

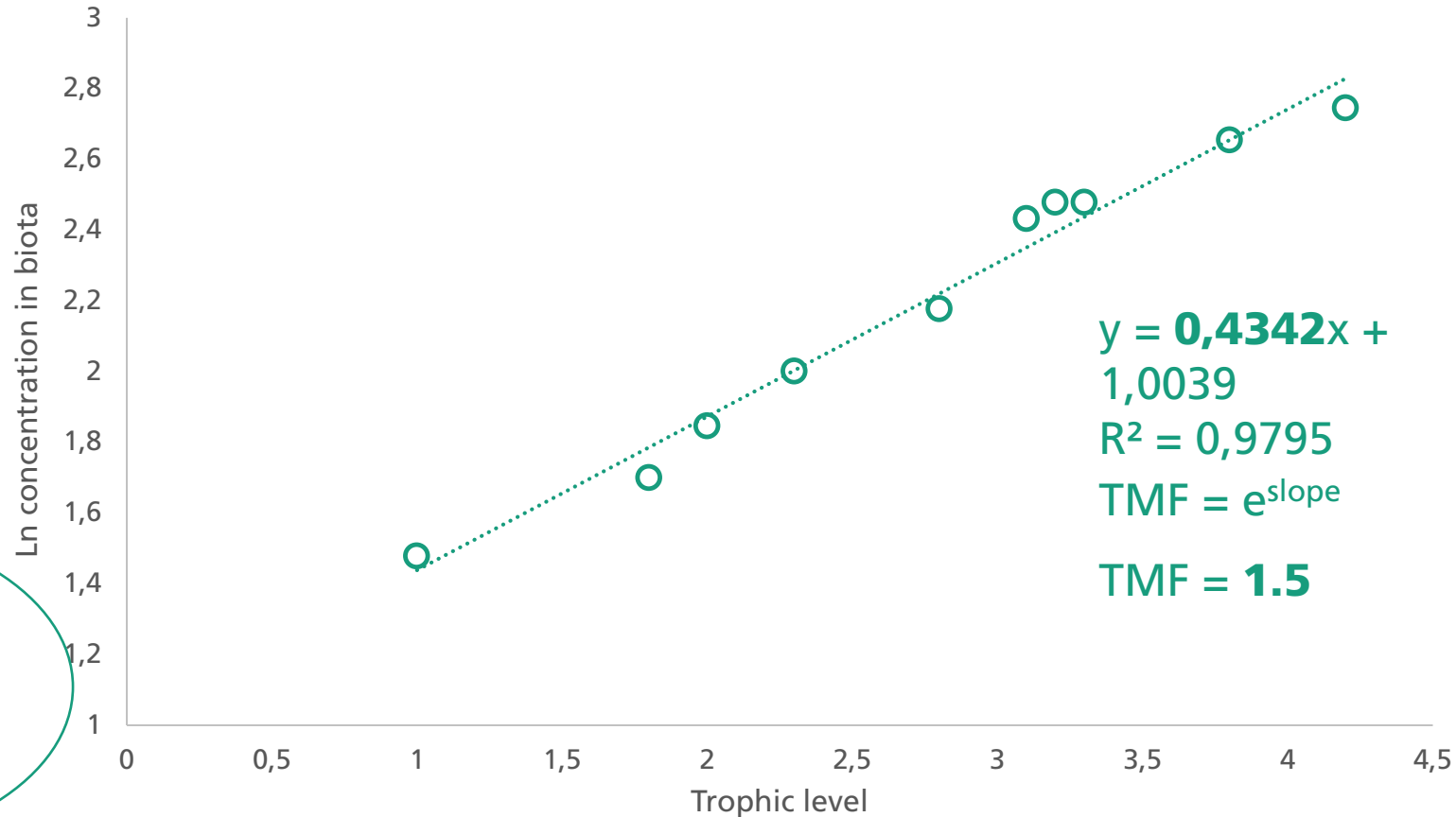
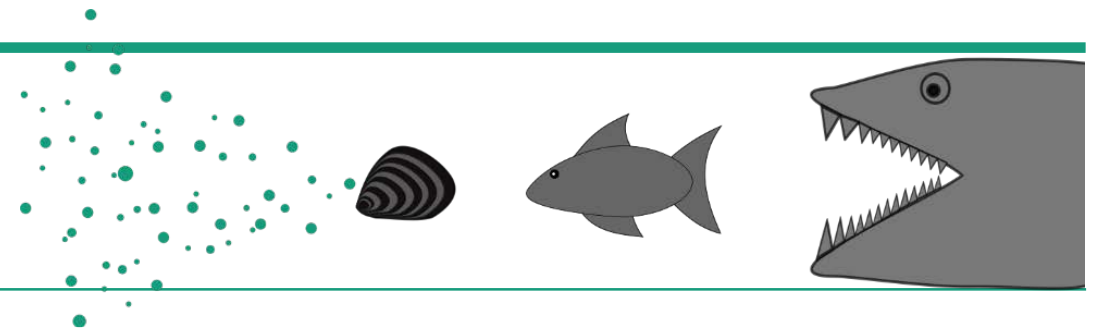
Food web on ice:

An application of a benchmarked TMF approach to emerging substances



Verena Kosfeld, Heinz Rüdell, Christian Schlechtriem, Caren Rauert, Jan Koschorreck

