



# Bioaccumulation of PFOS in Freshwater Fish: Evolving Perspectives on an Emerging Contaminant and Implications for Risk Assessments

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# Outline

- Context
- Overview of bioaccumulation
- PFOS preferentially accumulates in liver, blood, and other tissues
- PFOS depuration from fish is relatively rapid
- Early estimates of PFOS bioaccumulation subject to significant uncertainty
- Bioaccumulation estimates span orders of magnitude

# Context

- Recent EU Environmental Quality Standards (EQS) for PFOS
  - 9,1 ng/g ww biota (fish; for protection of human health)
  - 0,65 ng/L freshwater
  - 0,13 ng/L saltwater
  - Requires increased monitoring
  - Goal is to achieve good chemical status by 2027

# Bioaccumulation

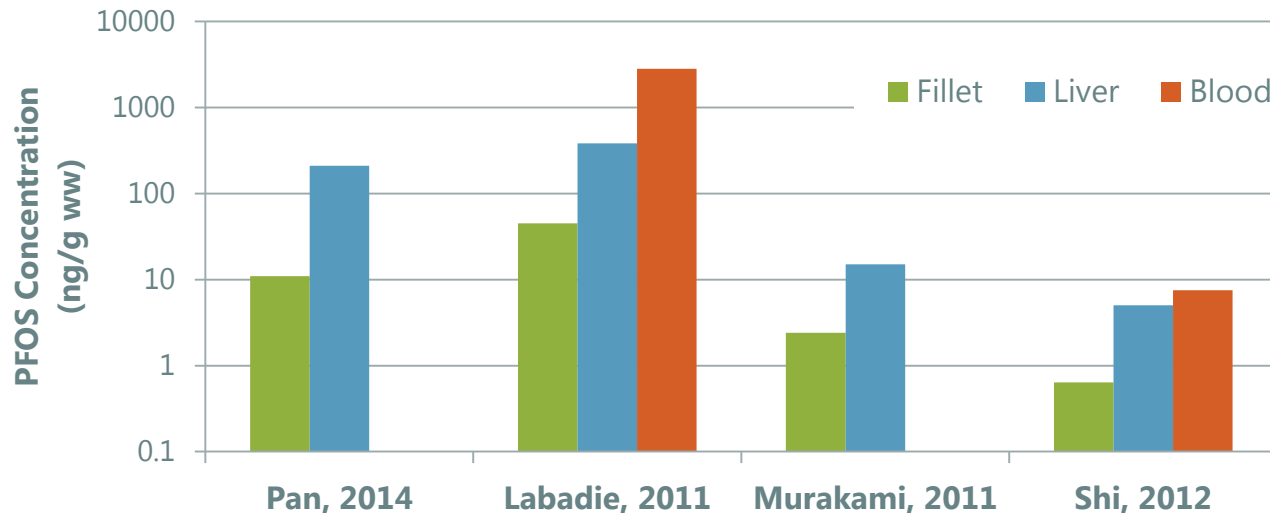
- Various metrics are used to describe bioaccumulation
  - BCF: bioconcentration factor
  - BAF: bioaccumulation factor
  - BMF: biomagnification factor

$$BAF = BCF \times BMF$$

- BCF criteria for bioaccumulative designation by European Chemicals Agency (ECHA): 2000 L/kg

