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Using historical datasets of PCBs in fish to assess effectiveness of management actions

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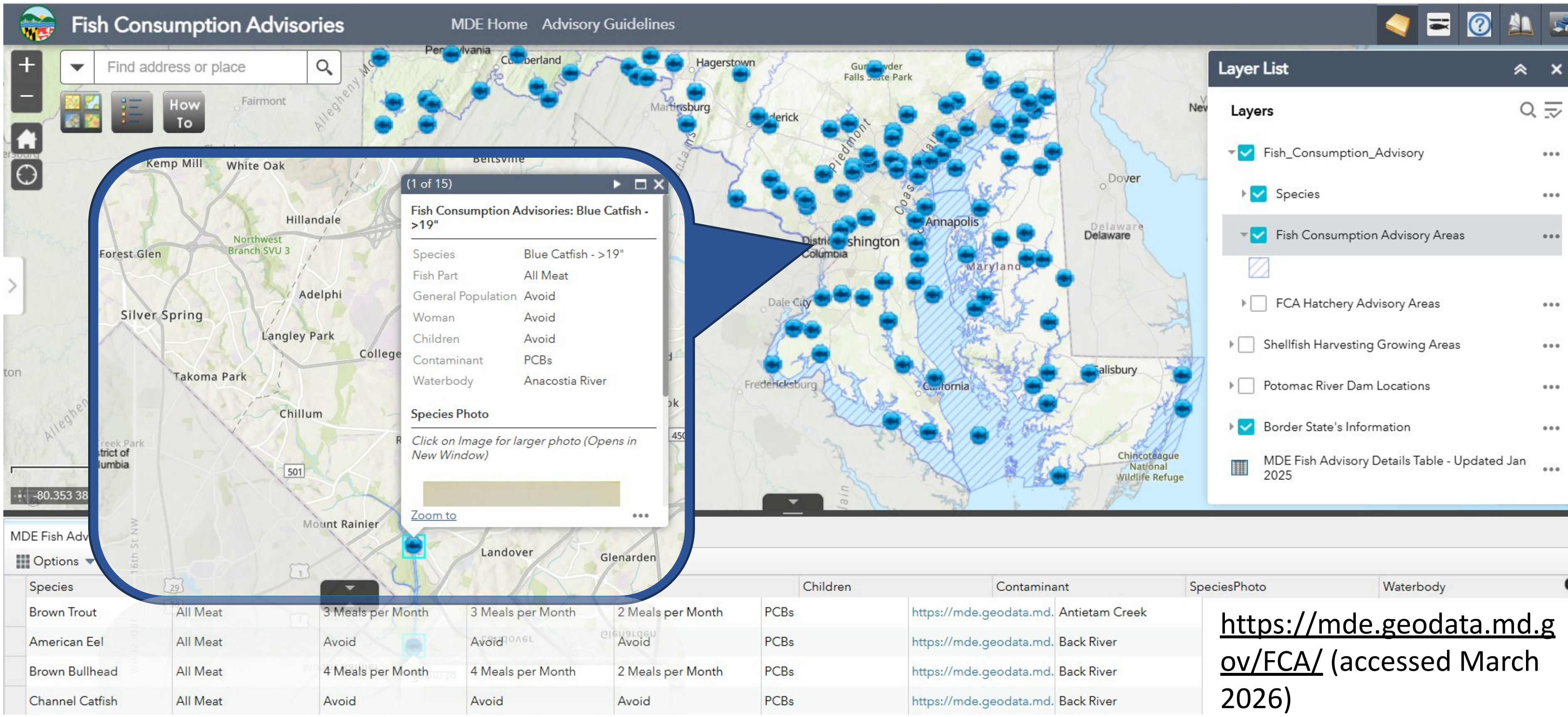
PCBs in MD - Background



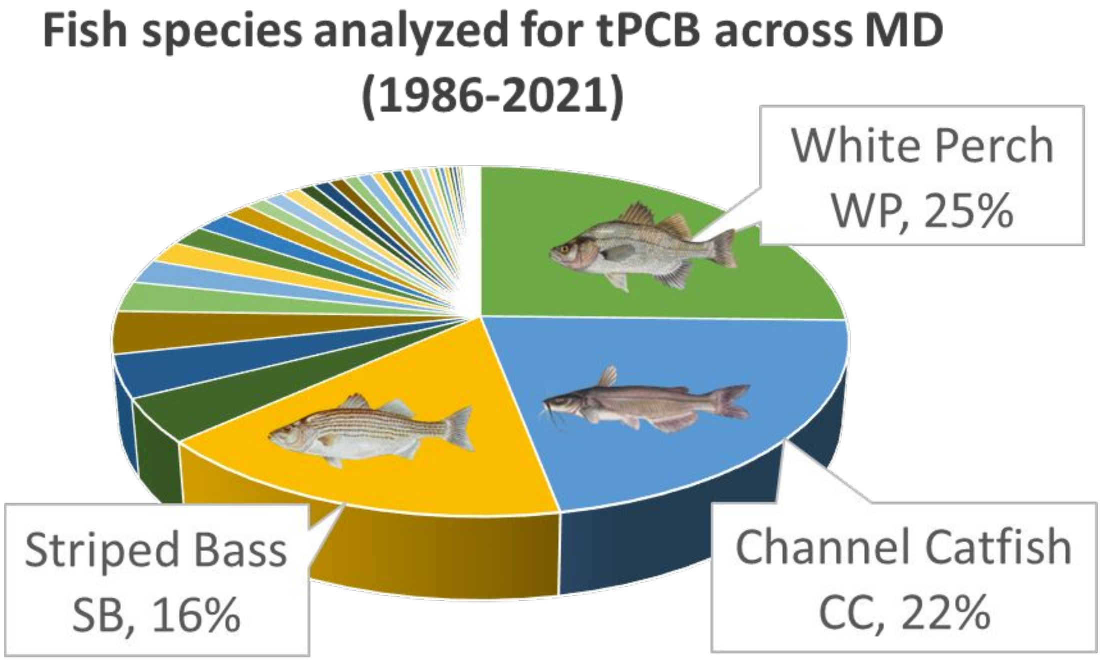
https://mde.geodata.md.gov/FCA/ (accessed March 2026)

- ❑ Widespread PCB contamination in waterways
- ❑ Still fish consumption advisory (FCA) due to PCBs
- ❑ Major impact to underprivileged communities

Can we use the historical FCA dataset to:

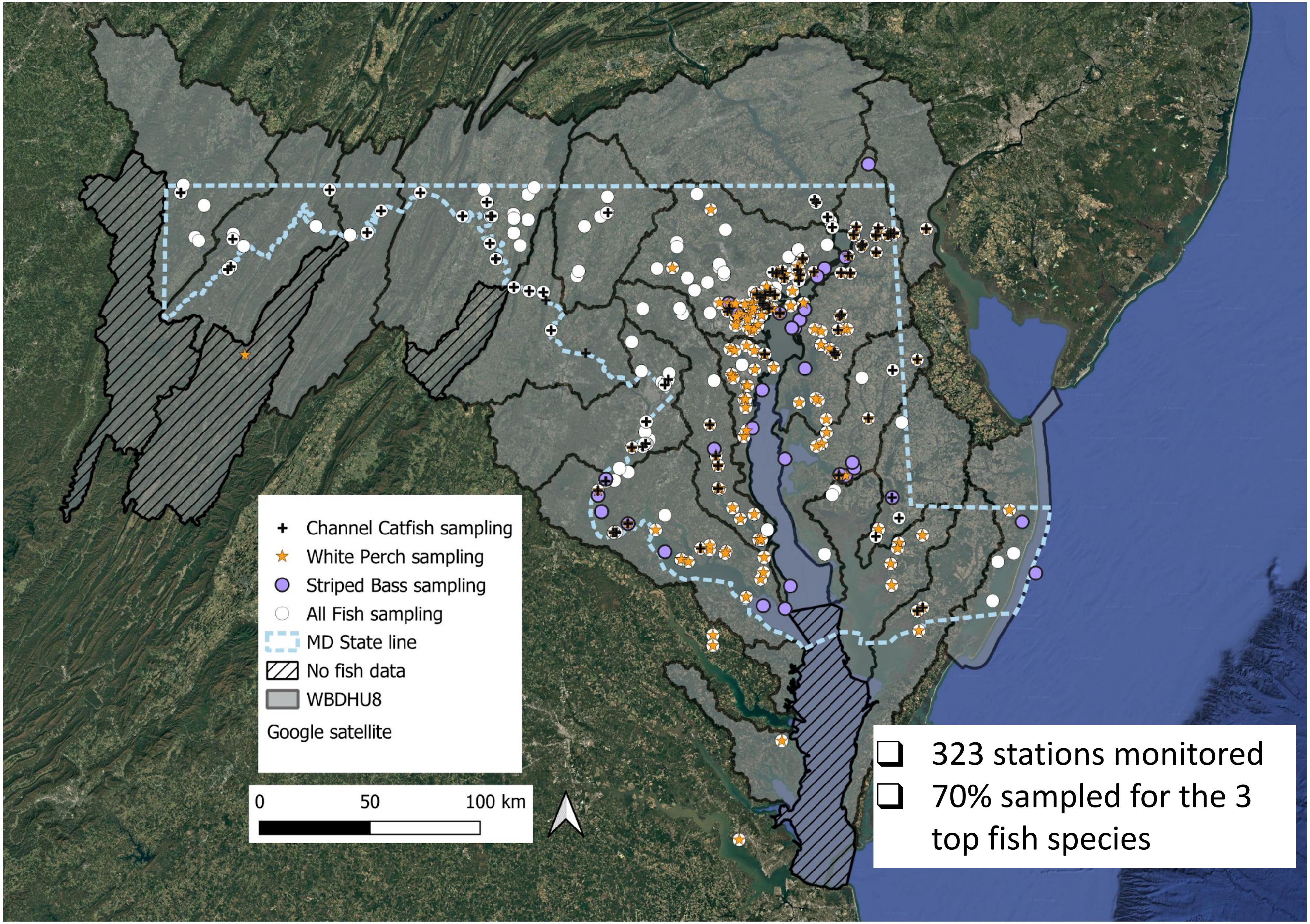
1. Evaluate spatio-temporal trend of PCBs in fish
2. Identify priority watersheds
3. Assess remedial action effectiveness

Fish analyzed for PCBs in MD watersheds from 1986 to 2021



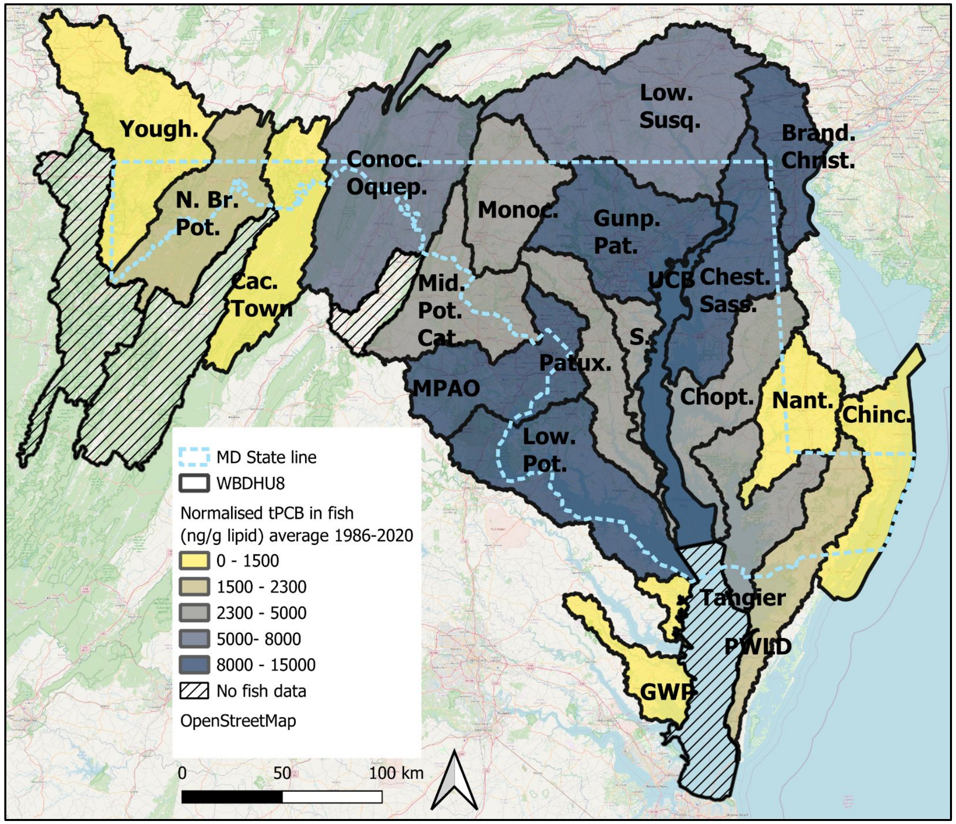
- 1920 fish composites collected in Maryland from 1986-2021
- UMBC has performed fish tissue analysis in fish for MDE from 2007
- Since 1986, total of 52 fish species analyzed over 35 years
- About 60% of the data from 3 species.

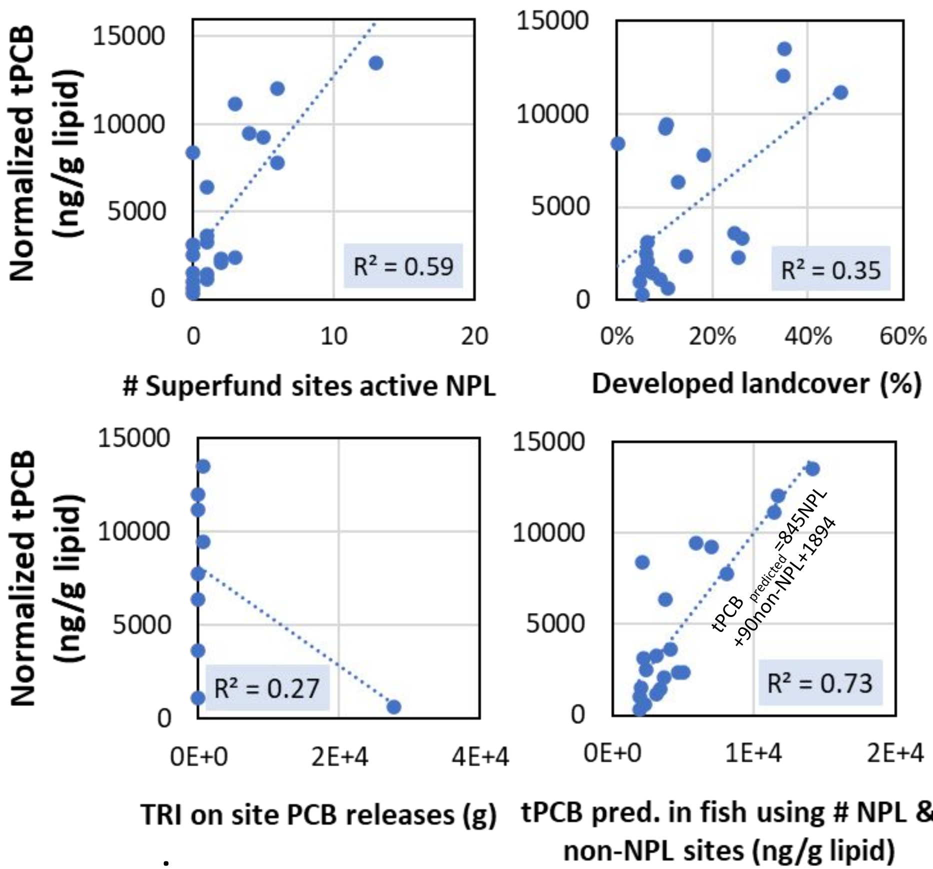
Spatial coverage of the top 3 fish species in MD