TMF STUDIES AND THE - FOOD WEB ON ICE -

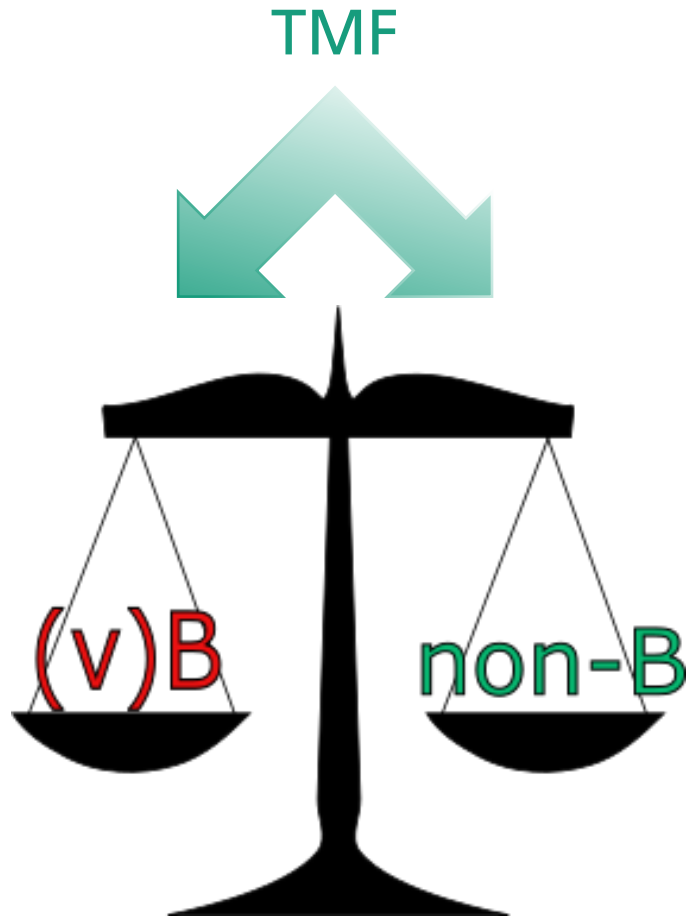


Average
accumulation
along a food
web

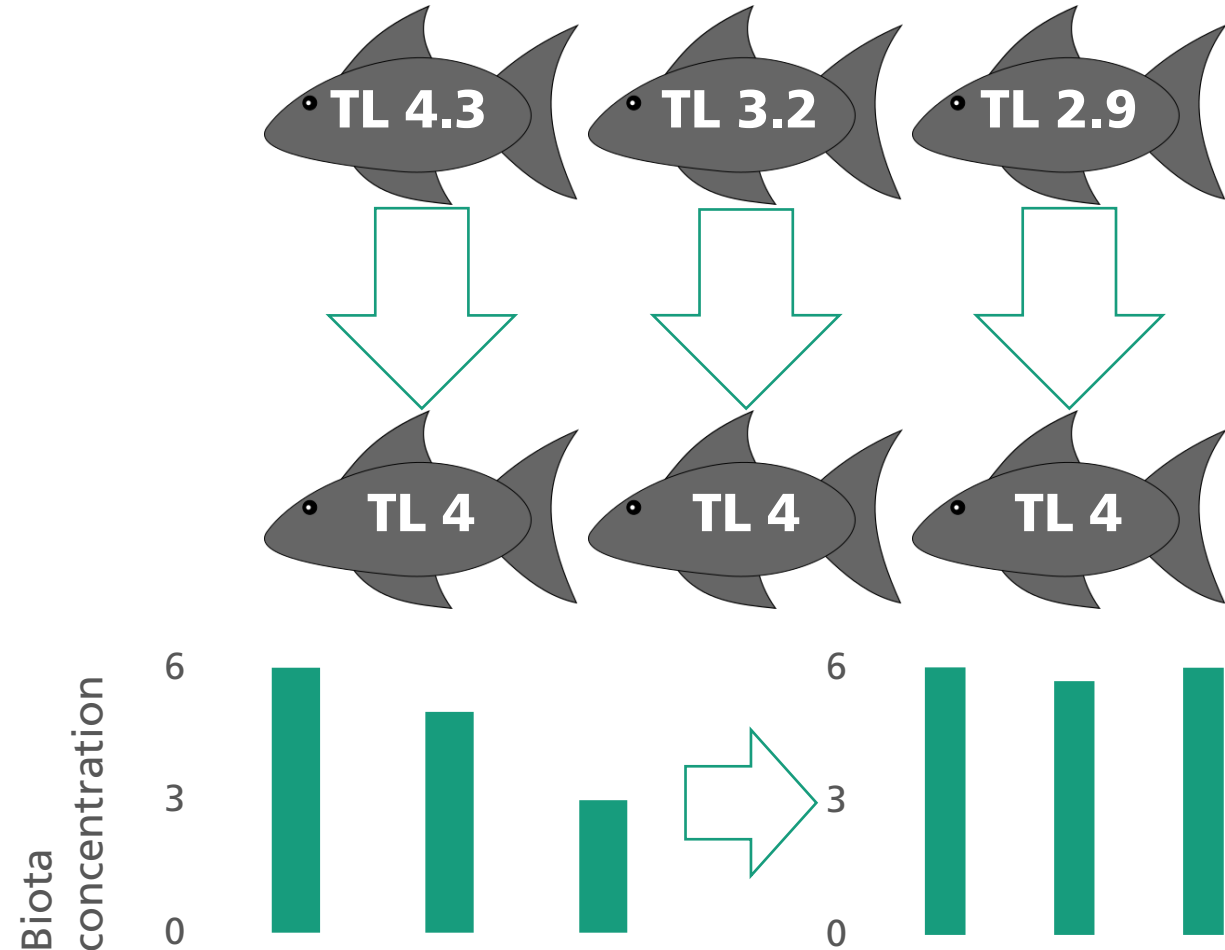
Based on
environ-
mental data

TMF – Application Opportunities

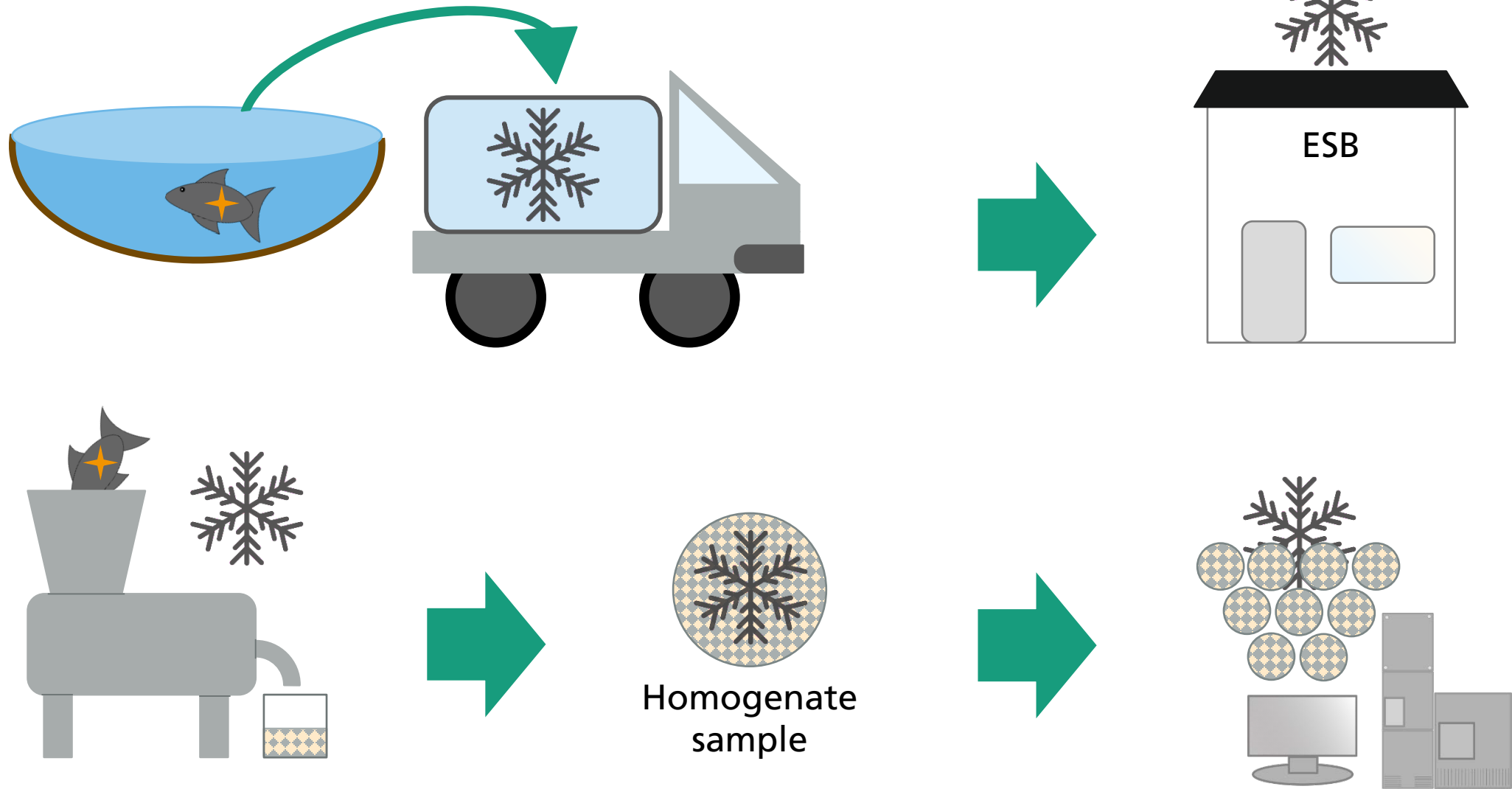
Regulation / B-assessment



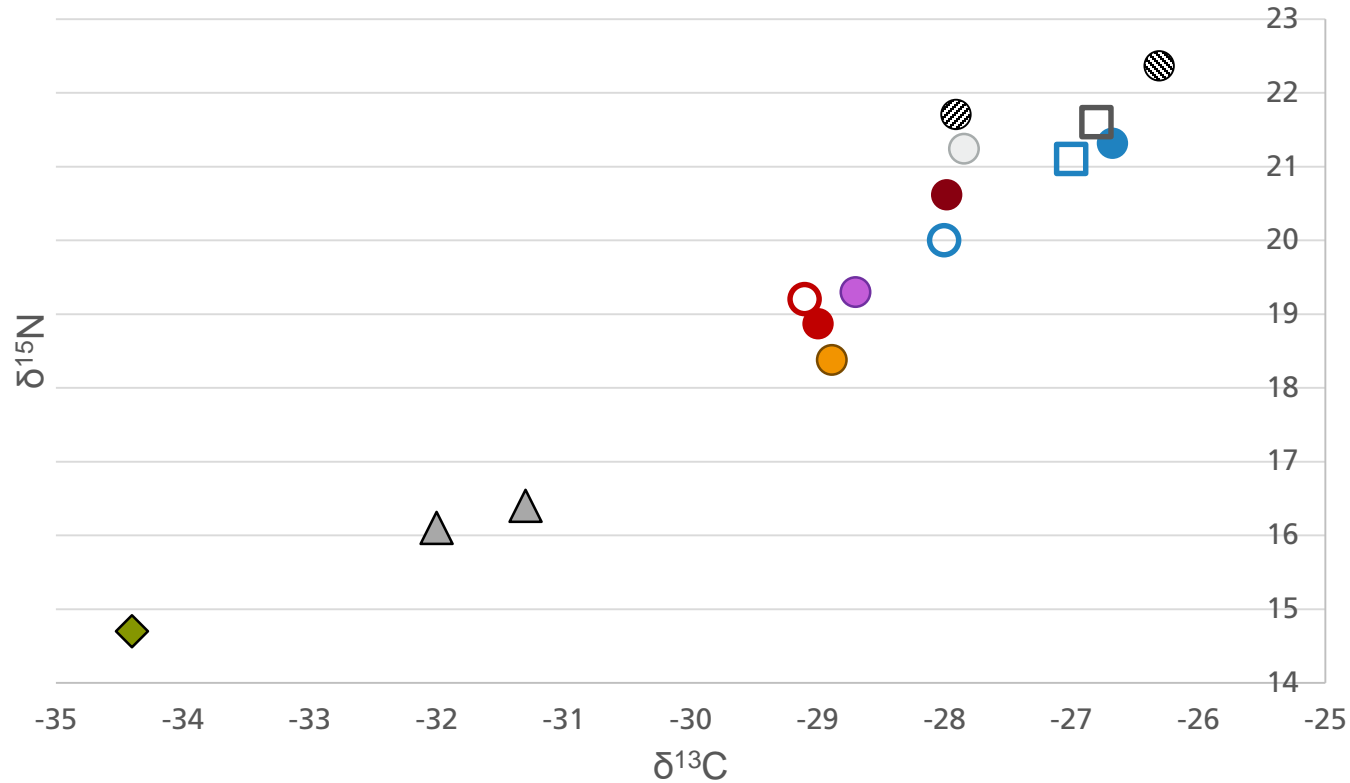
Water Framework Directive



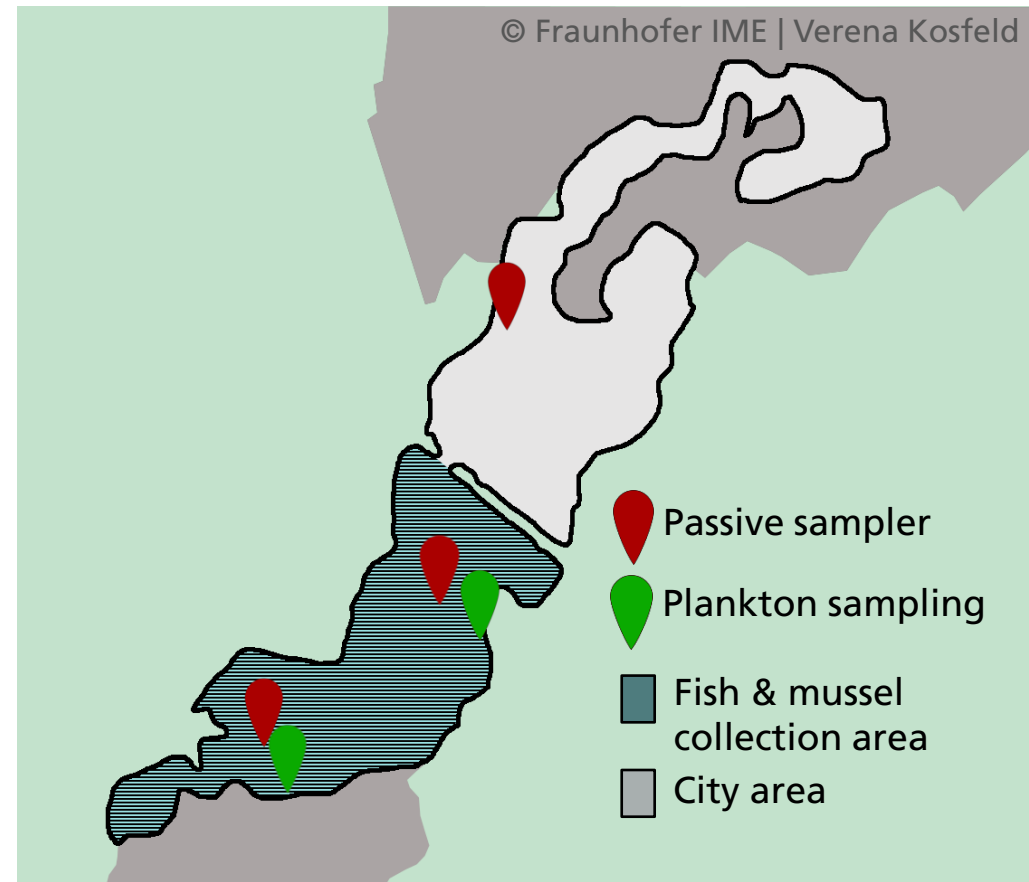
Food web on ice – Application of ESB protocols



Lake Templin food web



- ◆ Plankton fraction
- Roach (small)
- Roach
- ⊗ Pike-perch (Pool A)
- Perch 1 (Individual)
- ▲ Dreissena
- Perch (small)
- Perch
- ⊗ Pike-perch (Pool B)
- Pike 1 (Individual)
- Bleak
- White bream
- Pike
- Asp



Food web on ice – TMF calculation

- Basic TMF model:

- $$TP = \lambda + \frac{\delta^{15}N_{consumer} - \delta^{15}N_{baseline}}{2.3}$$

