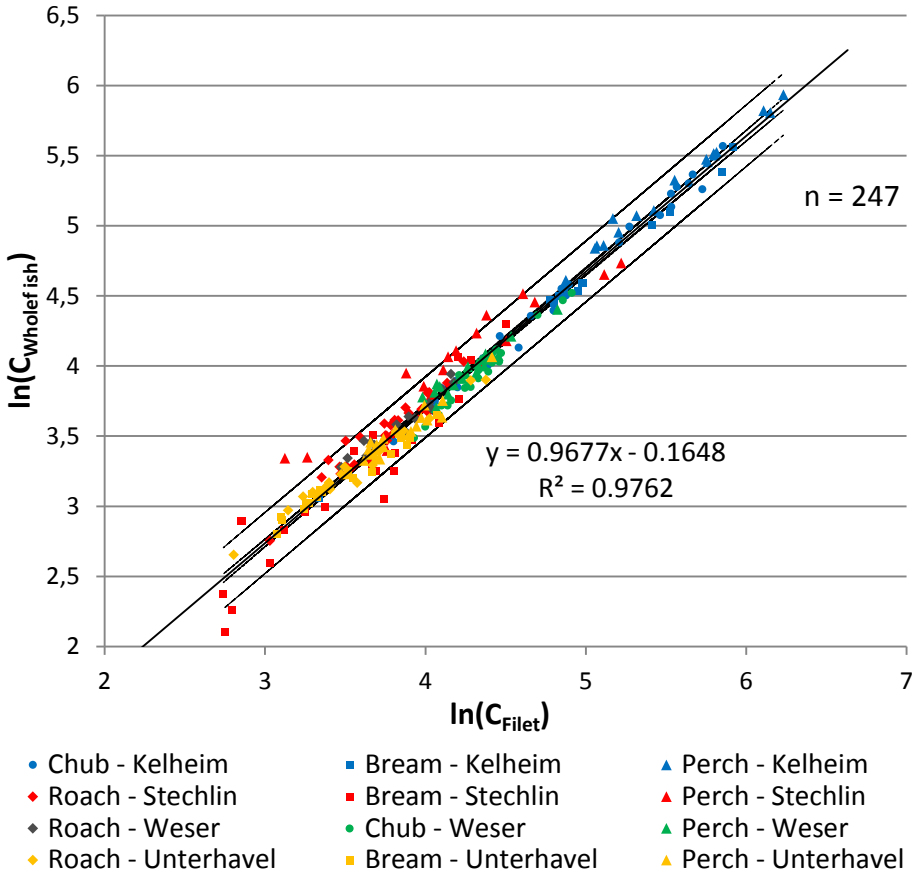
	Perch (out)	Perch (rec)	Trout (out)	Trout (rec)	Pike (out)	Pike (rec)
Number	169	58	73	80	147	58
Min	6	5	4	13	30	30
P5	63	32	21	27	70	46
P25	114	64	39	38	135	95
Median	187	92	52	56	219	142
P75	320	182	118	96	384	207
P95	612	354	219	190	811	325
Max	1187	631	341	280	2660	564

Mann-Whitney U-Test Perch/Pike – Chub/Bream/Roach

Outside the recommended range : $p < 0.0001$
Recommended length range: $p < 0.0001$


Compliance assessment against the EQS should be done using whole fish concentrations

Mercury – Whole fish *versus* filet concentration



Is there a significant difference between C_{wf} and C_f ?

Paired *t*-Test $\rightarrow$ **yes**

b = 0.9677 $\pm$ 0.019

b – Significant deviation from 1? (yes)

$\ln(C_{wf}) = a + b * \ln(C_f)$

$\ln(C_{wf}) = -0.1648 + 0.9677* \ln(C_f)$

d = average ($\ln(C_f) - \ln(C_{wf})$) = 0.2987

$k_{d\ (all\ fish\ species)} = e^{-d} =$ **0.74**

$C_{wf} = k_d * C_f$

	C_{filet}	$C_{whole\ fish}$	$C_{wf\ -95\%PI}$	$C_{wf\ +95\%PI}$
ln(C)	4.0000	3.7276	3.4898	3.9225
C	54.6	40.5	32.8	50.5