- ❑ 323 stations monitored
- ❑ 70% sampled for the 3 top fish species

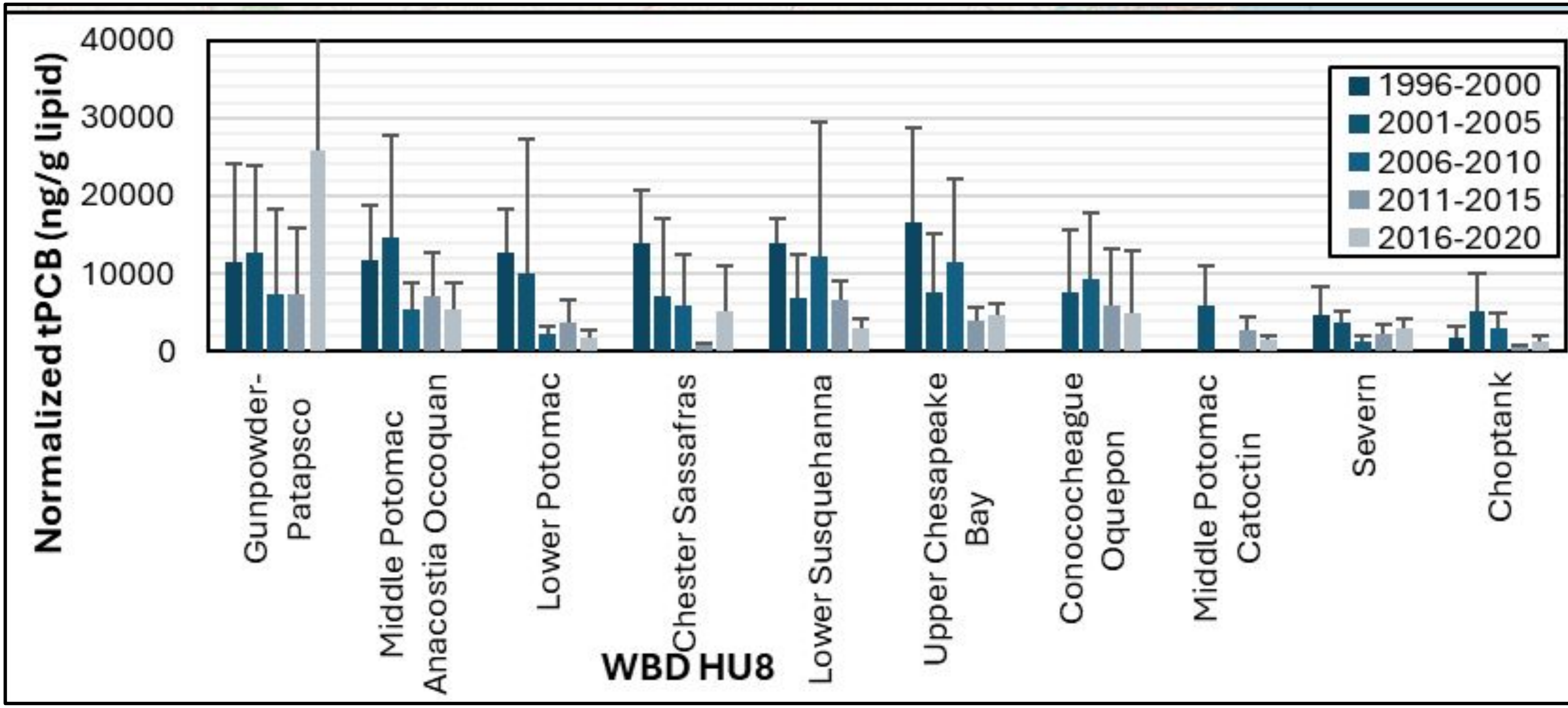
Watershed scale big picture across MD





- ❑ Lipid normalization enables comparison across species
- ❑ Gunpowder-Patapsco region, Middle Potomac Anacostia Occoquan (MPAO) and Lower Potomac show high PCB concentration in Fish
- ❑ Positive correlation with developed landcover
- ❑ Best predictions with number of superfund sites (on the NPL or not)per watershed

Fish PCB trends over 35 years in MD watersheds



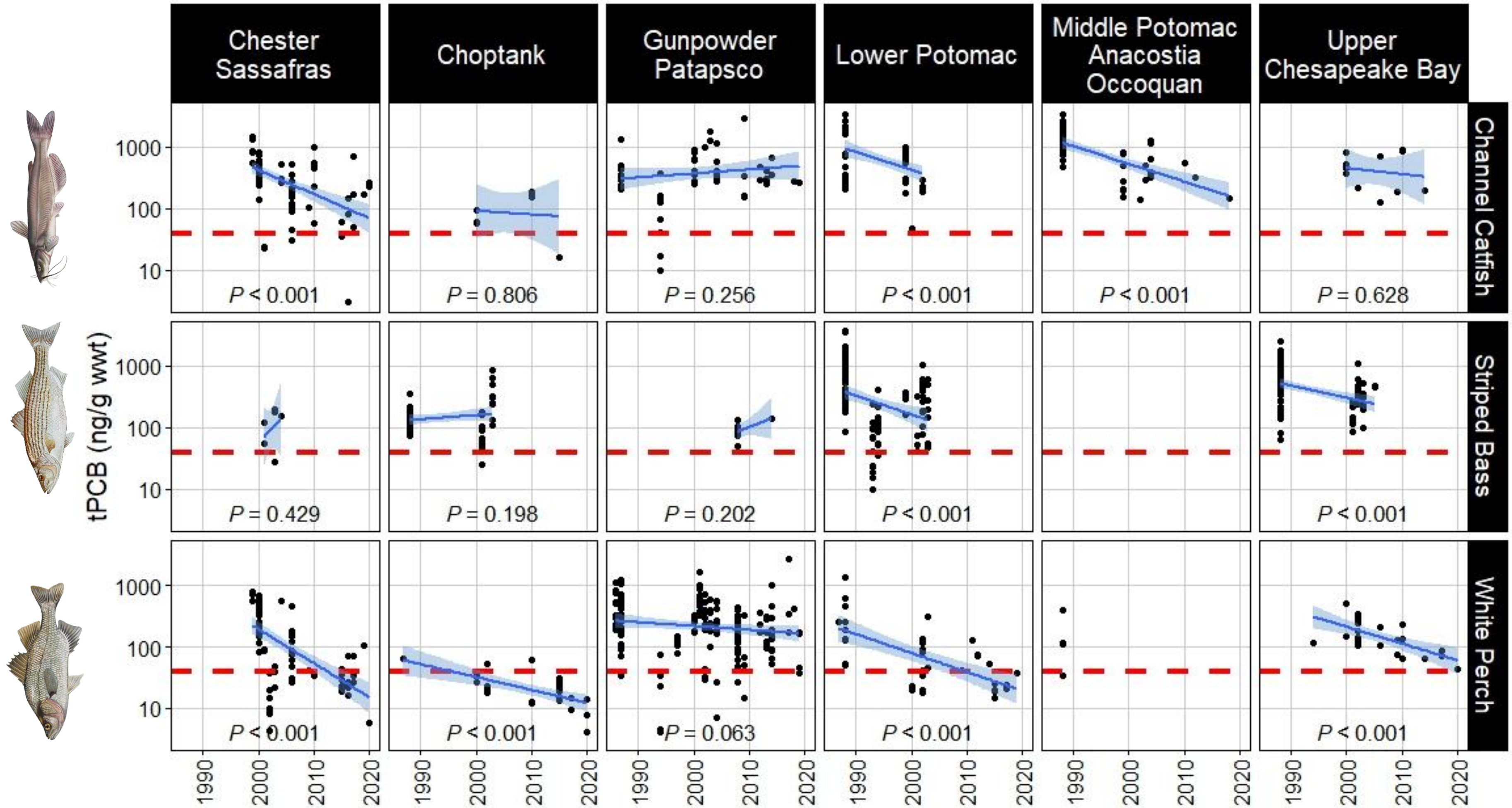
- Lipid normalized PCB concentrations (47 species) across watersheds over time
- Indication of recovery in some areas
- Weak or no recovery in other areas
- Gunpowder-Patapsco watershed not showing recovery