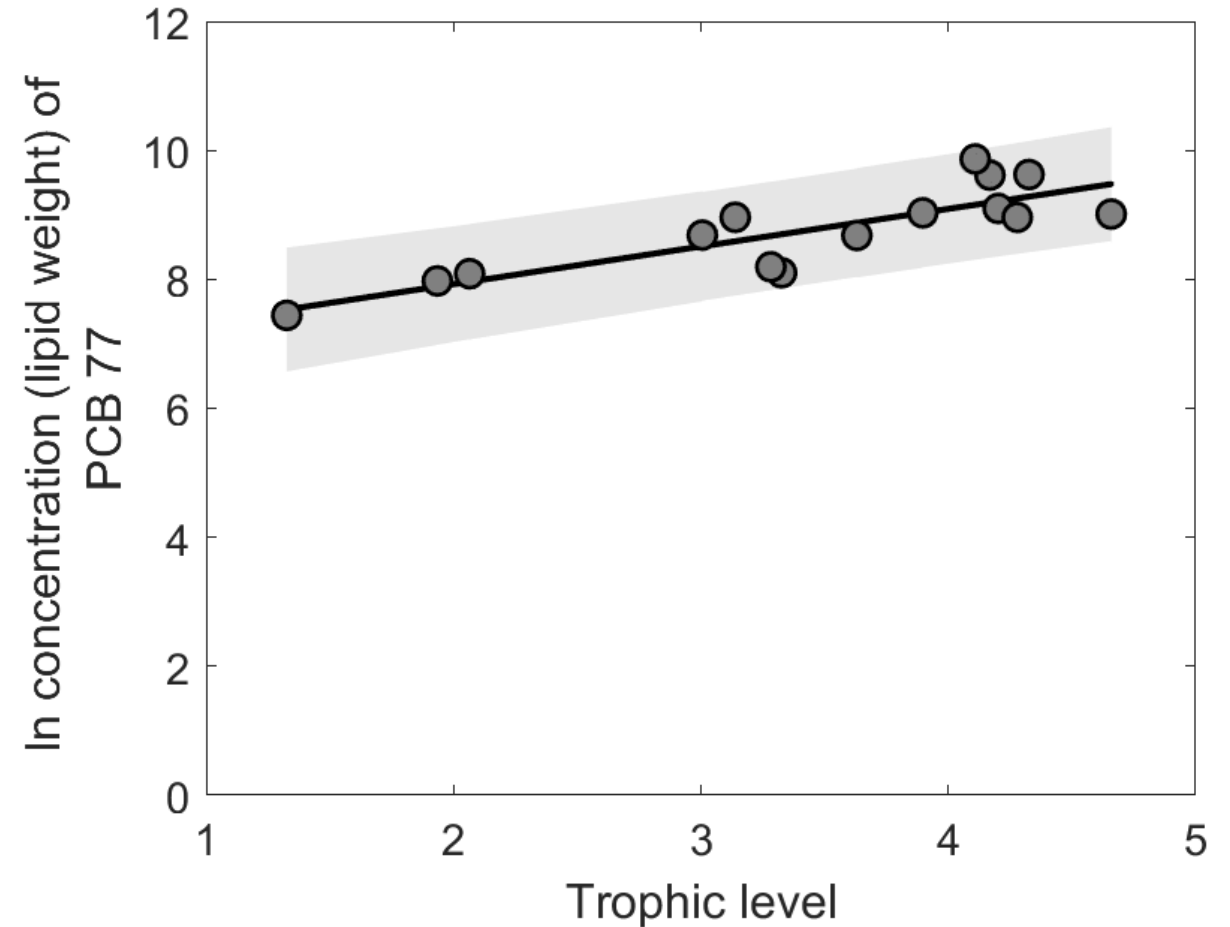
- Baseline: *Dreissena polymorpha*

- $TMF = e^a$

- $\ln C = a * TP + b$

- Data normalization

- Where appropriate



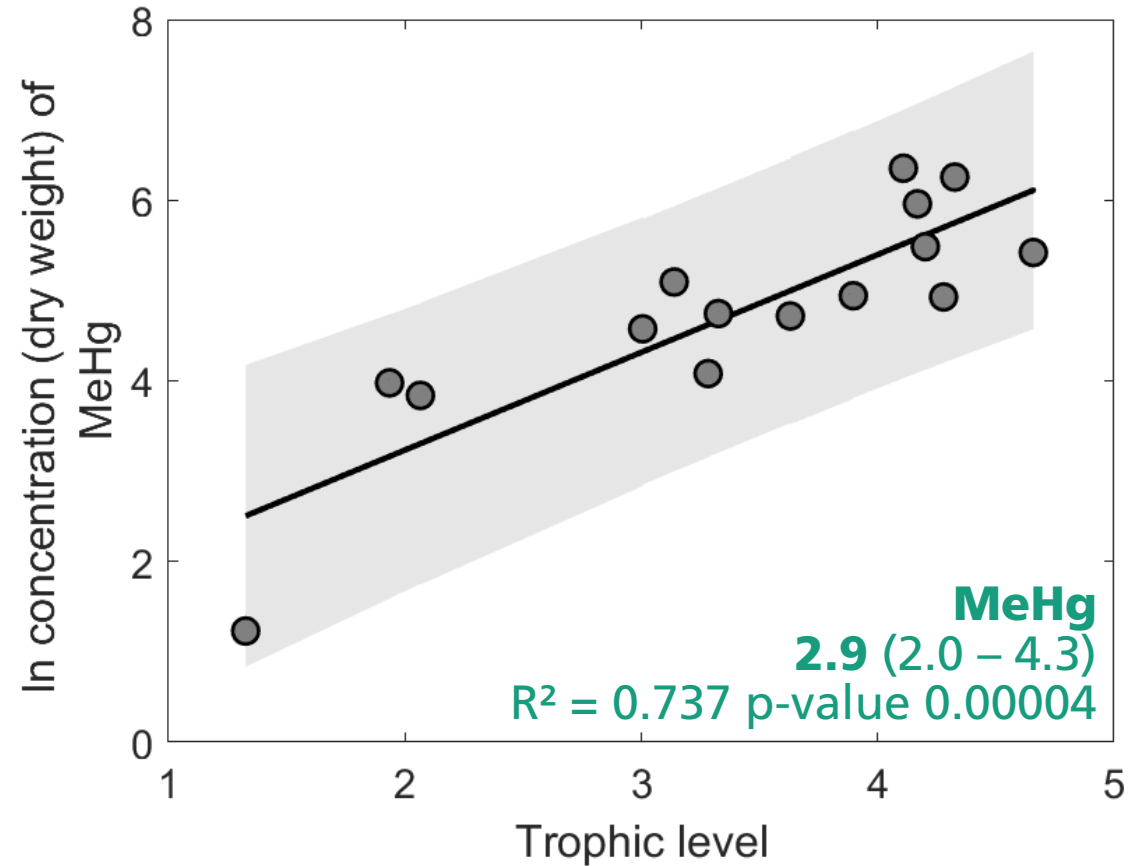
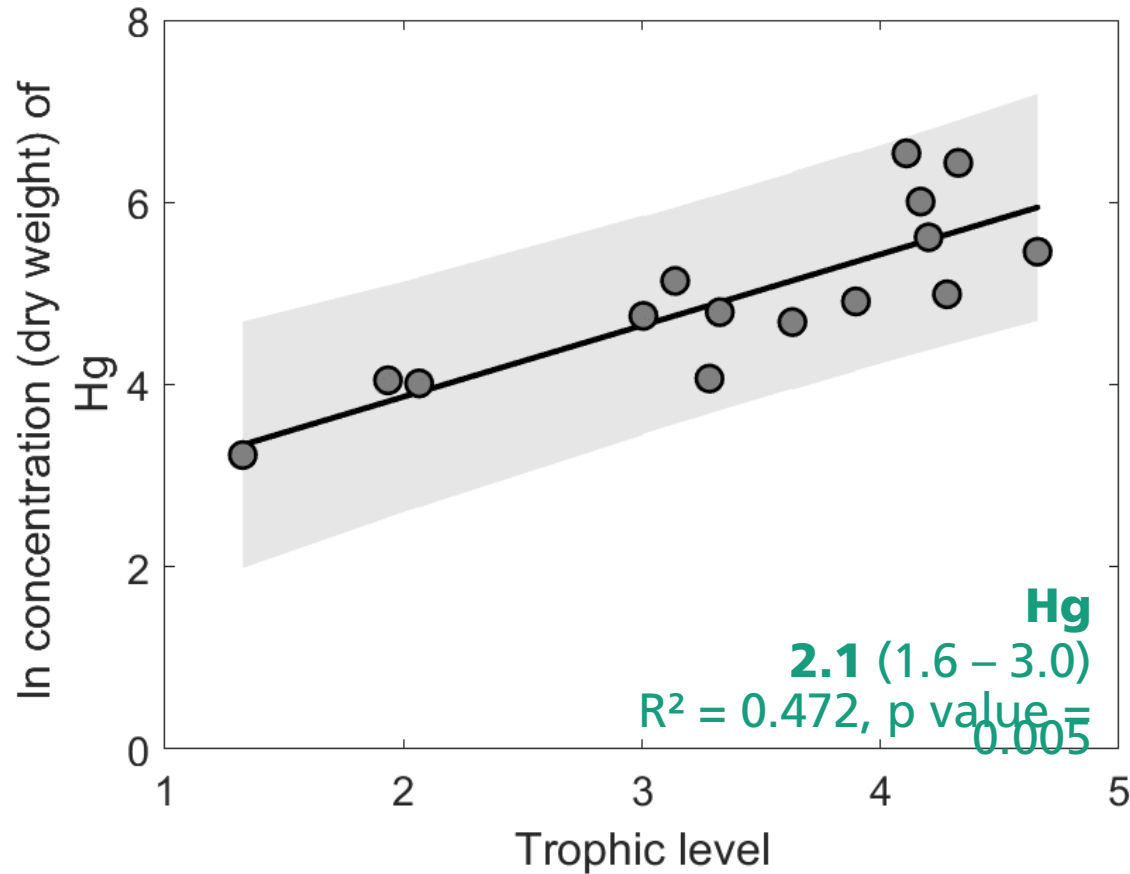
Chemicals analyzed in the Lake Templin food web

- **PCBs** → 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, 189, 28, 52, 101, 118, 138, 153, 180
- **PBDEs** → 28, 47, 49, 66, 71, 77, 85, 99, 100, 119, 126, 138, 153, 154, 156, 183, 184, 191, 196, 197, 206, 207, 209
- **Organochlorine pesticides** → Pentachlorobenzene, Hexachlorobenzene, alpha/ beta/ gamma Hexachlorocyclohexane, 2,4'-DDT, 4,4'-DDT, 4,4'-DDE, 4,4'-DDD, Aldrin, Dieldrin, Heptachlor, cis-Heptachlor epoxide, Heptachlor epoxide (trans), Heptachlor epoxide (Sum cis, trans), Octachlorostyrene
- **Mercury & Methylmercury**
- **PCDD/Fs** → 2,3,7,8-TetraCDD, 1,2,3,7,8-PentaCDD, 1,2,3,4,7,8-HexaCDD, 1,2,3,6,7,8-HexaCDD, 1,2,3,7,8,9-HexaCDD, 1,2,3,4,6,7,8-HeptaCDD, OctaCDD, 2,3,7,8-TetraCDF, 1,2,3,7,8-PentaCDF, 2,3,4,7,8-PentaCDF, 1,2,3,4,7,8-HexaCDF, 1,2,3,6,7,8-HexaCDF, 1,2,3,7,8,9-HexaCDF, 2,3,4,6,7,8-HexaCDF, 1,2,3,4,6,7,8-HeptaCDF, 1,2,3,4,7,8,9-HeptaCDF, OctaCDF
- **PFAS** → PFPrA, PFBA, PFPA, PFBS, PFHxA, PFHxS, PFHpA, PFOA, PFHpS, PFNA, PFOS-linear, PFOS-branched, PFDA, PFDS, PFDoA, PFTTrDA, PFUnA, PFTeDA, PFHxDA, PFODA, 4:2-FtS, 6:2-FtS, 8:2-FtS, 7PFHpA, ADONA, 9Cl-PF3ONS, FOSAA, MeFOSAA, FOSA, EtFOSAA, 11Cl-PF3OUdS, MeFOSA, EtFOSA, HFPO-DA, 6:2-diPAP, 8:2-diPAP, 6:2/8:2-diPAP, PFECHS