Do mercury concentrations in fish decline?
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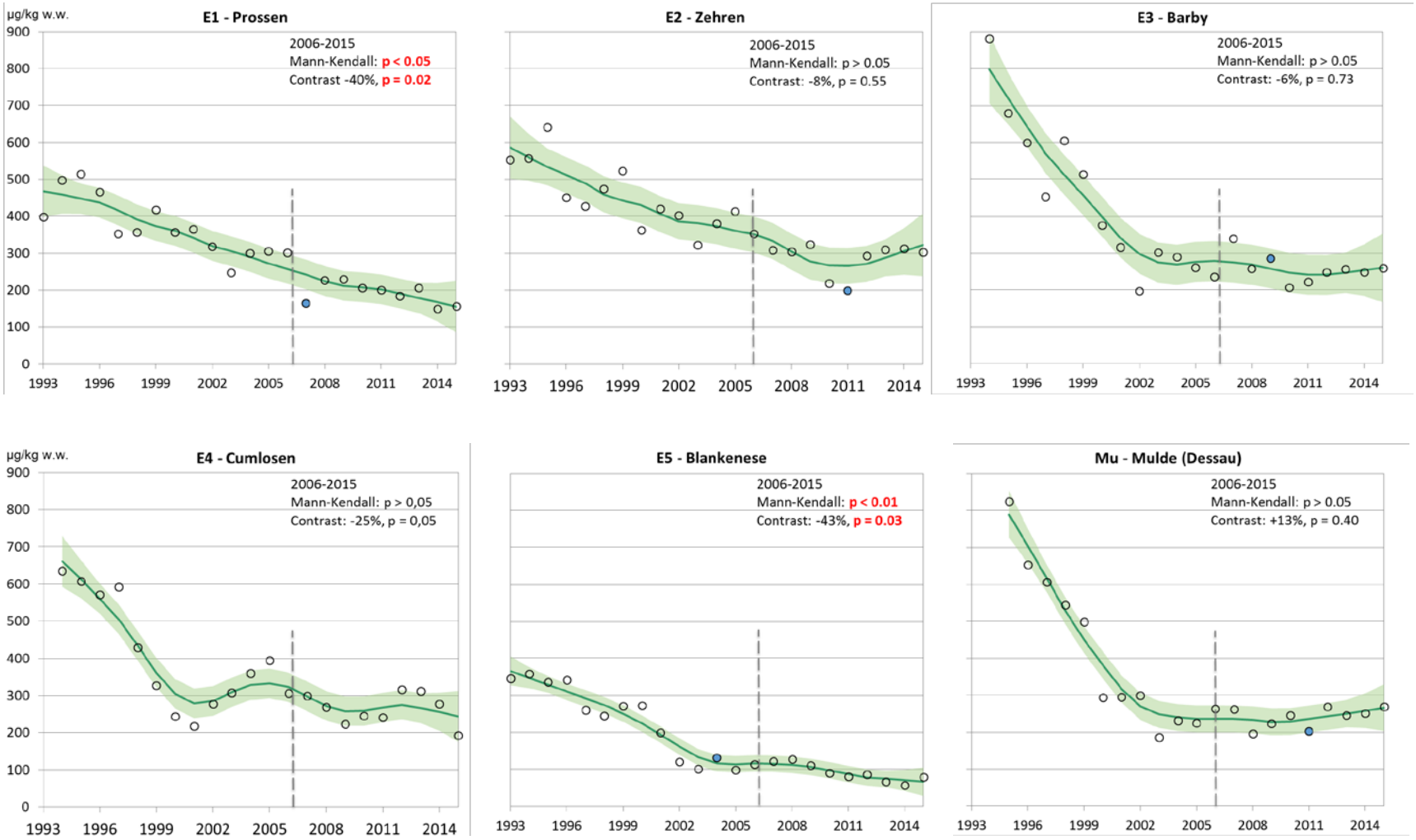
Trends in bream mercury concentration – River Elbe



Conclusion

- **Sampling of suitable species of appropriate age is crucial in designing fish monitoring programs for compliance checking**
- **Compliance assessment against EQS should be done using whole fish concentrations**
- **We established a reliable regression model allowing the conversion of muscle into whole fish concentrations**
- **Current median whole fish concentrations in prey fish aged 3-4 (5) years are between 41 and 61 µg/kg w.w.**
- **Trend information is scarce; data from ESB showed no or weak trends in Hg levels in fish in the period 2006 – 2015**

Currently, mercury levels in fish do not comply with the EQS

Available trend data suggest that this will continue to be so until 2027 and beyond

Acknowledgement