Hexachlorobenzene, pentachlorobenzene and polychlorinated biphenyls monitoring in fish and with passive samplers

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Objectives for this presentation

- Considerable amounts of data on contaminants in fish available in the Norwegian environmental contaminants database
- Extensive passive sampling (PS) done in rivers and along the coast in Norway

→ How can we compare these data?

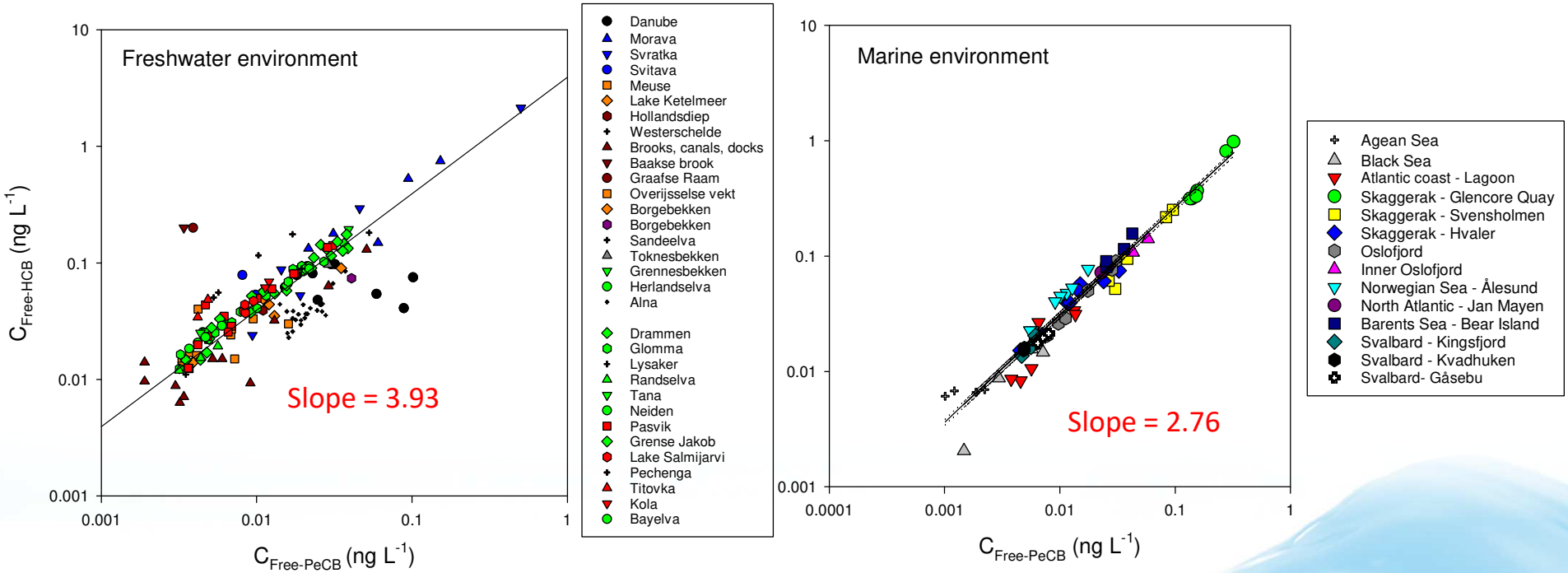
→ Suitable chemicals for comparison:

  - Hexachlorobenzene (HCB), and pentachlorobenzene (PeCB), both are priority substances
  - Polychlorinated biphenyls (PCBs)

Q1: Is there evidence of biomagnification of HCB in fish?

Q2: Are contaminant levels higher in fish than in water?

Passive sampling of HCB and PeCB in water*



- Correlation between freely dissolved HCB and PeCB concentrations in freshwater and in the marine environment.
- Constant $C_{w\text{-}HCB}/C_{w\text{-}PeCB}$ in water at sites remote from point sources of either of the chemicals

*Allan et al. (2021) Passive sampling and benchmarking to rank HOC levels in the aquatic environment. Scientific reports, 11(1), pp.1-12.

On the use of PS data to interpret biota data (i)

How can we investigate whether HCB biomagnifies?