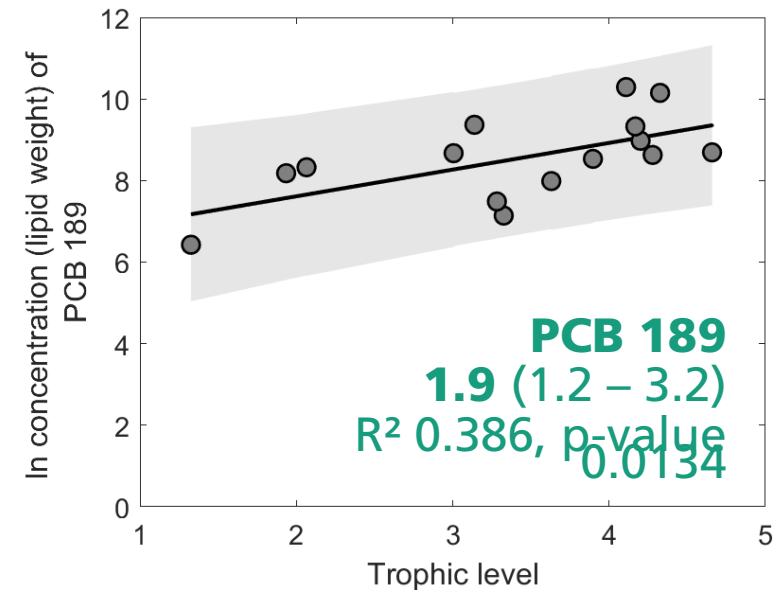
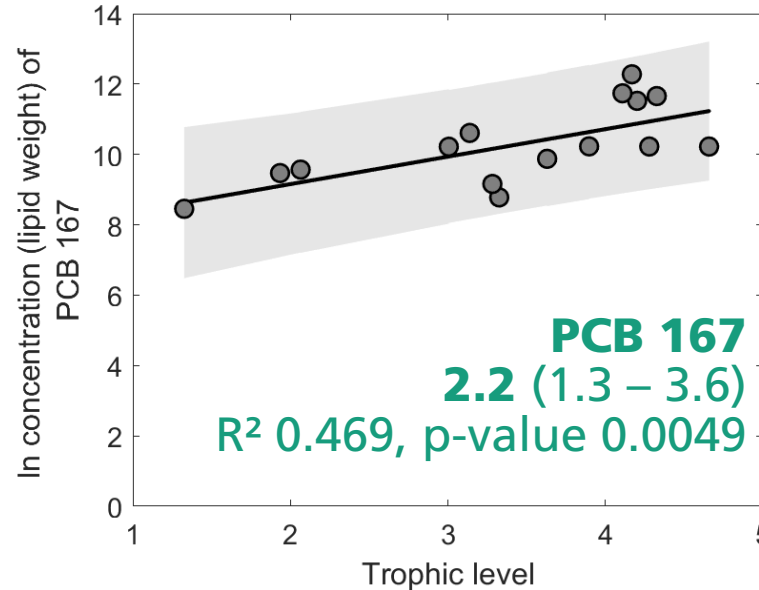
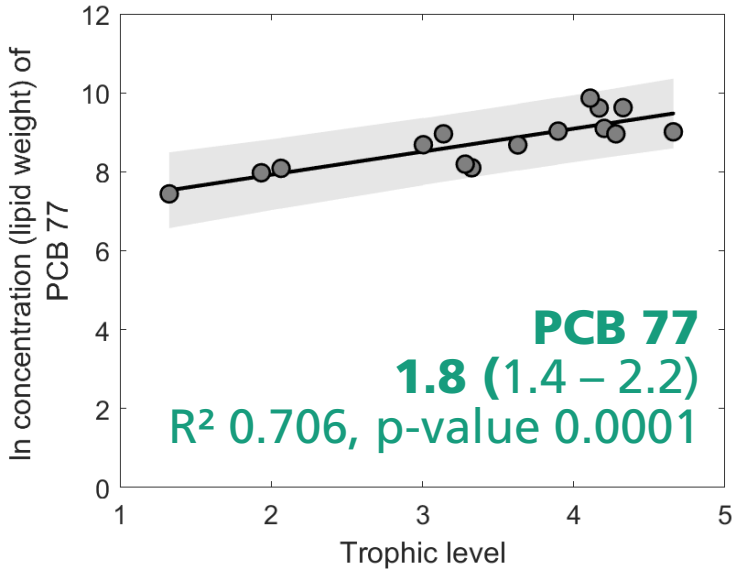
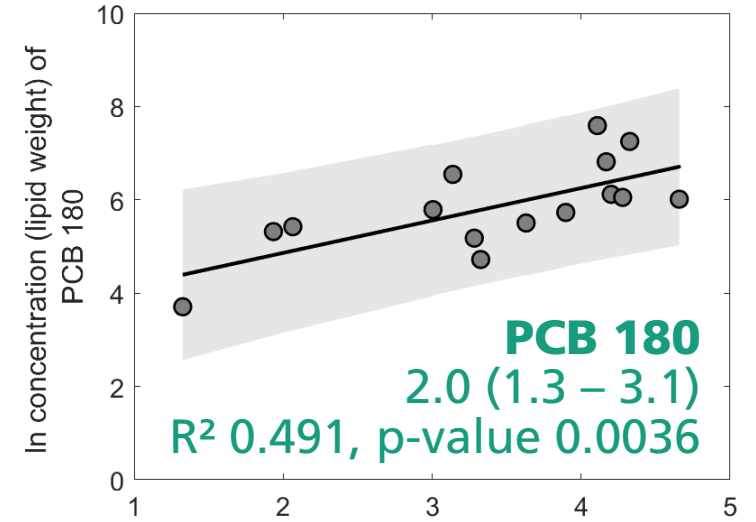
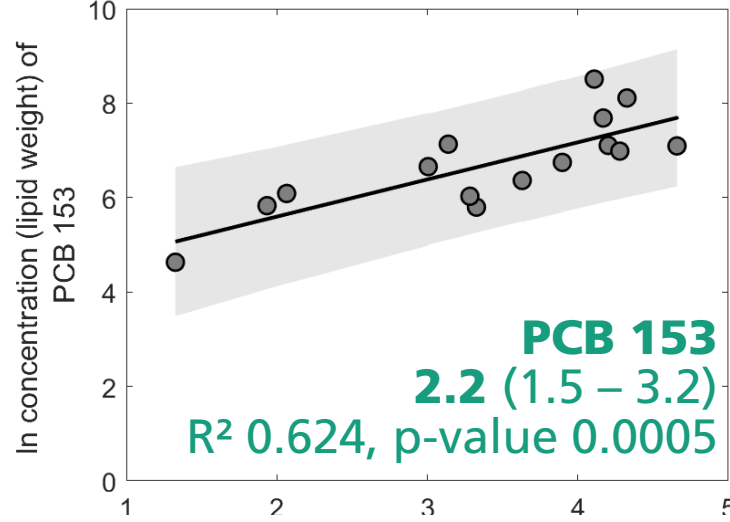
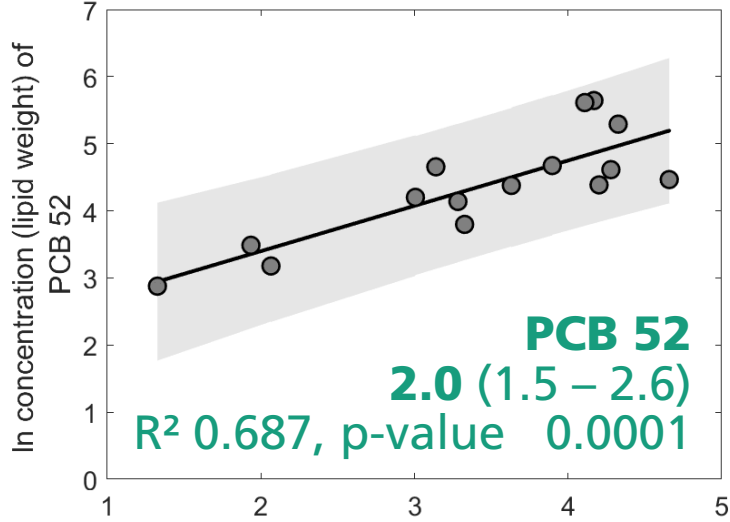
Chemicals analyzed in the Lake Templin food web - detected

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- **Mercury & Methylmercury**
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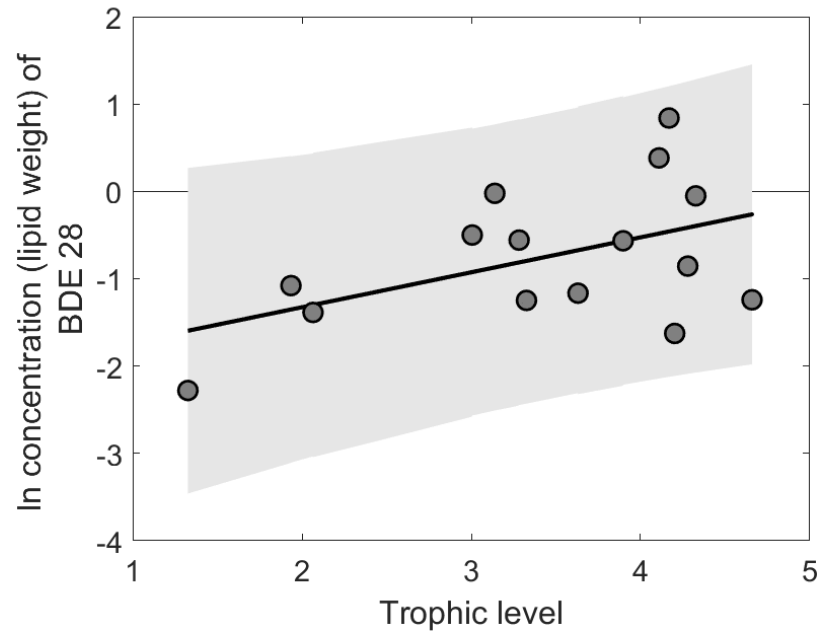
Exemplary TMF plots – Mercury & methylmercury