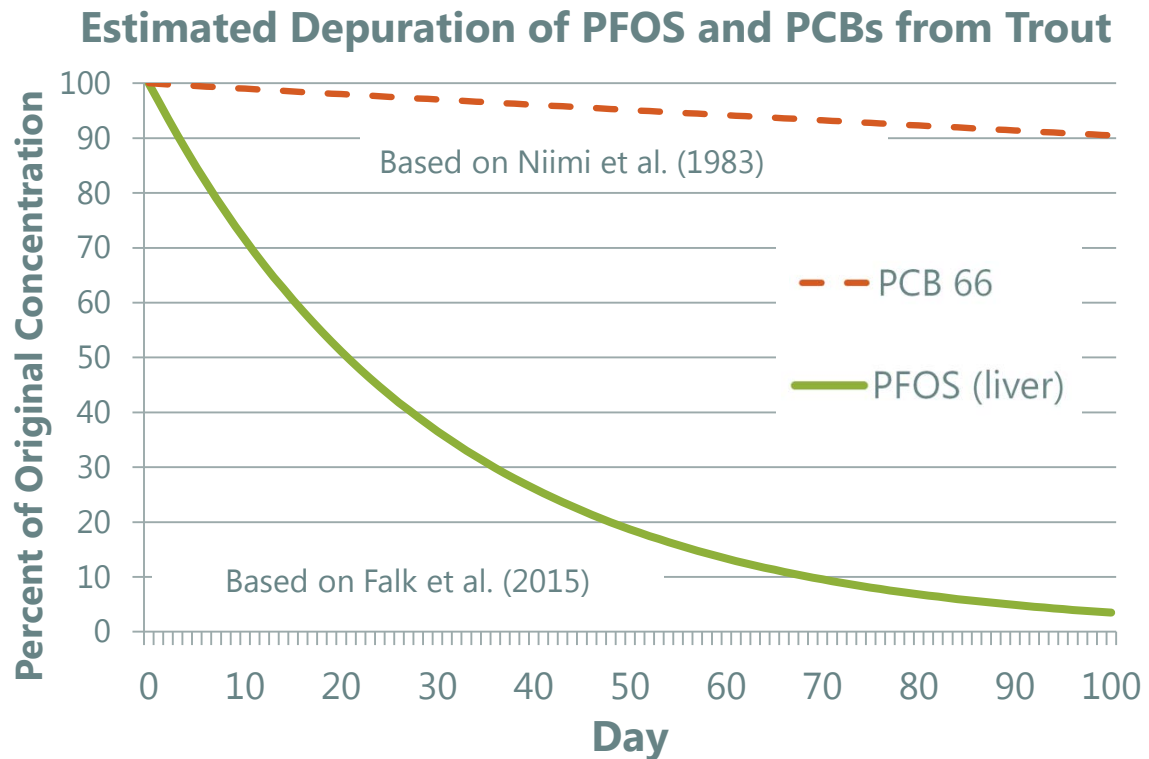
# Specific Nature of PFOS Bioaccumulation

- Laboratory studies indicate that PFOS associates most strongly with certain proteins, not fats (lipids)
- Field studies show PFOS accumulates in blood and liver (and certain other tissues) more than in fillet (muscle)
- Accordingly, estimates of bioaccumulation will depend on tissue analyzed



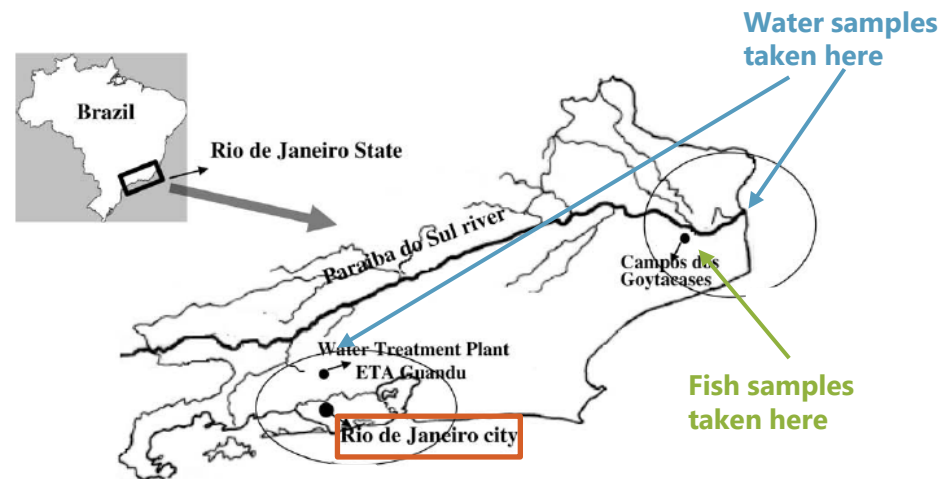
# PFOS is Rapidly Depurated by Fish

- Much faster than from most PCBs
- Tissue concentrations reflect recent exposure
- Temporal pairing of fish and water concentrations are key in predicting BAFs