- Some assumptions:
  - Constant $C_{w\text{-}HCB}/C_{w\text{-}PeCB}$ in water (remote from point sources of either of the chemicals)
  - Hexachlorobenzene is a potential biomagnifier
  - Pentachlorobenzene does not biomagnify

- Calculate lipid-based ("abiotic") bioconcentration factors from $K_{lip\text{-}SR}$ and $K_{SR\text{-}w}$:

$$\frac{BCF_{lip,x}}{BCF_{lip,PeCB}} = \frac{K_{lip-w,x}}{K_{lip-w,PeCB}} = \frac{K_{lip-sr,x}K_{sr-w,x}}{K_{lip-sr,PeCB}K_{sr-w,PeCB}}$$

- Calculate hypothetical HCB/PeCB concentration ratio in fish:

$$\frac{C_{lip,equiv,x}}{C_{lip,equiv,PeCB}} = \frac{BCF_{lip,x}}{BCF_{lip,PeCB}} \frac{C_{free,x}}{C_{free,PeCB}}$$

Ratio of C_{Free} from passive sampling

On the use of PS data to interpret biota data (ii)

- The calculated ratio of bioconcentration factor – BCF_{lip}- is 3.4

Compound	$logK_{sr\text{-}w}$ ($L\ kg^{-1}$)[a]	$K_{lip\text{-}sr}$ ($kg\ kg^{-1}$)[a]	$logBCF_{lip}$ ($L\ kg^{-1}$)	BCF_{lip} ($L\ kg^{-1}$)	$BCF_{lip,x}/BCF_{lip,PeCB}$
PeCB	4.62	7.38	5.49	307650	1
HCB	5.05	9.35	6.02	1049087	3.4

[a]For AlteSil silicone rubber[14]

- Estimate hypothetical HCB/PeCB ratio in fish to check if HCB biomagnifies

  With TMF = 1 for TL = 1, and TMFs of 3.4 (range of 2-4) for HCB**

	$C_{free,HCB}/C_{free,PeCB}$[a]	$BCF_{lip,HCB}/BCF_{lip,PeCB}$[b]	$BAF_{lip,HCB}/BAF_{lip,PeCB}$		$C_{lip,HCB}/C_{lip,PeCB}$[d]	
			TL=3	TL=4	TL=3	TL=4
Freshwater	3.93	3.4	39 (14-55)	134 (27-218)	155 (53-214)	525 (107-855)
Marine	2.76	3.4	39 (14-55)	134 (27-218)	108 (37-150)	369 (75-600)

**applying range of trophic magnification factors (TMF) found from literature

On the use of PS data to interpret biota data (iii)

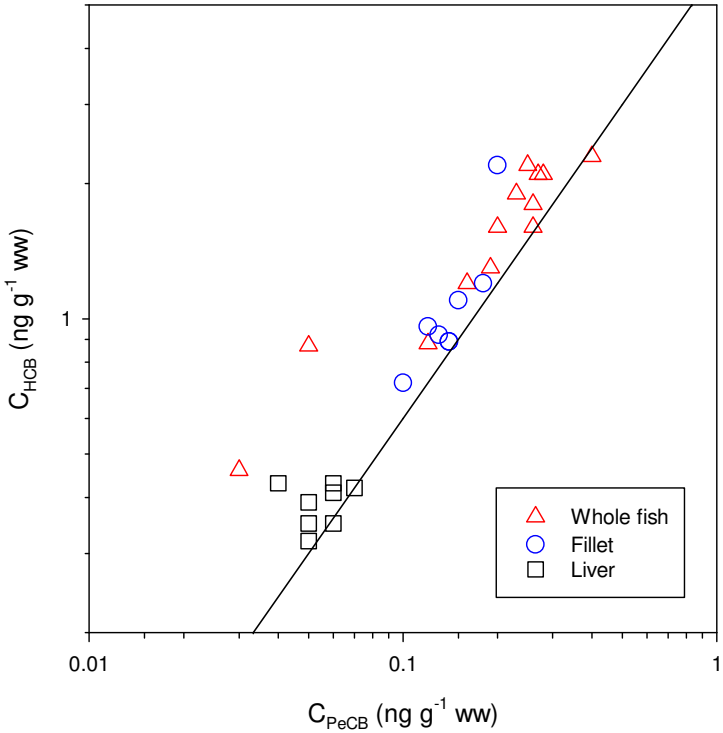
- Compare HCB/PeCB concentration ratio in fish from monitoring data* with hypothetic ratio to check for bioconcentration of the two chemicals