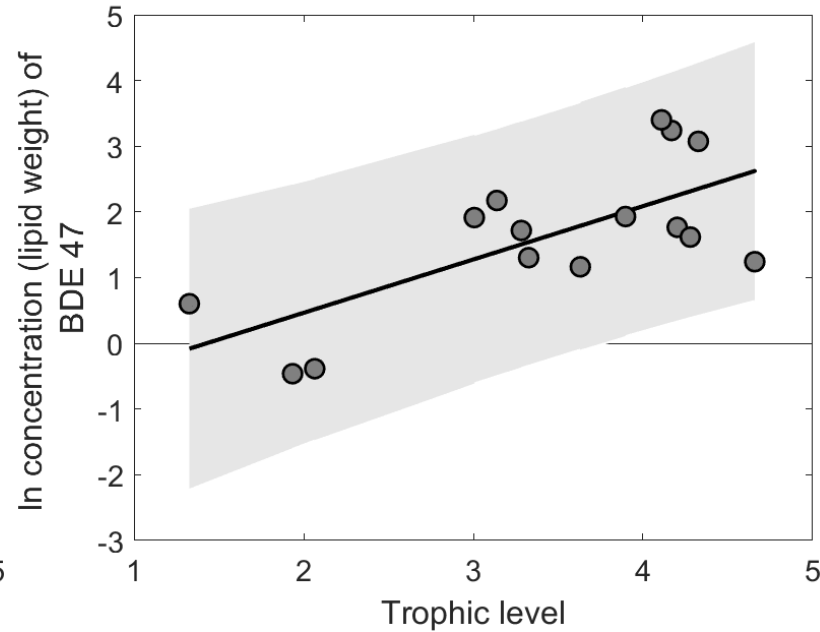
Exemplary TMF plots – PCBs



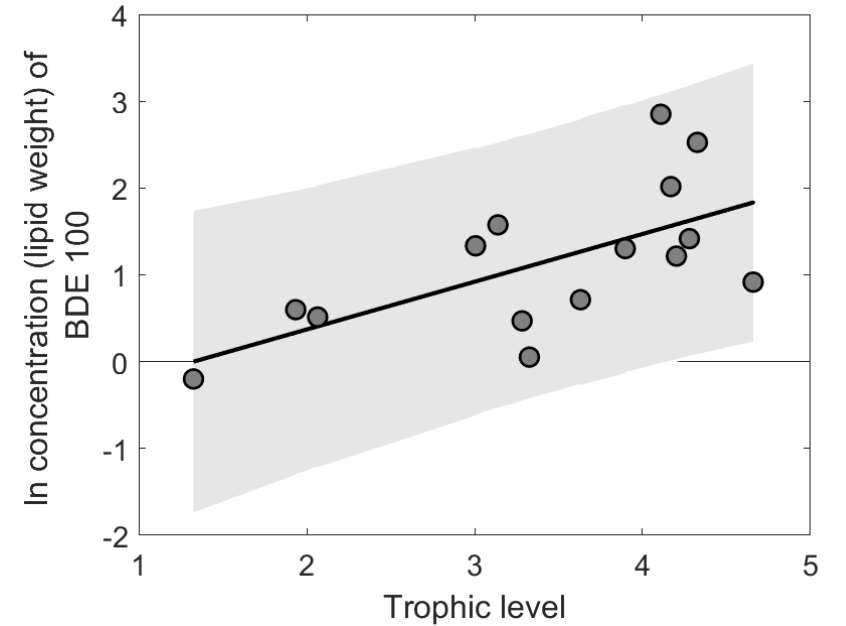
Exemplary TMF plots – PBDEs



BDE 28
1.5 (1.0 – 2.3)
 R^2 0.237, p-value 0.0657

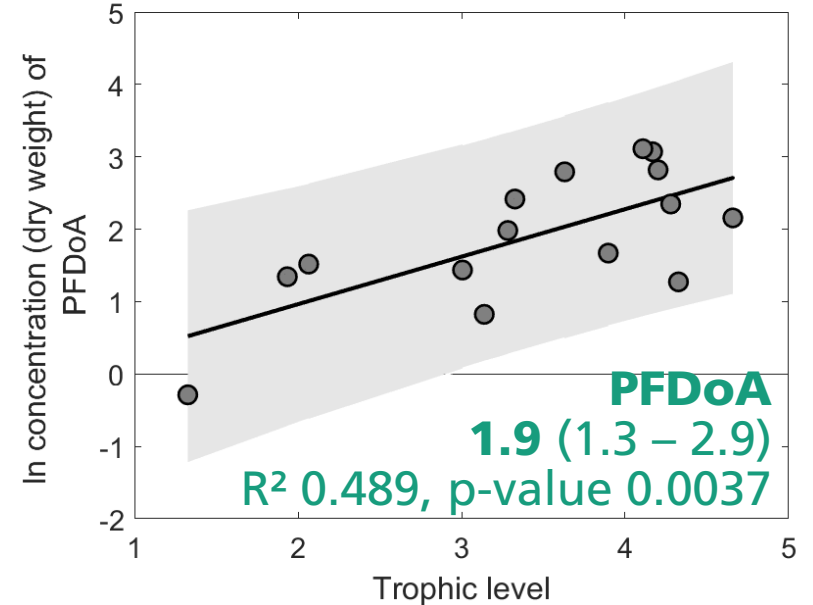
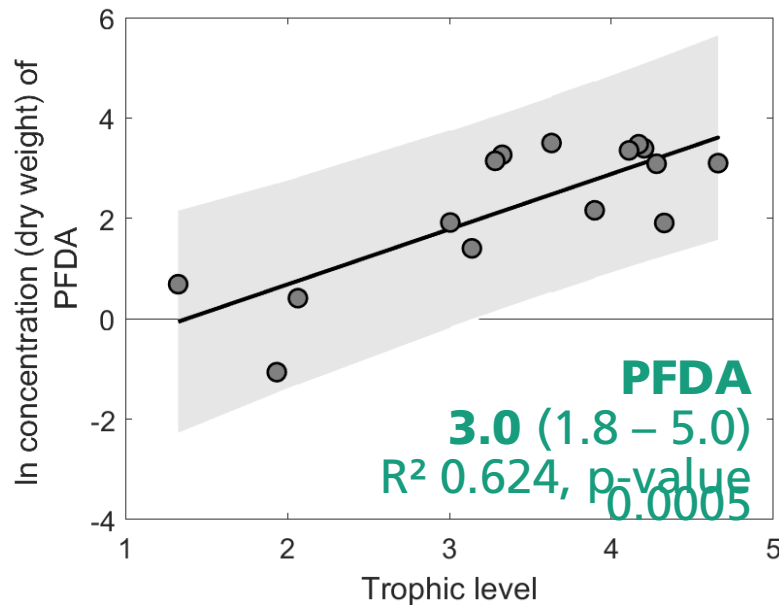
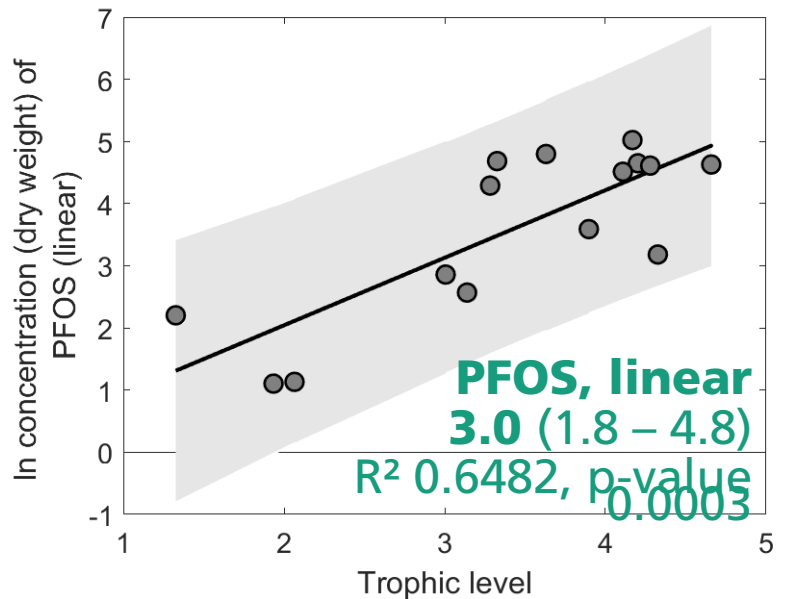
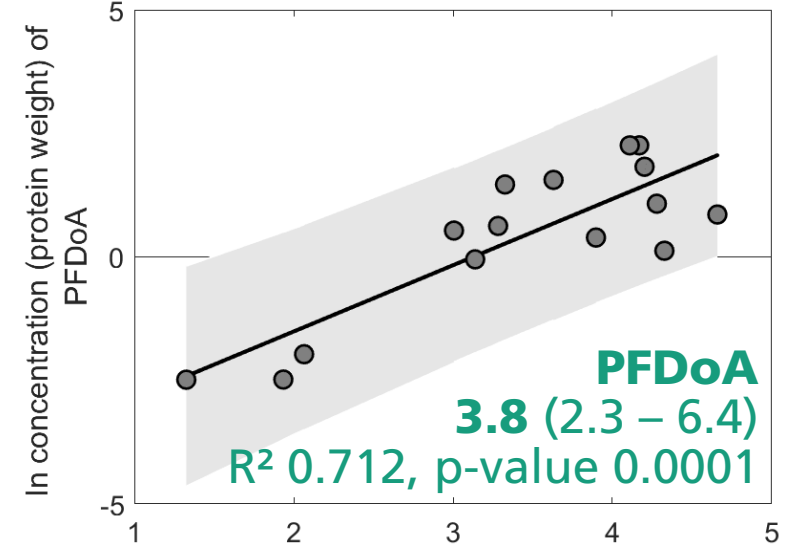
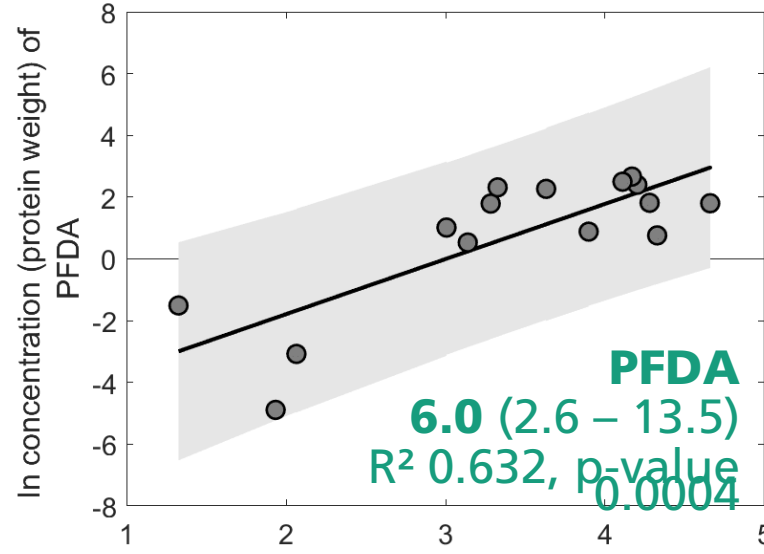
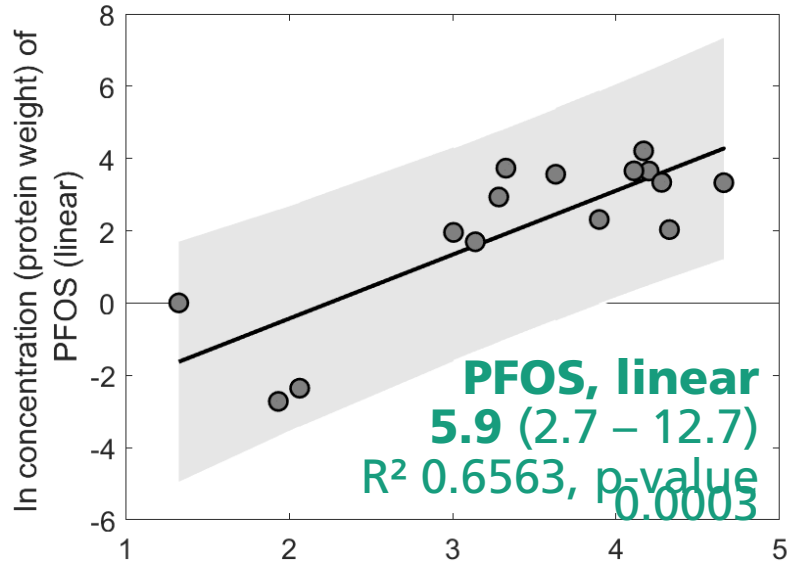