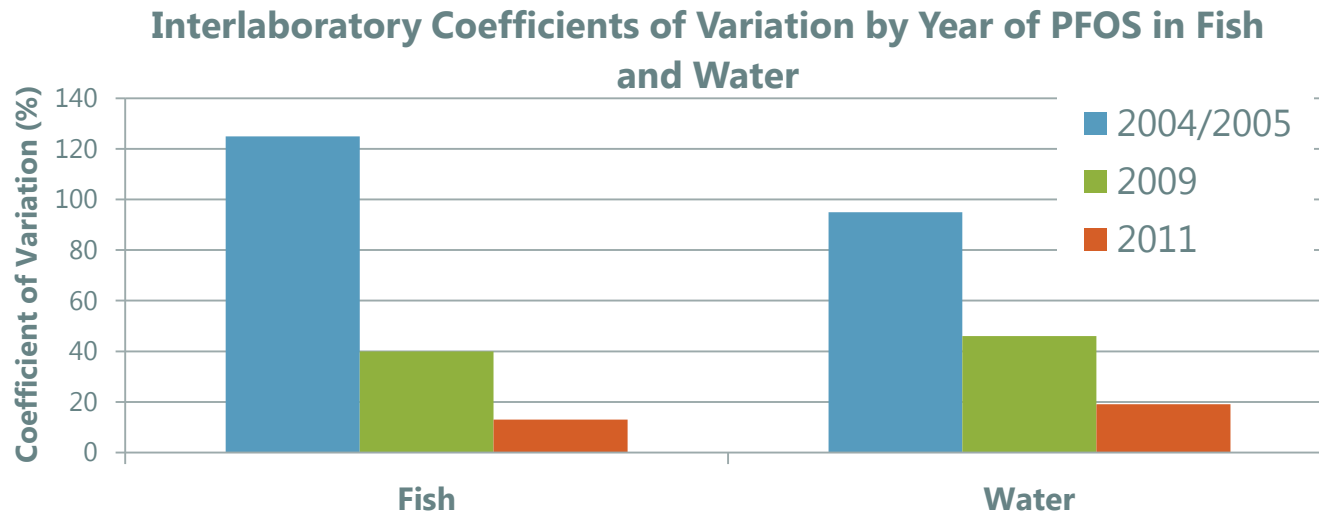
# Importance of Geographical and Temporal Pairing

- Many papers do not adequately pair fish and water samples they use
  - Borga et al. (2005): “A recurring problem in many studies is that water and biota were not sampled simultaneously or from the same locations”
  - Boulanger et al. (2004): Fish from Michigan collected in 1990s; water from Lakes Erie and Ontario collected in 2003
  - Quinete et al. (2009): Water and fish samples are 34 to 250 km apart



# Evolution of PFOS Analytical Procedures

- Interlaboratory studies were conducted in 2004/2005, 2009, and 2011

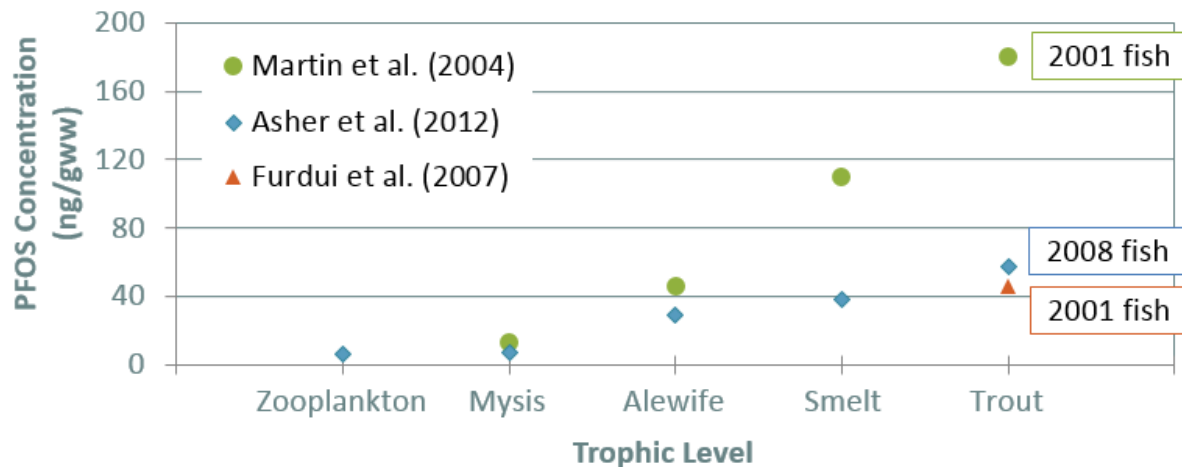


- Early results subject to substantial uncertainty
- Improvements have been realized, but some uncertainty remains

Sources include: van Leeuwen et al. (2006), van Leeuwen et al. (2009), and Weiss et al. (2013)