- Compare chemical activity in fish and in water for sampling locations where passive sampling and fish monitoring was conducted in parallel

$$\frac{A_{Fish}}{A_{water}} = \frac{C_{Fish,lip}}{C_{lip,equiv}} = \frac{C_{Fish,lip}}{K_{lip-sr} K_{sr-w} C_{free}}$$

*Fish data from the Norwegian environmental contaminants database https://vannmiljo.miljodirektoratet.no/

Caged brown trout in the river Alna (Oslo)*

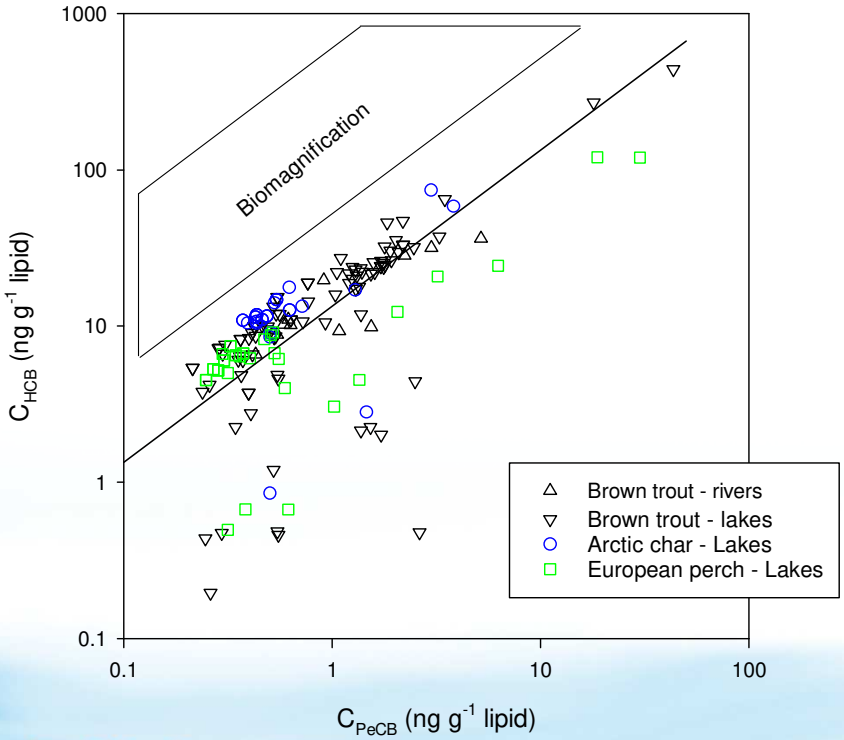


With caged fish not allowed to feed, bioconcentration of the two chemicals was expected

Excellent agreement between the HCB/PeCB concentration ratio in fish and the predicted HCB/PeCB concentration ratio using-BCF_{lip} and ratio of C_{free} (line)

*Allan et al (2013) In vivo passive sampling of nonpolar contaminants in brown trout (Salmo trutta). *Environmental science & technology*, *47*(20), pp.11660-11667.