Estimated fish PCB natural attenuation rates in MD

WBD HU8	Fish species	n	Slope (log tPCB.yr^{-1})	Intercept (log tPCB)	P	R2	$t_{1/2}$ (years)	Attenuation (%.yr^{-1})	Estimated year of recovery
Chest. Sass	CC	95	-0.0391	80.9	<0.001	0.27	8	-4%	2028
	SB	11	-0.015	31.9	0.746	0.01	ND	-2%	**No trend**
	WP	87	-0.0557	114	<0.001	0.38	5	-6%	2018
Choptank	CC	8	0.00583	13.6	0.806	0.01	ND	1%	**No trend**
	SB	56	0.00672	-11.3	0.198	0.03	ND	1%	**No trend**
	WP	25	-0.021	43.4	<0.001	0.44	14	-2%	1991
Gunp. Pat.	CC	69	0.00654	-10.5	0.256	0.02	ND	1%	**No trend**
	SB	8	0.0348	-68	0.202	0.25	ND	3%	**No trend**
	WP	184	-0.00672	14.8	0.063	0.02	ND	-1%	**No trend**
Low. Pot.	CC	59	-0.0294	61.3	<0.001	0.19	10	-3%	2031
	SB	110	-0.0308	63.8	<0.001	0.11	10	-3%	2020
	WP	40	-0.0309	63.8	<0.001	0.42	10	-3%	2013
MPAO	CC	57	-0.0289	60.5	<0.001	0.4	10	-3%	2038
	SB	0	ND	ND	ND	ND	ND	ND	ND
	WP	4	ND	ND	ND	ND	ND	ND	ND
UCB	CC	11	-0.00988	22.4	0.628	0.03	ND	ND	**No trend**
	SB	124	-0.0486	99.4	<0.001	0.46	6	-5%	2013
	WP	24	-0.0274	57.2	<0.001	0.43	11	-3%	2030

- Total PCBs by key species show no trend for several watersheds
- Ones that show decline, range from 2% to 6% yr^{-1} similar to natural attenuation rates seen elsewhere

Fish PCB trends over 35 years in MD watersheds

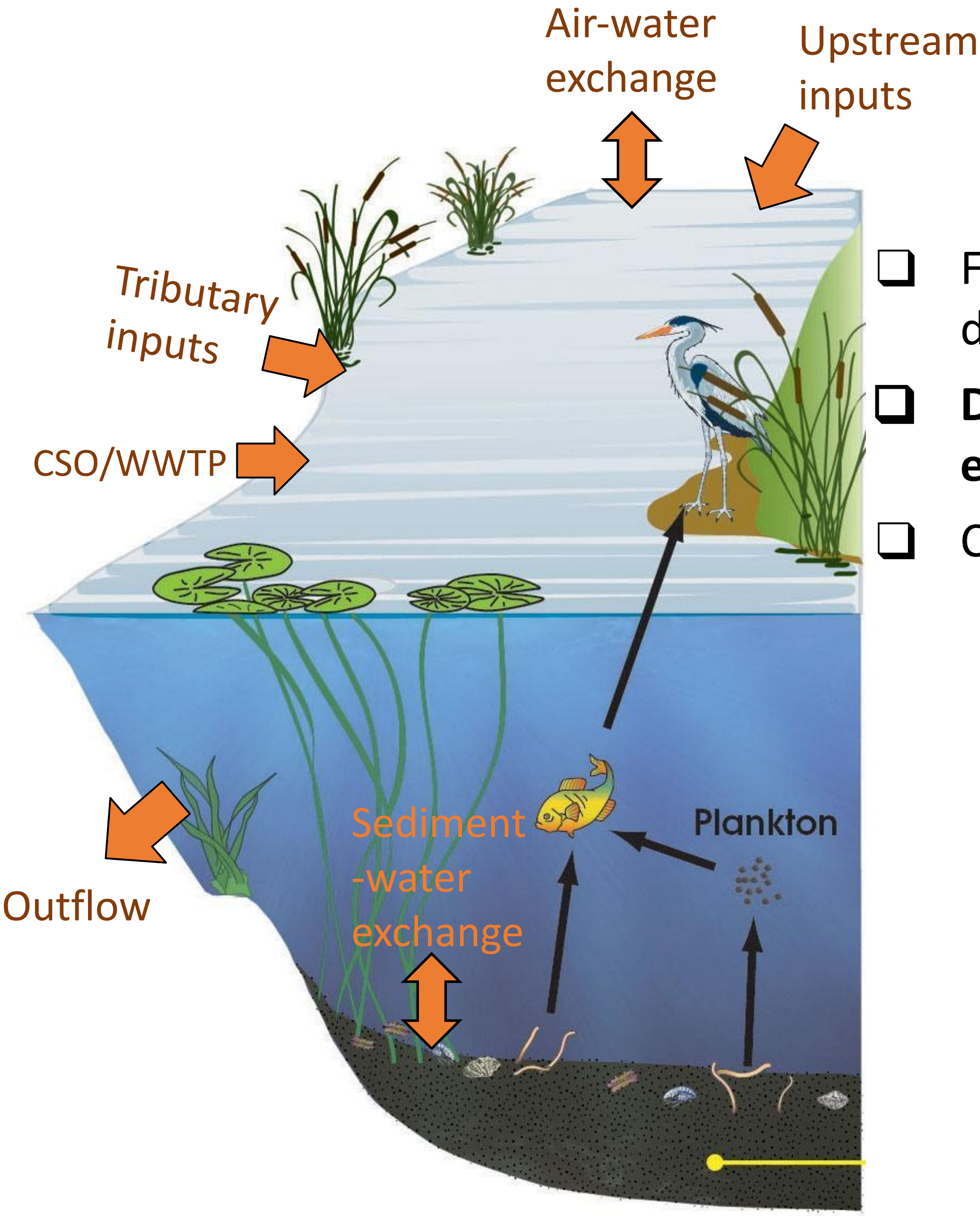


- ❑ Indication of recovery in some areas
- ❑ Weak or no recovery in other areas
- ❑ Gunpowder-Patapsco watershed not showing recovery

Key observations from the paper

- Much remains to be done for PCBs in MD.
- 5 decades since the PCB ban several watersheds still experience consumption advisories
- Provides sober insights on anticipated recovery for emerging pollutants that are similarly persistent and bioaccumulative
- Gunpowder-Patapsco and Anacostia-Potomac with large urban influence show no decline in recent years
- Concerted efforts are necessary to identify:
  - deposits of legacy contaminated sediments
  - upland sources of ongoing inputs
- Recovery of the aquatic resources will require the allocation of resources to clean up identified contaminated sites