BDE 47
2.3 (1.4 – 3.7)
 R^2 0.494, p-value 0.0035

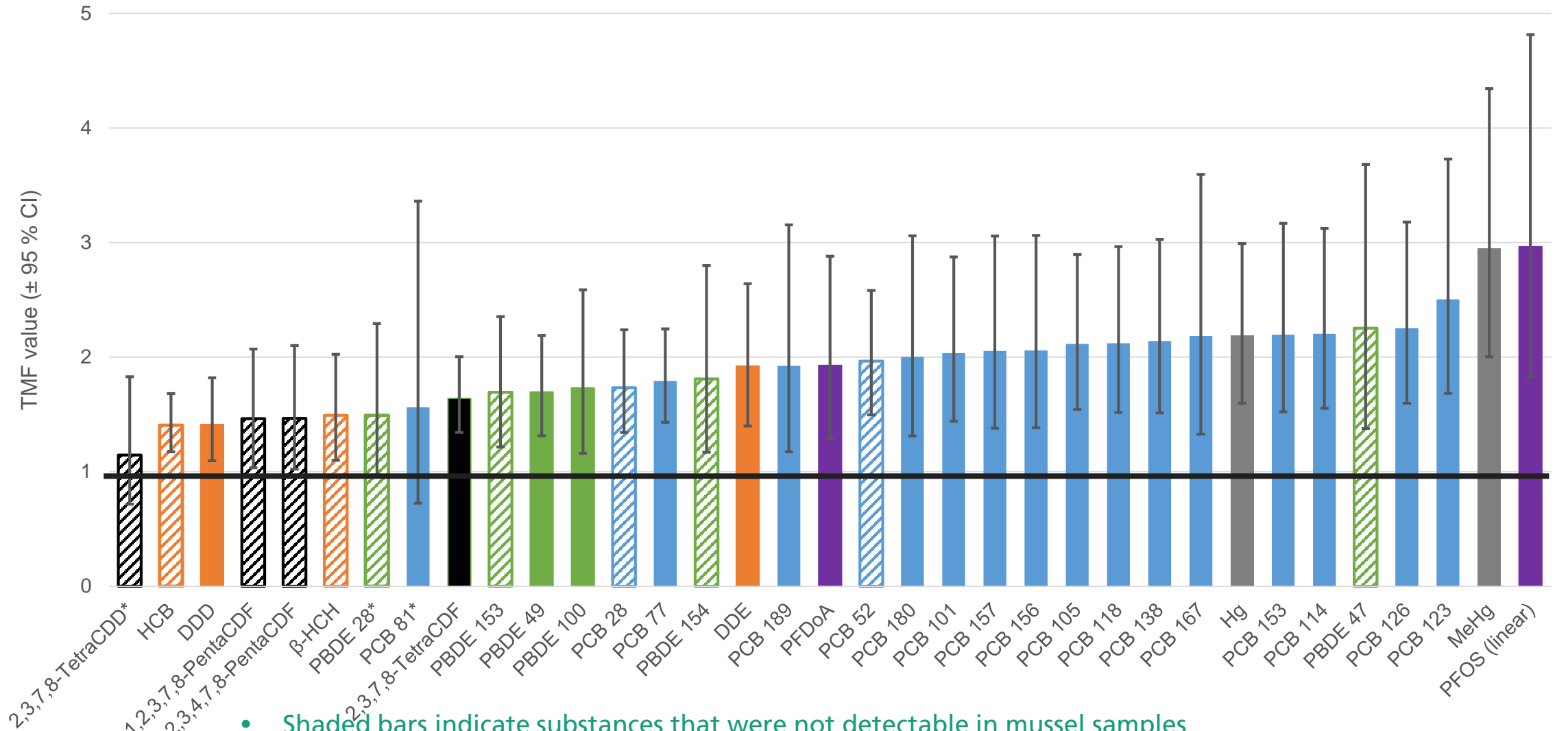


BDE 100
1.7 (1.2 – 2.6)
 R^2 0.403, p-value 0.0110

Exemplary TMF plots - PFAS

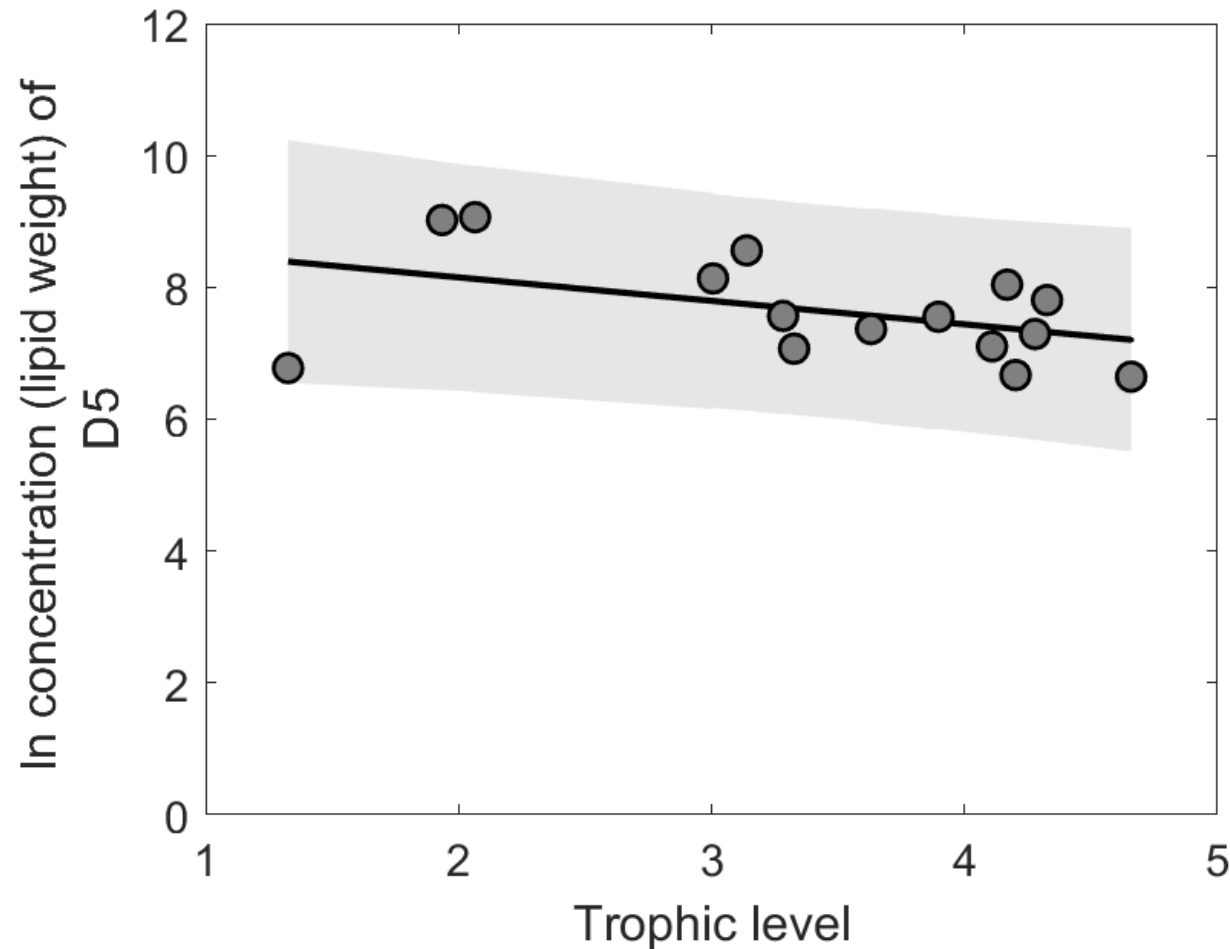
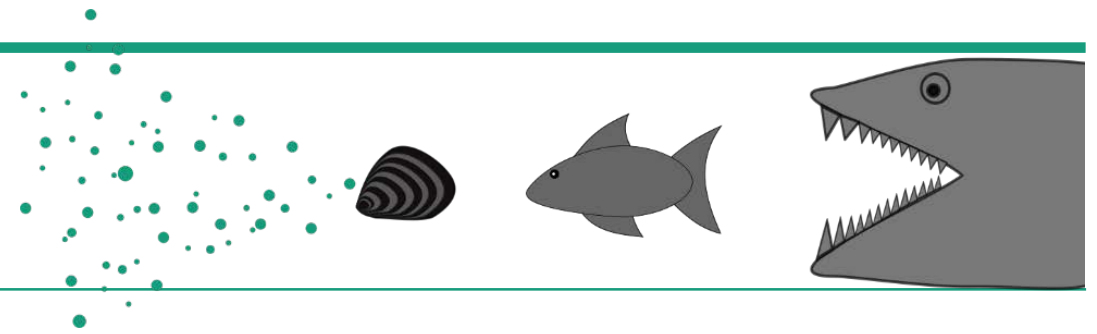


Lake Templin TMFs – an overview



- Shaded bars indicate substances that were not detectable in mussel samples
- An asterisk (*) marks substances, that had no significant ($p < 0.05$) correlation between TP & In concentration