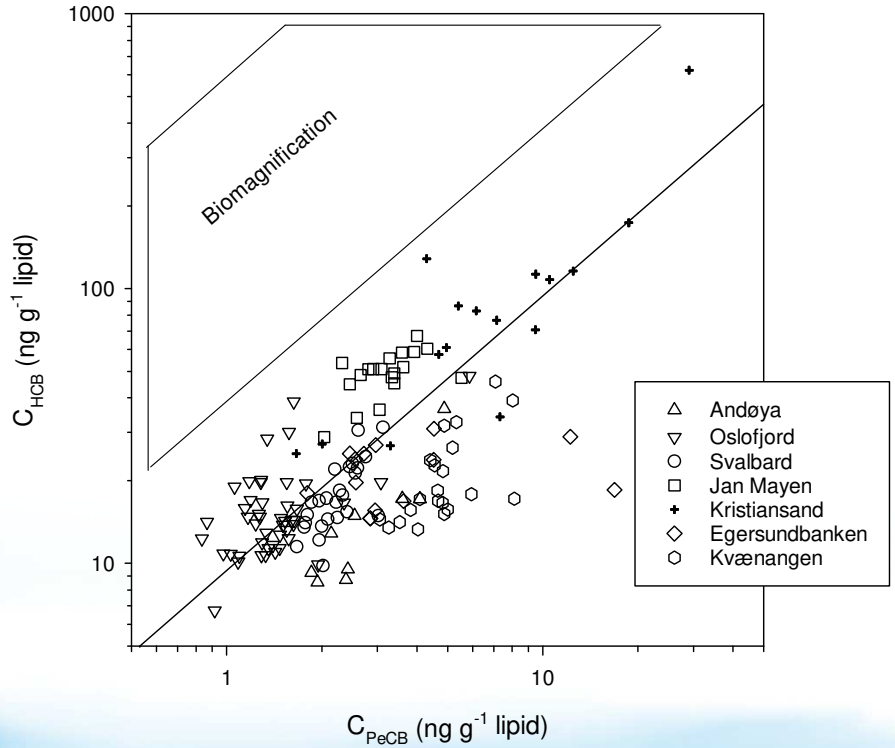
HCB and PeCB in freshwater fish of Norway



- Fish data collection*:
  - Use of most paired HCB/PeCB data available in the database for the last 5-10 years
  - Single fish & composite fish datasets (fillet and/or whole fish)
  - Data from lakes and rivers
  - Few values below LOD/LOQ
- Most data in agreement with ratio indicating bioconcentration of the two compounds when comparing with water
- No indication of biomagnification of HCB
- For the entire fish dataset (n=167), the HCB/PeCB concentration ratio is 17.4, corresponding to:
  - A $C_{free,HCB}/C_{free,PeCB}$ ratio of 5 rather than 3.93
  - A TMF of 1.1 for a fish at TL = 4 and 1.15 for a fish at TL= 3.

*https://vannmiljo.miljodirektoratet.no/,

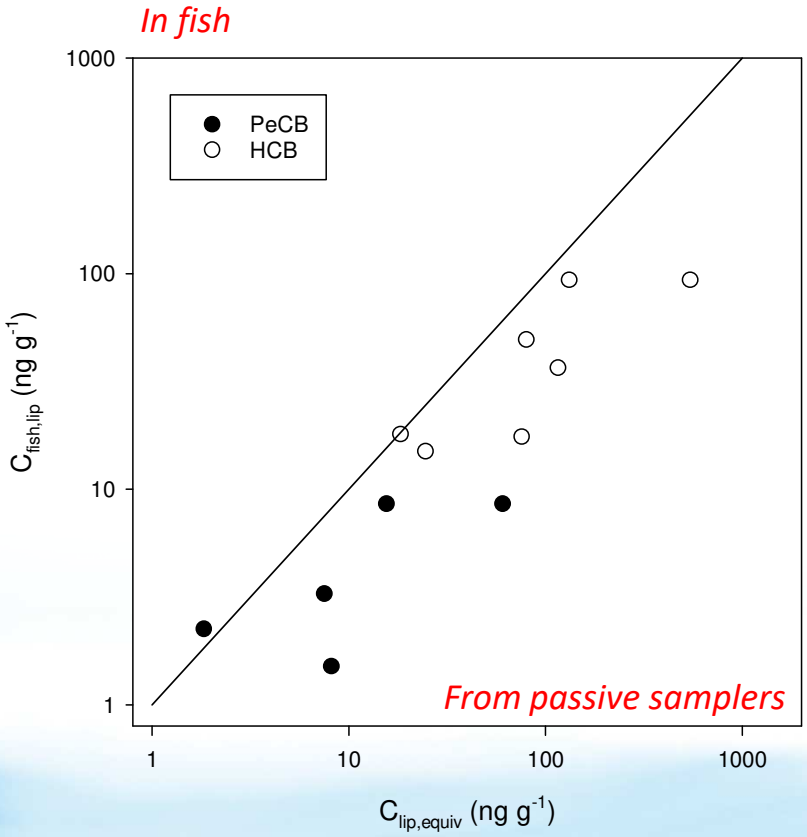
HCB and PeCB in cod from the Norwegian coast