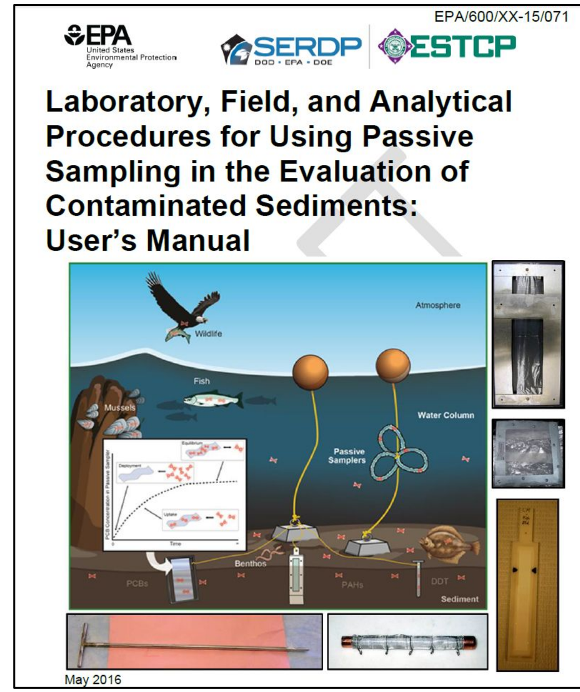
How are PCBs still getting into fish?



- Fish are exposed through water and diet
- **Dissolved concentrations control exposure**
- Contributions to water from:
  1) Contaminated bed sediments
  2) Inputs from tributaries and outfalls
  3) Air-water exchange
  4) CSO/WWTP
  5) Runoff of contaminated soil sites

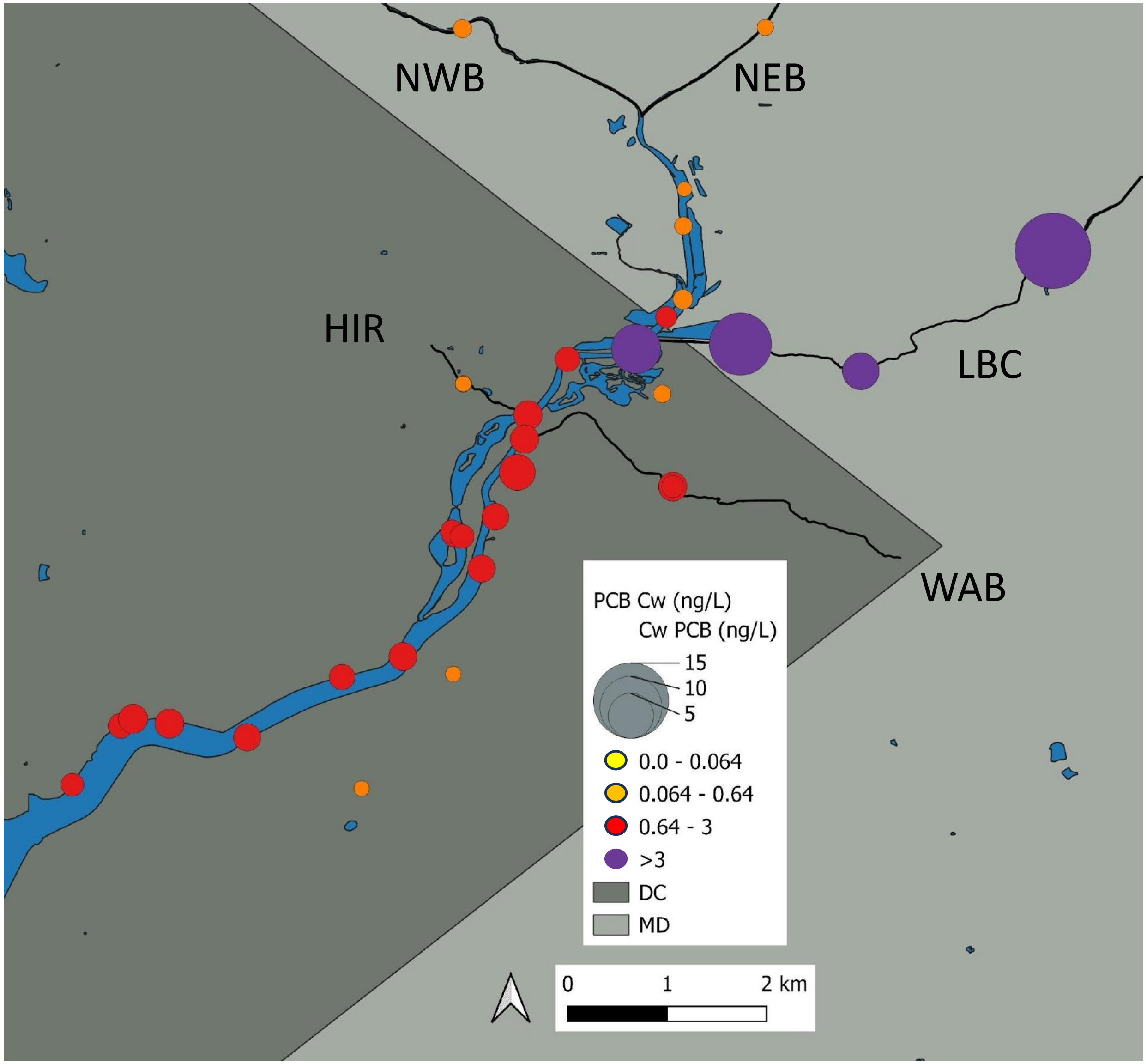
Passive sampling enabling dissolved PCB measurement

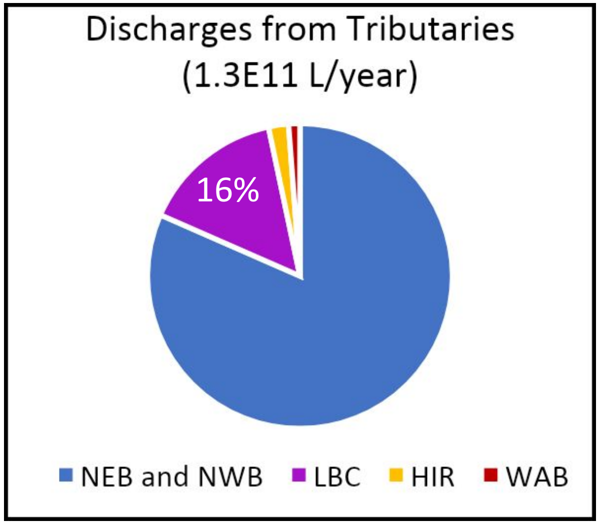
- New approach: Integrative passive sampling
- Samplers deployed in surface water, sediment porewater, and air
- Followed latest procedures for passive sampling and data interpretation