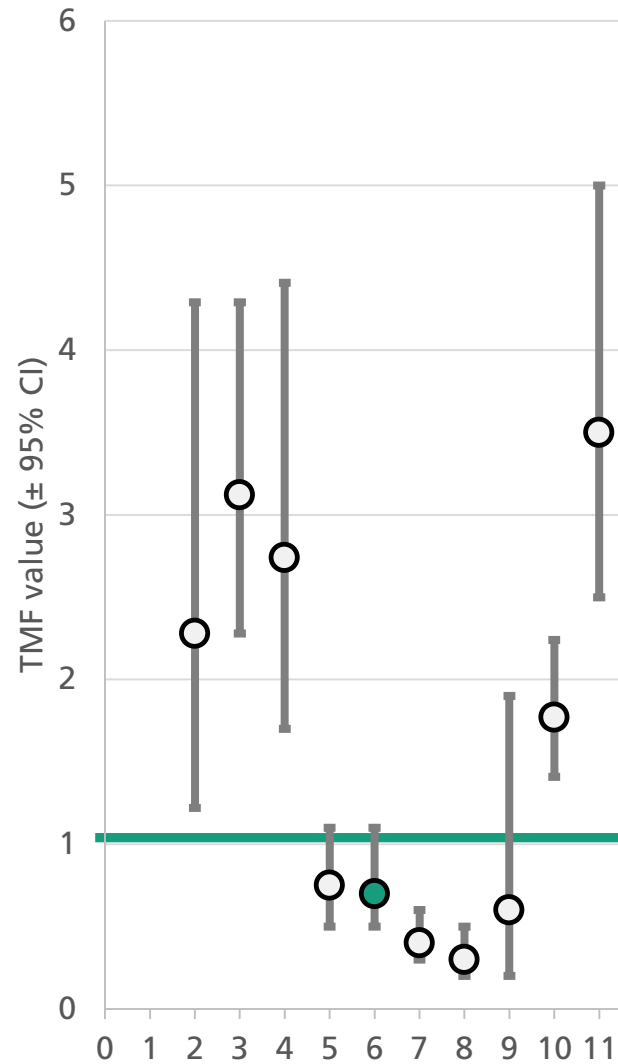
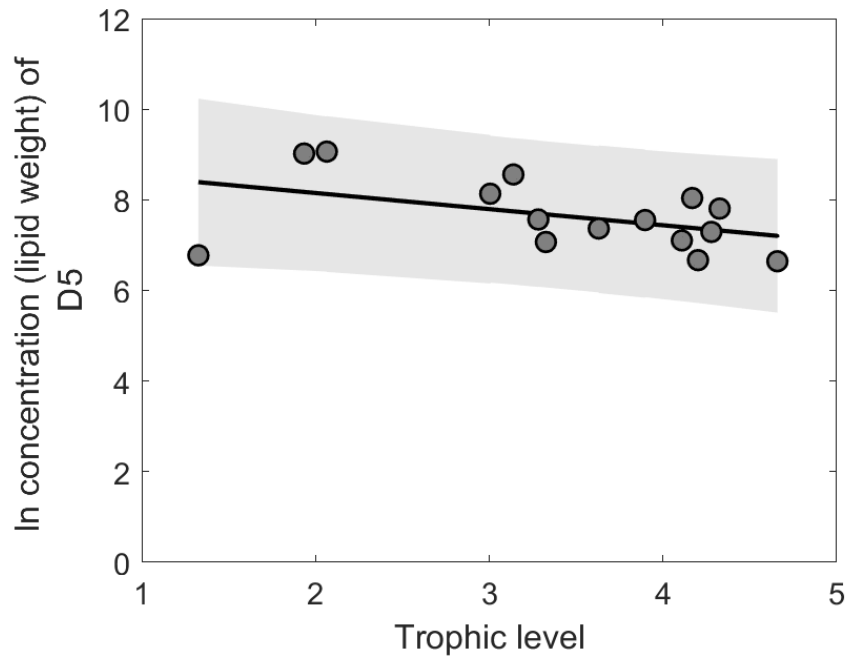
DISTRIBUTION OF D5 IN THE 'FOOD WEB ON ICE'



TMF (lipid weight):

- **0.7 (0.5 – 1.1)**
- p value: 0.0955
- R^2 : 0.199

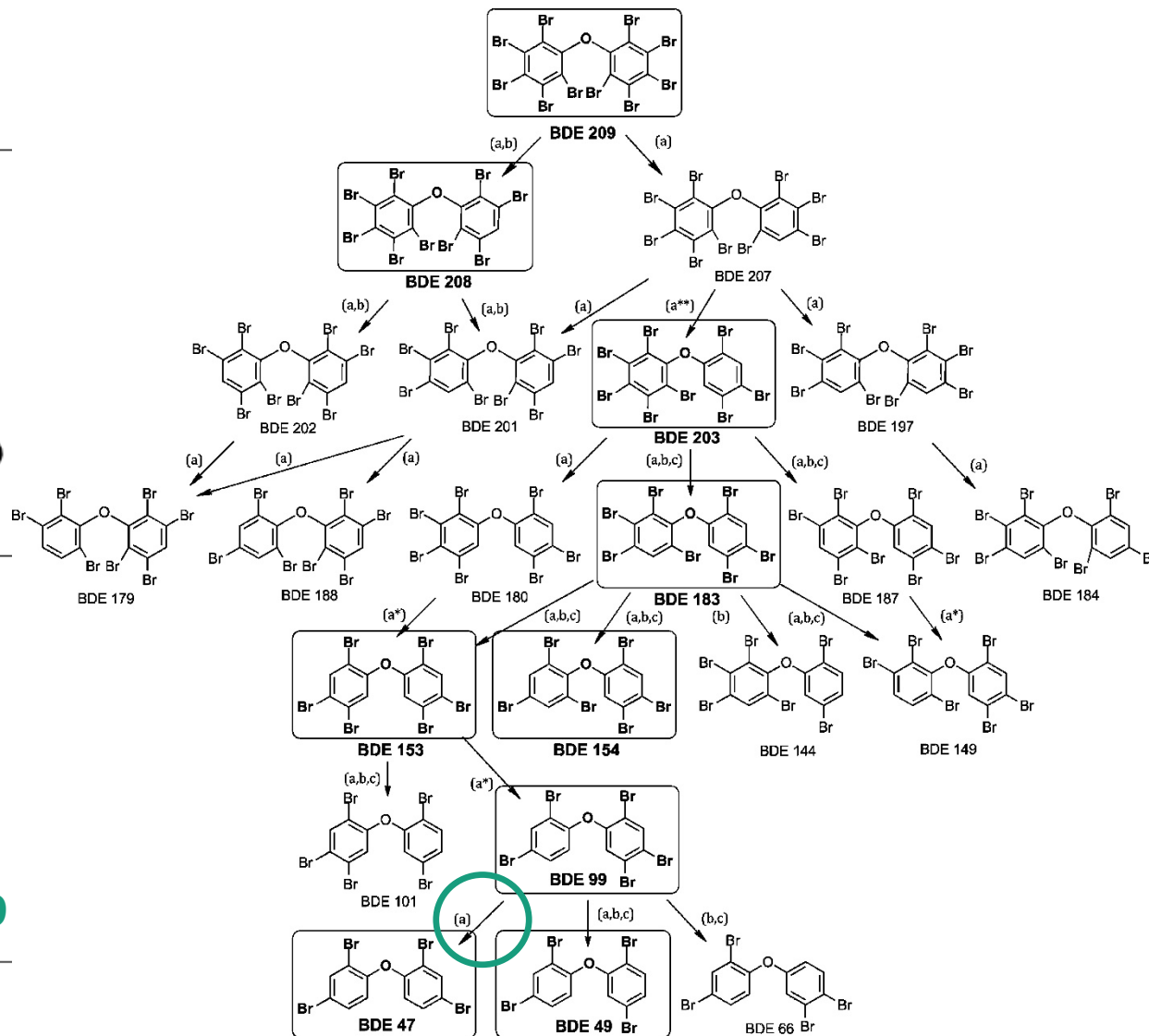
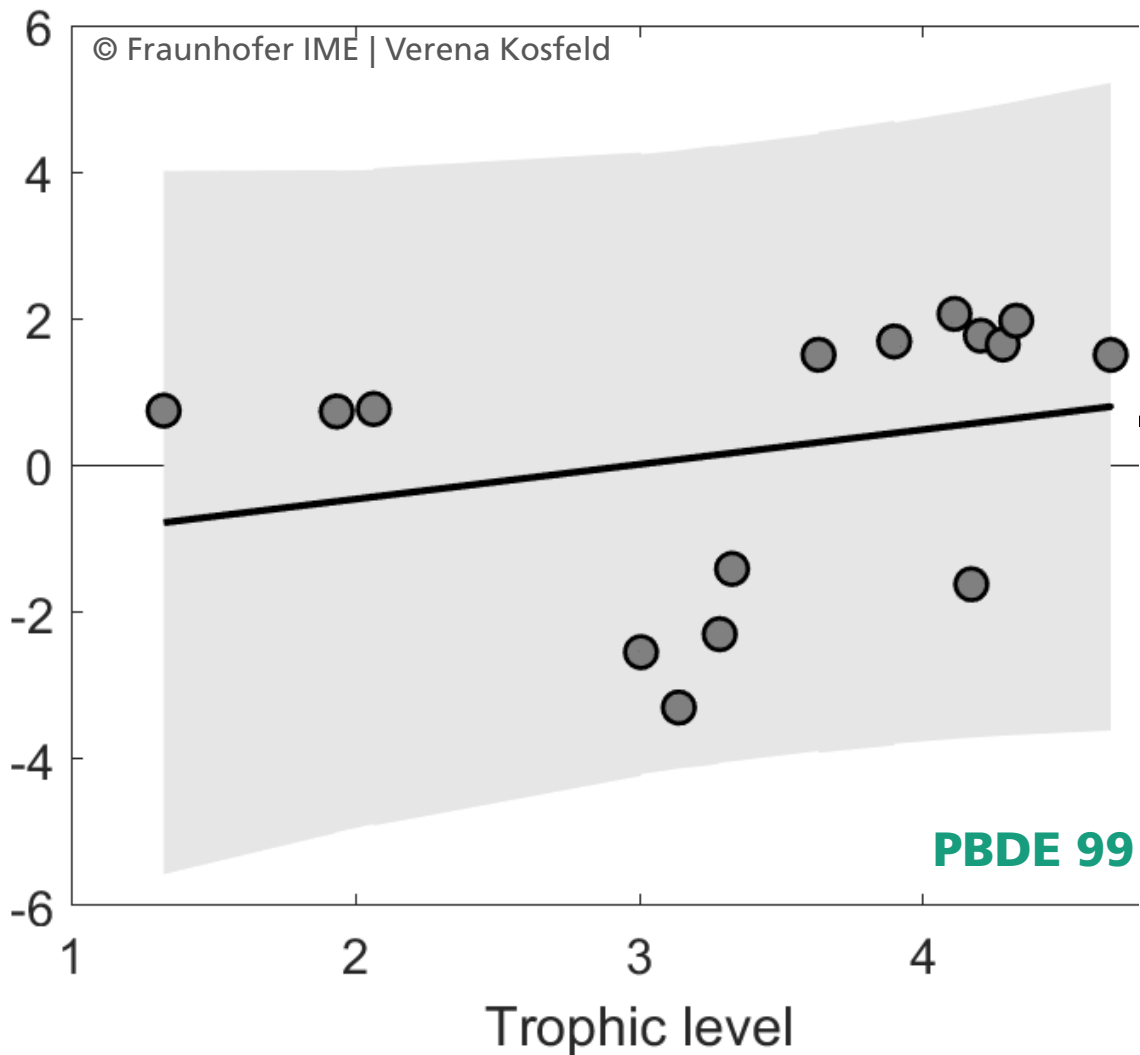
Distribution of D5 in the 'Food web on ice'



Study	Ecosystem	doi
1	Freshwater	10.1002/etc.3242
2	Freshwater	10.1021/es300875d
3	Freshwater	10.1021/es404374j
4	Freshwater	10.1021/es404374j
5	Freshwater	10.1016/j.envpol.2013.12.003
6	Freshwater	This study
7	Marine	10.1016/j.scitotenv.2017.11.237
8	Marine	10.1016/j.scitotenv.2017.11.237
9	Marine	10.1016/j.scitotenv.2016.10.189
10	Marine	10.1021/es505445e
11	Marine	10.1016/j.ecoenv.2019.04.034