- Fish data gathering*:
  - Use of most paired HCB/PeCB data available in the database for the last 5-10 years
  - Single fish & composite fish datasets
  - Extraction and analysis from cod liver
  - Few values below LOD/LOQ
- No fish data indicating biomagnification of HCB in cod when comparing with water

*https://vannmiljo.miljodirektoratet.no/,

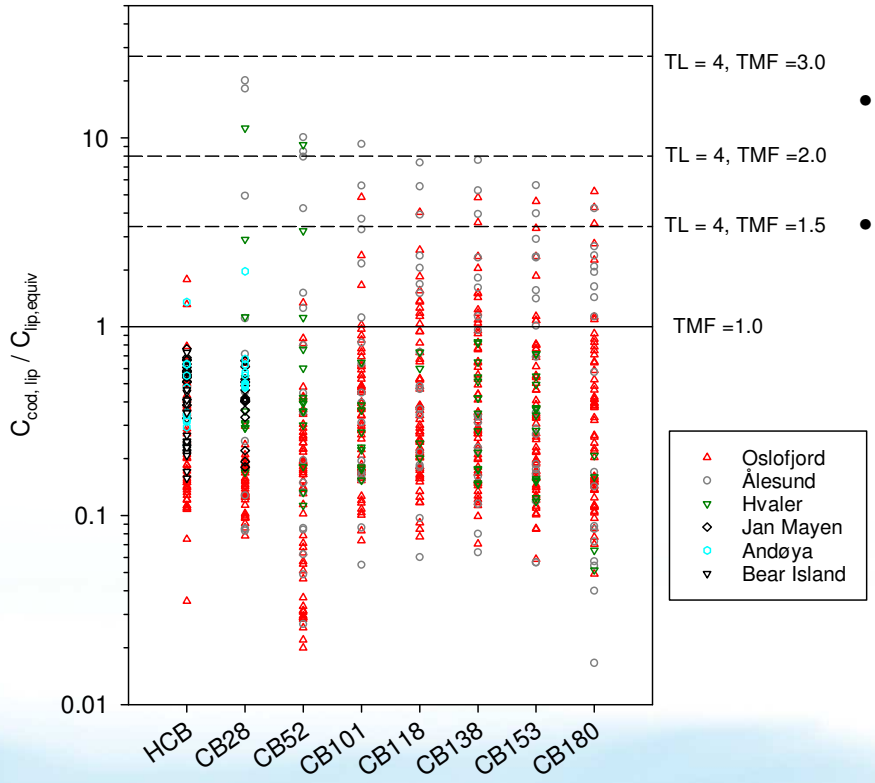
HCB and PeCB in cod from the Norwegian coast



- Cod and PS data from Andøya, Bear Island, Jan Mayen, Kristiansand, Oslofjord and Svalbard (2009-2017)*
- Lipid-based cod liver concentrations of HCB and PeCB ($C_{fish\text{-}lip}$) at or below HCB and PeCB concentrations in lipid at equilibrium with the water ($C_{lip,equiv}$) estimated from passive sampling
- No fish data indicating biomagnification of HCB in cod with TMFs for HCB reported in the literature

*https://vannmiljo.miljodirektoratet.no/,

PCBs in cod from the Norwegian coast



- Cod expected to have a Trophic level (TL) of 3-4
- Most data indicating PCB levels in cod (liver) not higher than in water

Conclusions

- No apparent biomagnification of HCB in Norwegian freshwater fish commonly used for WFD monitoring (when comparing with water)
  → Fish data strongly connected to levels in water
- No apparent biomagnification of HCB in cod from Norwegian coastal areas
- Lipid-based cod liver concentrations of HCB and PeCB hardly ever above concentrations in lipids that would be at equilibrium with the water estimated from passive sampling ($C_{lip,equiv}$)
- Most PCB concentrations in cod do not exceed $C_{lip,equiv}$ calculated from PS data for contiguous measurement