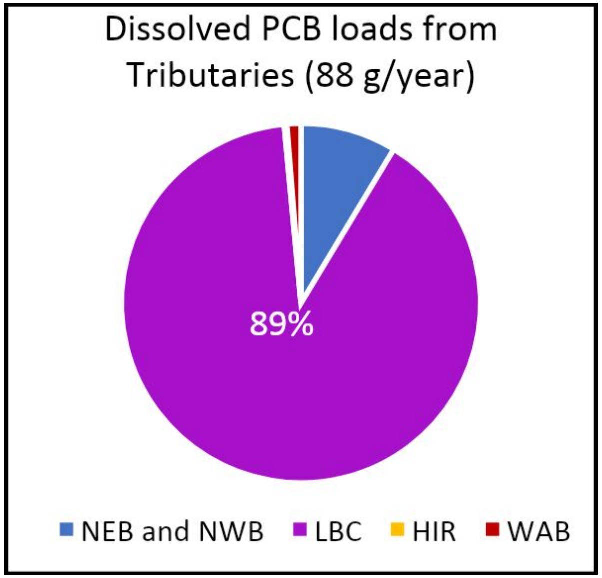


Defining the correct metric of measurement is critical

PCB concentration in water column of Anacostia River



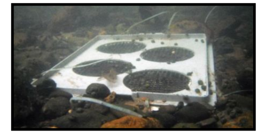




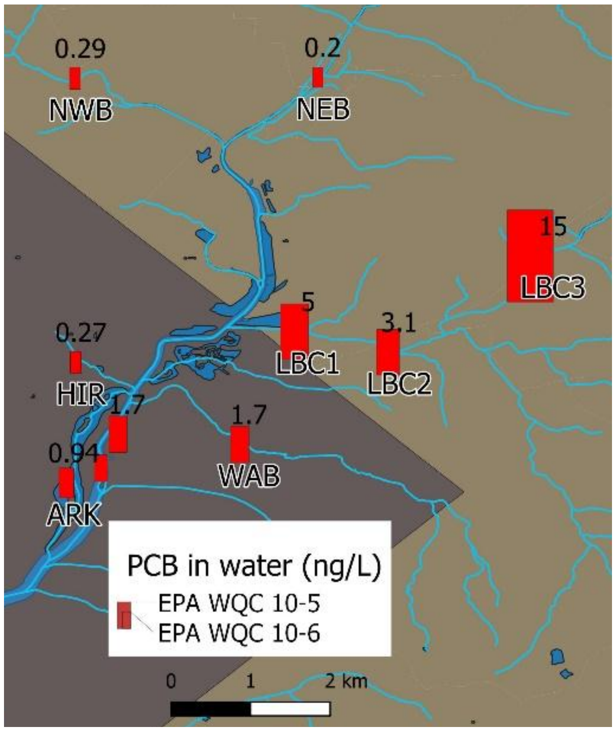
Comparison of passive sampler data to PCB in mussel and fish