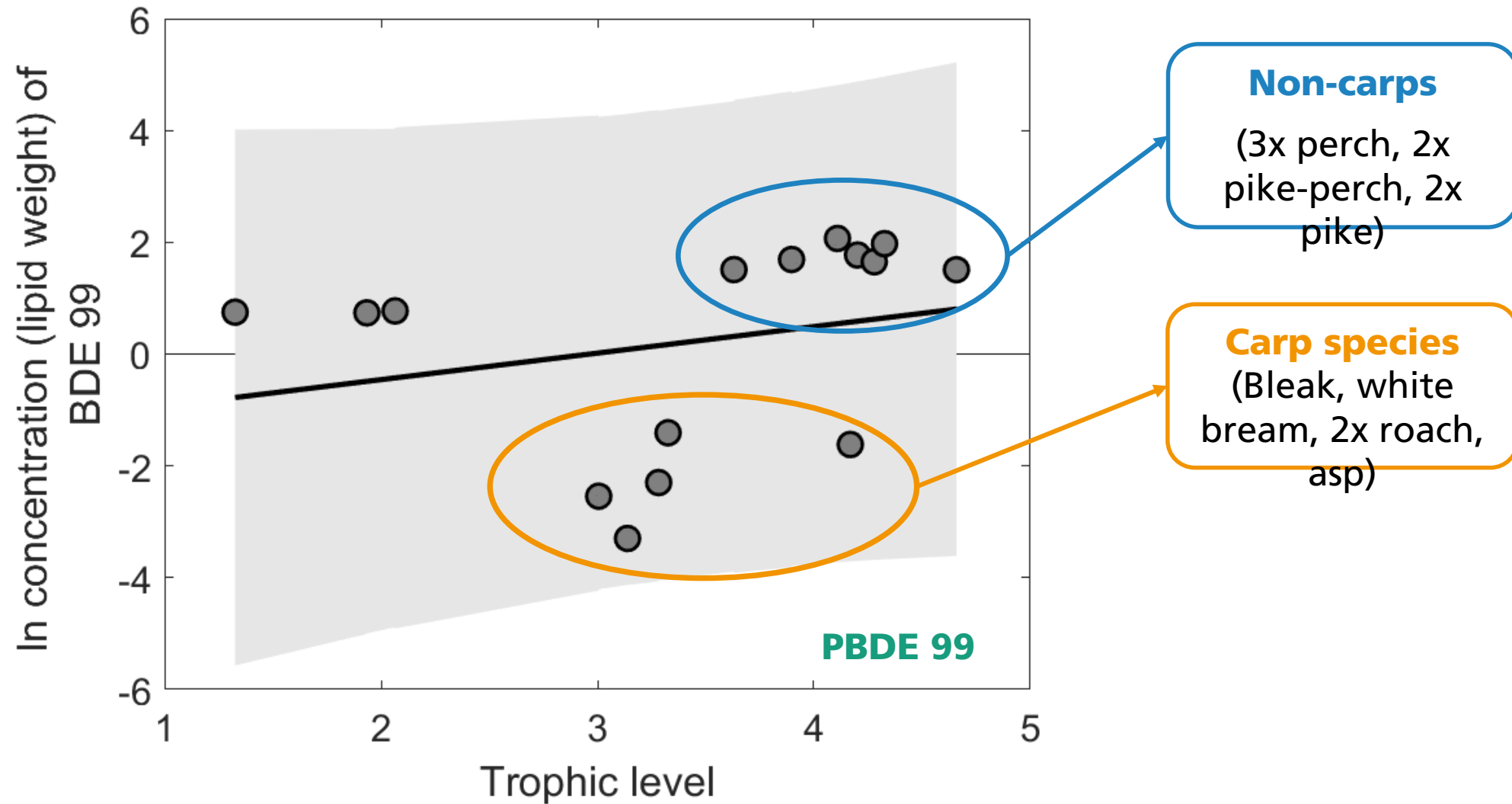
TMFs and metabolism – PBDE 99

In concentration (lipid weight) of BDE 99



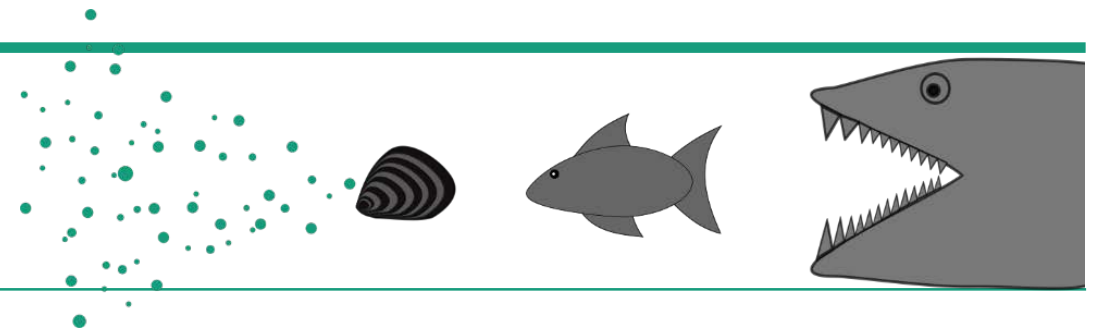
Roberts et al. 2011 (doi: 10.1021/es103934x)

TMFs and metabolism – PBDE 99



FOOD WEB ON ICE

- ADDITIONAL ANALYSES -

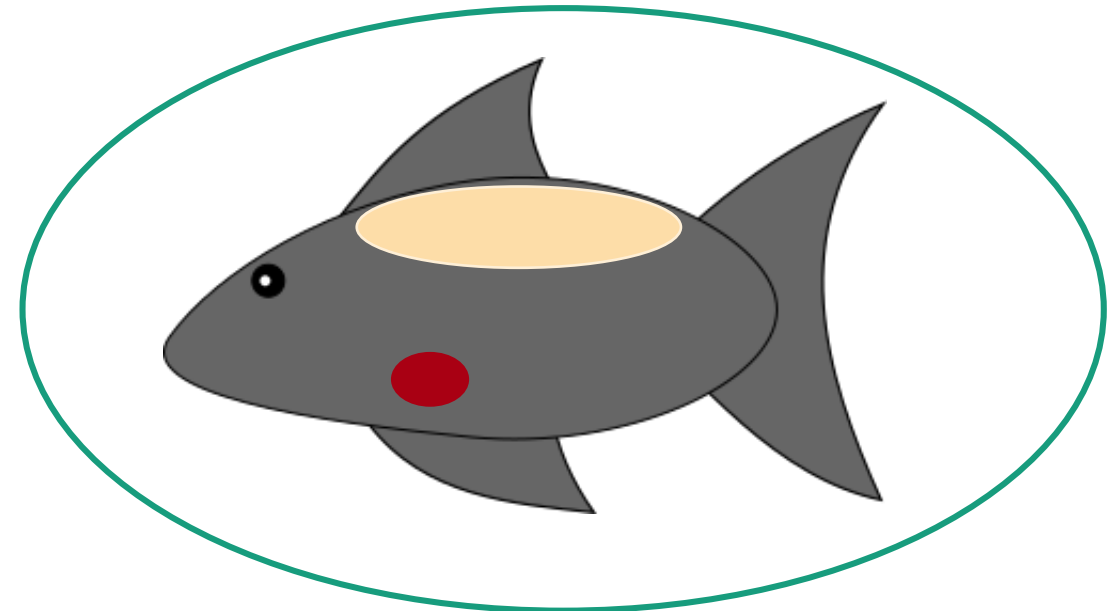


Pharmaceuticals

Caffeine
Carbamazepine
10-Hydroxy-10,11-dihydrocarbamazepine
Triamcinolone acetonide
Diclofenac
Canrenone

Pyrethroids

Tefluthrin
Transfluthrin
I-Cyhalothrin
Permethrin
Cypermethrin
Deltamethrin



Matrix:

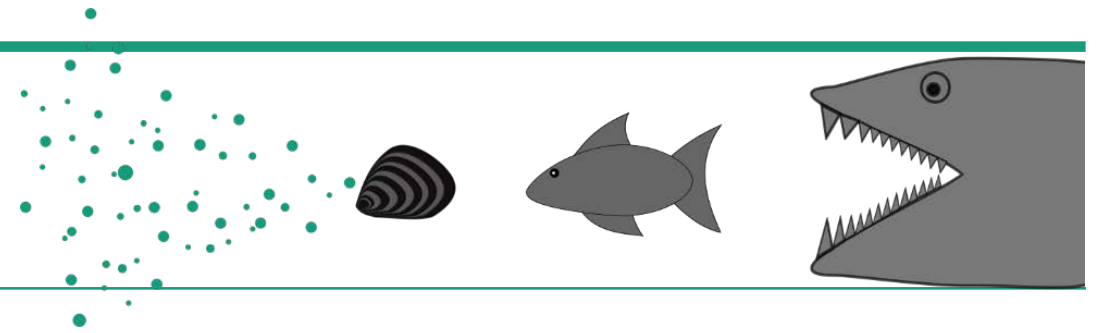
Whole fish

Muscle

Liver

FOOD WEB ON ICE

- ADDITIONAL ANALYSES -



Screening: Chlorinated paraffins

Data available

Complex dataset

Data evaluation in progress

Stockholm University

Screening: Polar compounds

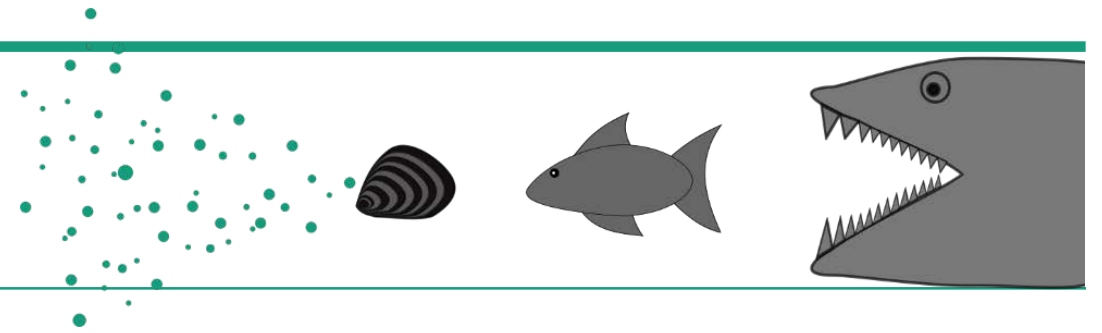
Coupled targeted & NTS approaches

Complex dataset

Data evaluation in progress

Eawag

CONCLUSIONS



■ Food web on ice approach

- Valuable tool
 - Many analyses on identical sample set - Ideally comparable data
 - Cost saving & rapidly available
- Increased chances to understand underlying accumulation processes in the food web

■ Plausibility check

- “Stockholm substances” accumulate in food web
- Different accumulation profiles were covered (lipophilic compounds, mercury, PFAS)

■ Holistic view required

- TMF concept & analyzed ecosystem
- Metabolism and food chain composition may need more focus

Thank you for your attention

Funding:

Investigation of the bioaccumulation of chemicals in an exemplary food chain (Food web on ice)

FKZ 3717 65 416 0

Funding period: 2017 -2021



Umwelt 
Bundesamt