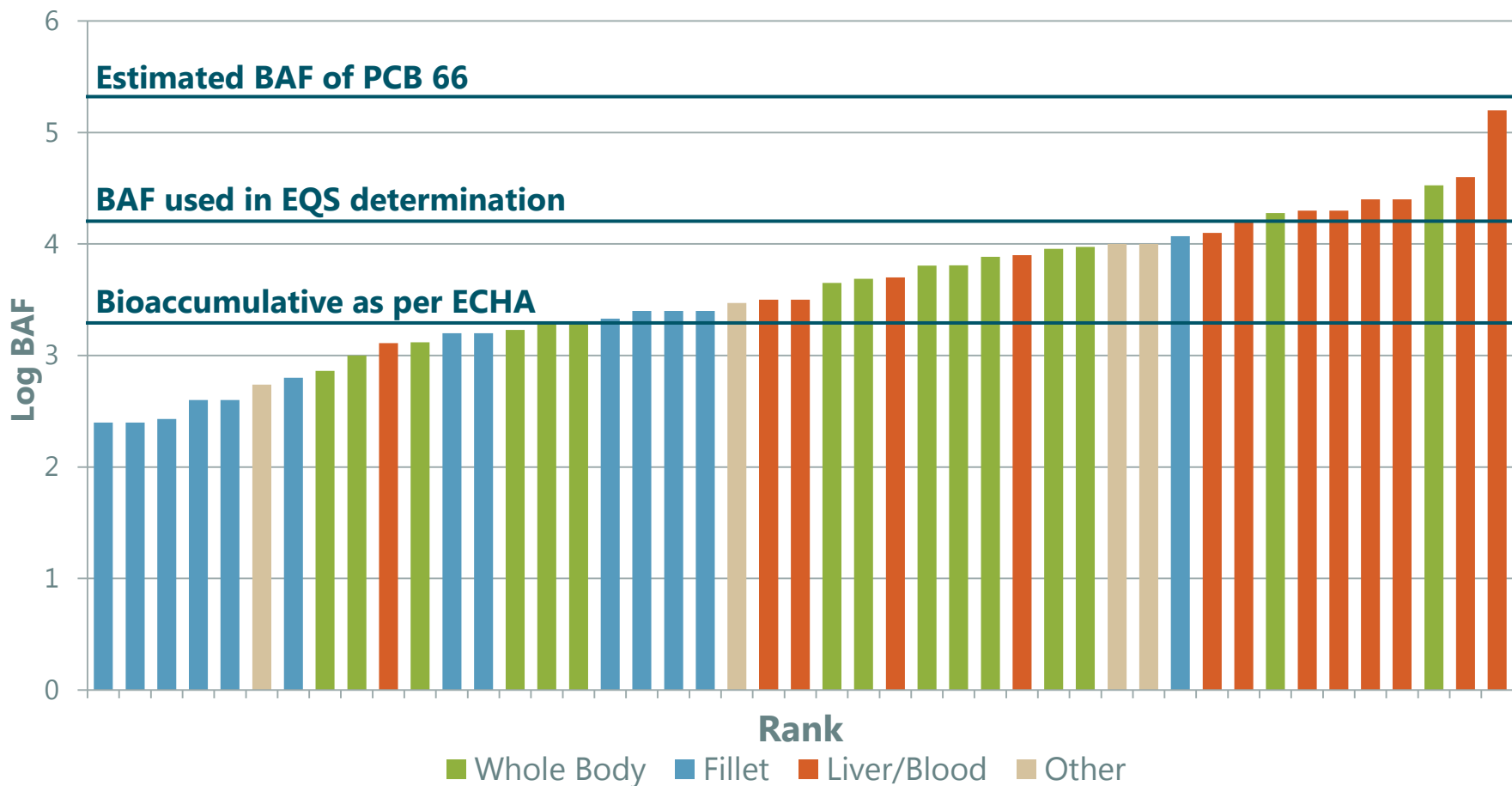


# Lake Ontario Pelagic Food Web



- Martin et al. (2004): Oldest paper, widely cited
  - Exhibits higher bioaccumulation
- Asher et al. (2012): More recent
  - Exhibits lower bioaccumulation
- Data suggest improvements in analytical methods largely account for temporal patterns

# Overview of BAF Values in the Recent Literature



Sources include: de Solla et al. (2012), Kwadijk et al. (2010), Labadie et al. (2011), Asher et al. (2012), Pan et al. (2014), Zhou et al. (2012), Awad et al. (2011), Murakami et al. (2011), De Silva et al. (2011), Ahrens et al. (2015)

# ECHA BAF value

$$BAF = BCF \times BMF$$

- “The highest, reliable BCF value for whole fish was noted to be 2796.” EU (2011)
  - This value is from a 2001 laboratory study
  - Exposure concentration > 1 000x typical environmental concentrations
  - Bluegill only
- BMF set to 5
  - Based on studies with acknowledged low reliability
  - No studies newer than 2008 considered
- Resulting BAF =  $(2796 \times 5) = 13\,980$

Source: EU, 2011. PFOS EQS dossier. p. 22

# Conclusions

- PFOS (and other PFAS) bioaccumulation is importantly different from most other organic chemicals
- Substantial uncertainty in PFOS BAF remains
  - Evolution of analytical methods
  - Rapid depuration from aquatic species complicates monitoring
  - Significant variations across tissues
- Rapid depuration provides opportunity for relatively rapid recovery of fish concentrations following cessation of sources
- Water-based EQS (0,65 ng/L) is below typical commercial laboratory reporting limits
- Many of the general concepts herein apply not just to PFOS, but other PFASs as well

# Questions/Discussion