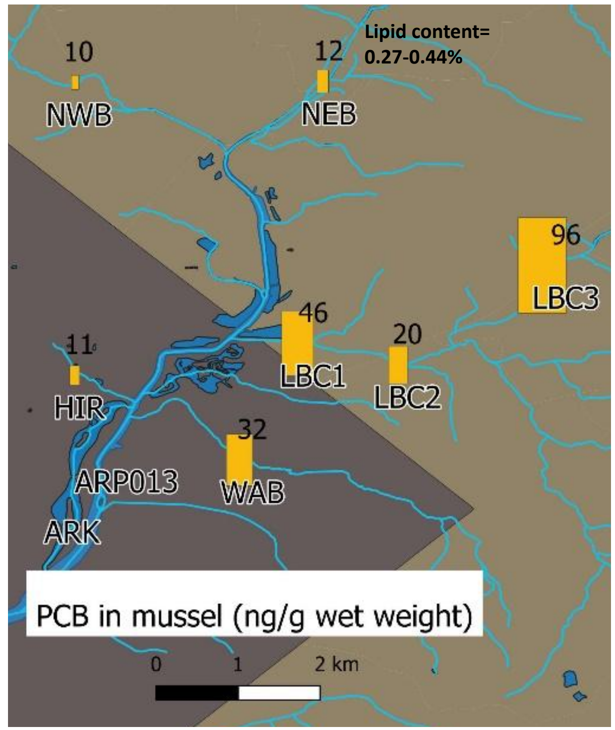
Passive sampler LDPE 2 mil

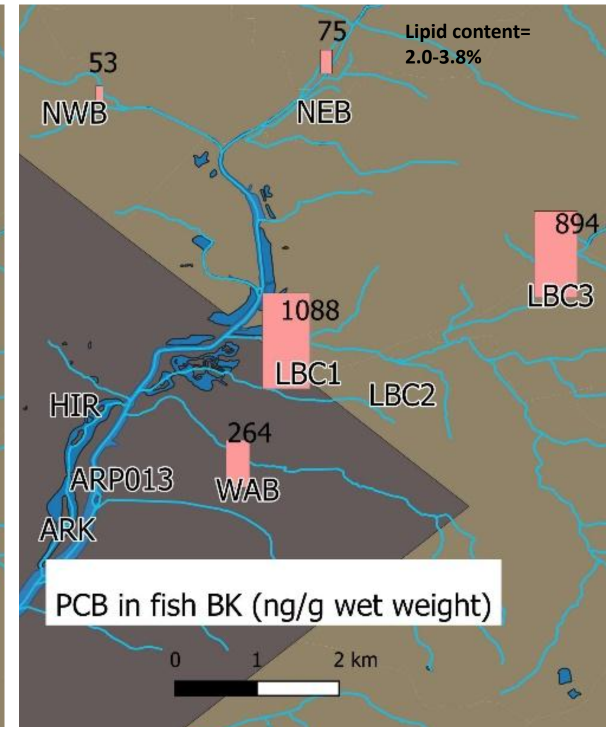
Mussel Eastern elliptio EE



Fish Banded killifish BK*





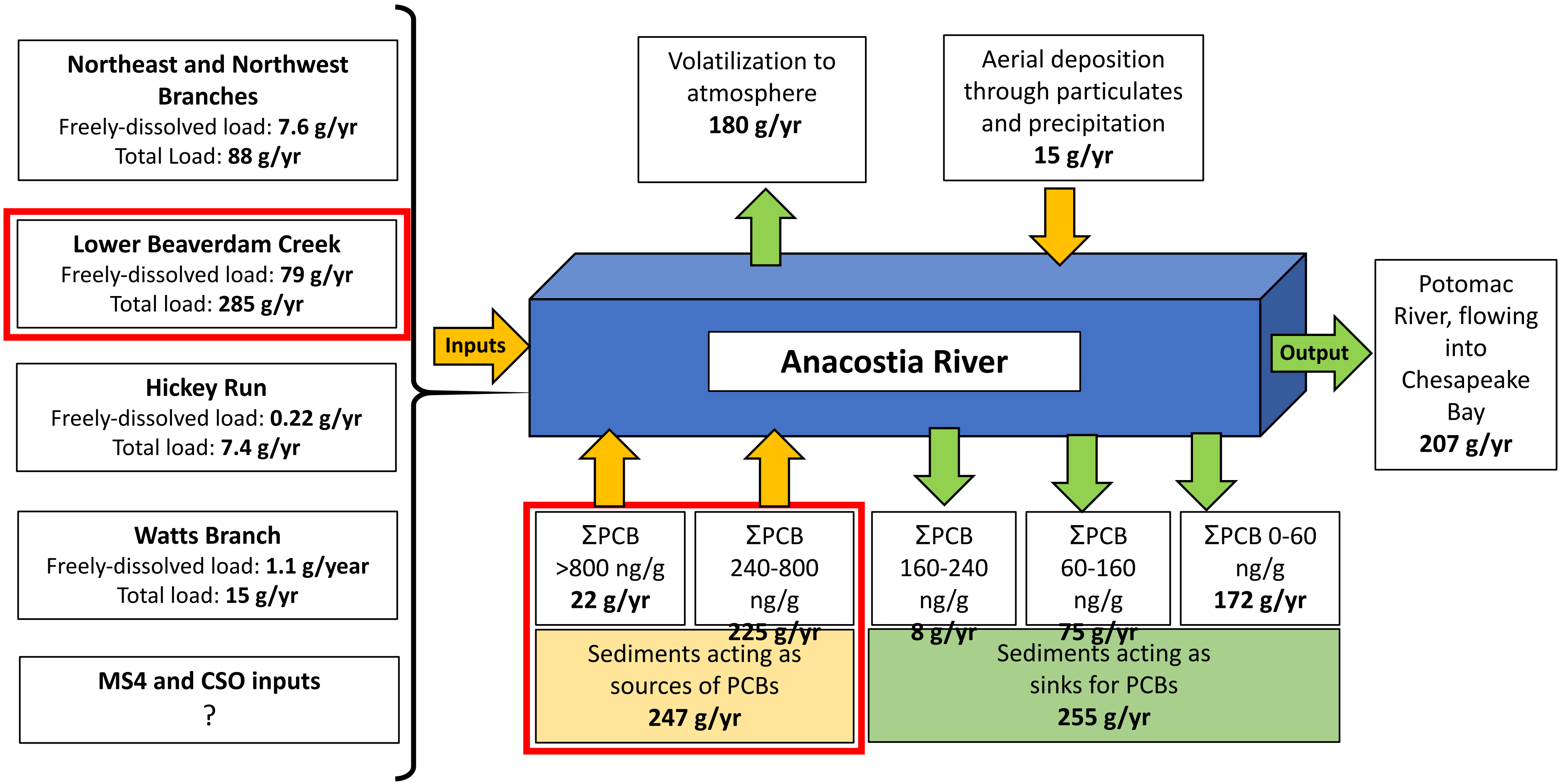


→ Passive sampler measurements match uptake in mussel and fish

Lombard, N. et al. Codeployment of Passive Samplers and Mussels Reveals Major Source of Ongoing PCB Inputs to the Anacostia River in Washington, DC. Environmental Science & Technology 57 (3), 1320-1331. 2023

* Pinkney A. & Perry E. 2020. Polychlorinated biphenyls and Organochlorine pesticide concentrations in Whole Body Mummichog and Banded Killifish from Anacostia River watershed. Report prepared for Government of the District of Columbia, DOEE

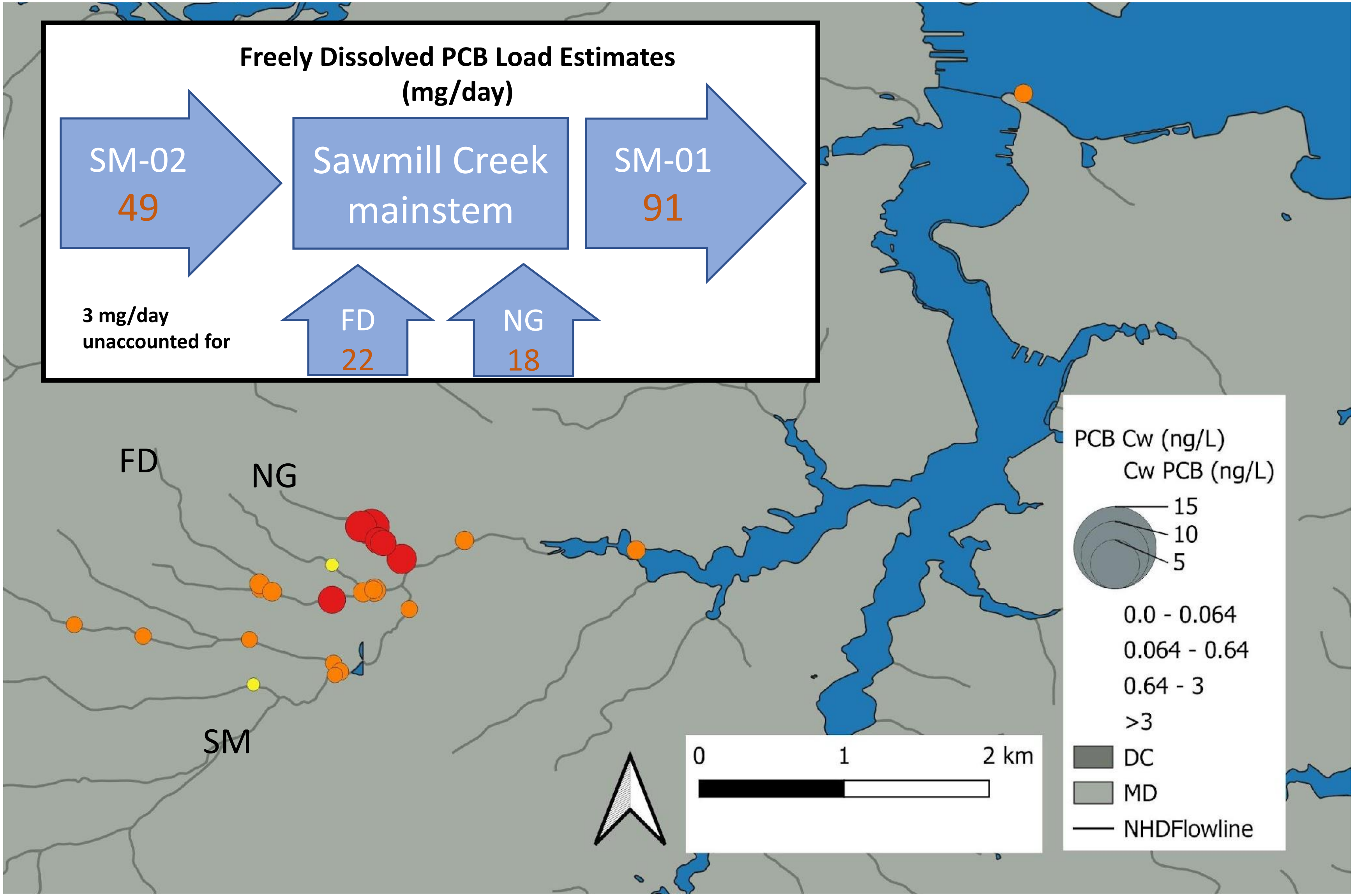
PCB mass balance of Anacostia River



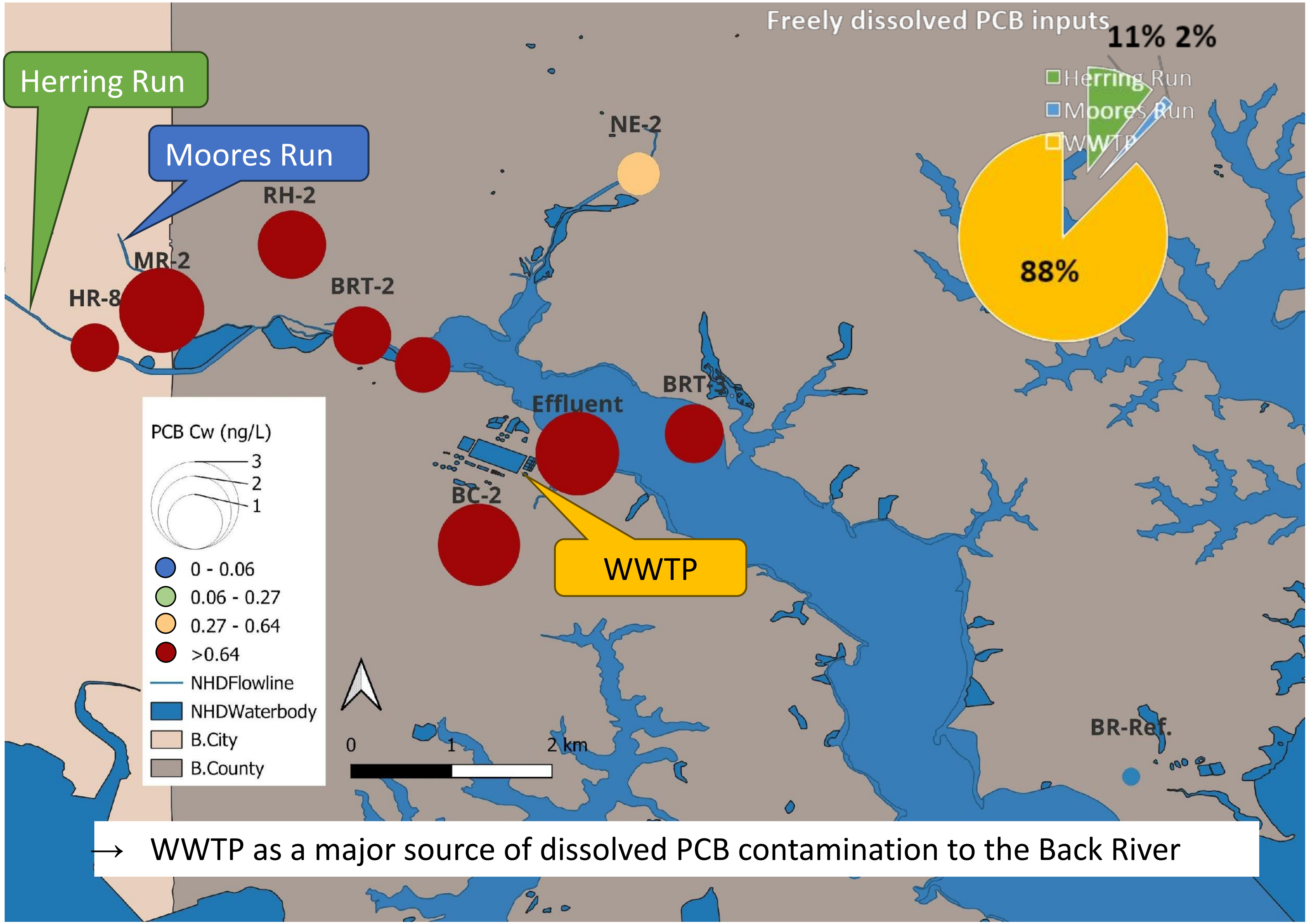
Ghosh, U., Lombard, N., Bokare, M., Pinkney, A. E., Yonkos, L., & Harrison, R. (2020). *Passive samplers and mussel deployment, monitoring, and sampling for organic constituents in Anacostia River tributaries: Final Report 2016-2018.* **https://bit.ly/3jGETAm**. Submitted to Dev Murali, DC Department of Energy and Environment (DOEE).

Ghosh U., Lombard N., Cheung L., Ghosh O. (2025). *Anacostia River Monitoring with Passive Samplers and Mussels to Refine Site Conceptual Model and defines Baseline Conditions : Report Year 2 (Final).* Submitted to Dev Murali, DC Department of Energy and Environment (DOEE).

PCB concentration in water column of Sawmill Creek

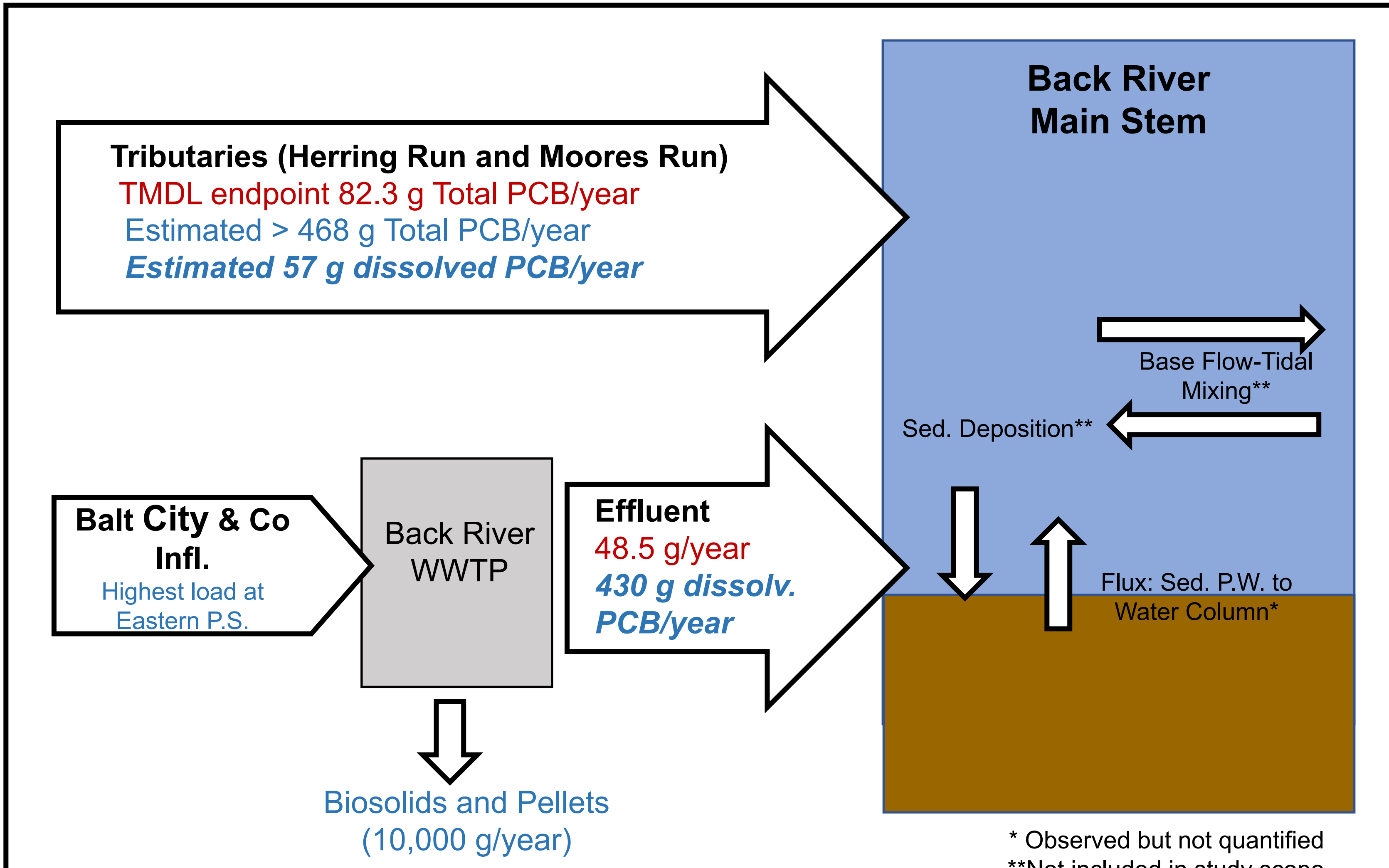


PCB concentration in water column of Back River 2018/19



→ WWTP as a major source of dissolved PCB contamination to the Back River

WWTP remains a major source of PCBs to Back River



Adapted from Majcher et al., 2022

Majcher, E., Ghosh, U., Needham, T., Lombard, N., Foss, E., Bokare, M., Joshee, S., Cheung, L., Damond, J., and Lorah, M., 2022, Refining sources of polychlorinated biphenyls in the Back River watershed, Baltimore, Maryland, 2018–2020: U.S. Geological Survey Scientific Investigations Report 2022–5012, 58 p., https://doi.org/10.3133/sir20225012.

OVERALL CONCLUSIONS

- Fish in many locations exceed thresholds for safe consumption
- Urban areas with industrial footprint correlated to elevated PCBs
- Although banned 5 decades ago, PCBs continue to be released from contaminated land sites and sewer pipes
- Freely dissolved concentrations critical in defining exposure
- PCB mass balances in rivers help identify key sources that need to be controlled
- Combine monitoring with fate modeling to refine conceptual models and guide effective interventions

Acknowledgments and contacts

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Disclosure statements:

- I serve as an expert witness in PCB litigation
- I am a co-inventor of two patents related to the technology described for which I am entitled to receive royalties. One invention was issued to Stanford University (US Patent # 7,101,115 B2), and the other to the University of Maryland Baltimore County (UMBC) (U.S. Patent No. 7,824,129). In addition, I am a partner in a startup company (Sediment Solutions) that has licensed the technology from Stanford and UMBC and is transitioning the technology in the field.