

Results of EPA's Assessment of Fish Tissue from U.S. Rivers for Mercury and Persistent Organic Compounds with Implications for Aquatic Life and Human Health

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National Rivers and Streams Assessment



Fish Tissue Indicator

Mercury data- (n=541/542)

sites: 162 Urban sites

379 Non-urban

Legacy organic
contaminant data-
(n=540/542):

163 Urban sites

377 Non-urban

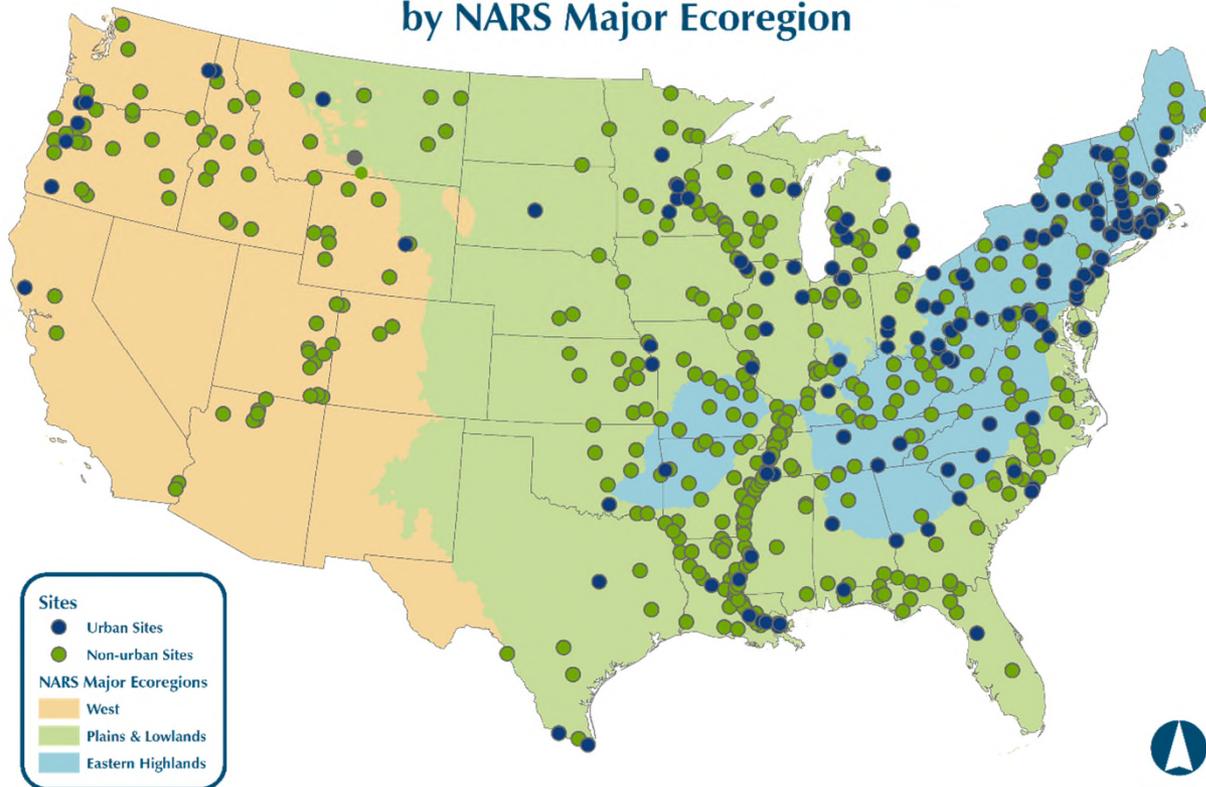


National Rivers and Streams Assessment

- Out of 1,924 sites on rivers within the conterminous United States- 542 sampled that are 5th order or greater in size
- Randomized site selection process yields nationally-representative weighted results
- Analyses are of sites where fish samples were collected and fillets analyzed (sampled population) which represent approximately 51,663 river miles.



National Rivers and Streams Assessment Urban and Non-urban Sampling Locations by NARS Major Ecoregion



NRSA Sampling Locations $n = 542$



Sample Collection

- Sampling conducted 2008-2009
- A single composite sample consisting of five adult fish of the same species and similar size (min > 75% max) of fish was collected from each site.
- Target species: ubiquitous, abundant, easily identified, consumed by humans, large.
- Fillets were composited using the batch method.



NRSA Analyses

541 sites: Mercury

Direct Mercury Analyzer EPA method 7473
(Journal article in preparation)

Organic Analytes for 540 Sites

21 PCB Congeners
PCB 8-209

8 PBDE Congeners:
BDE 47, 66, 99, 100,
138, 153, 154, 183

Method: GC-ECD

(Journal article in preparation)

20 Organochlorine
pesticides

Aldrin

alpha-BHC

gamma-BHC

alpha-Chlordane

gamma-Chlordane

2,4'-DDD

4,4'-DDD

4,4'-DDE

2,4'-DDT

4,4'-DDT

Dieldrin

Endosulfan II

Endrin

Heptachlor

Heptachlor epoxide

Hexachlorobenzene

Mirex

cis-Nonachlor

trans-Nonachlor 7

Oxychlordane



Additional Fish Tissue Analytes not reported here

541 Sites:

Selenium: ICP-OES

Moisture: Karl Fisher titration

Lipids: Gravimetric method

163 urban sites:

**13 PFCs (HPLC-MS/MS)
Poster here now
(Journal article in preparation)**

**4 synthetic musks and two of their metabolites
(Presented SETAC 2011)**



Data are Nationally Representative

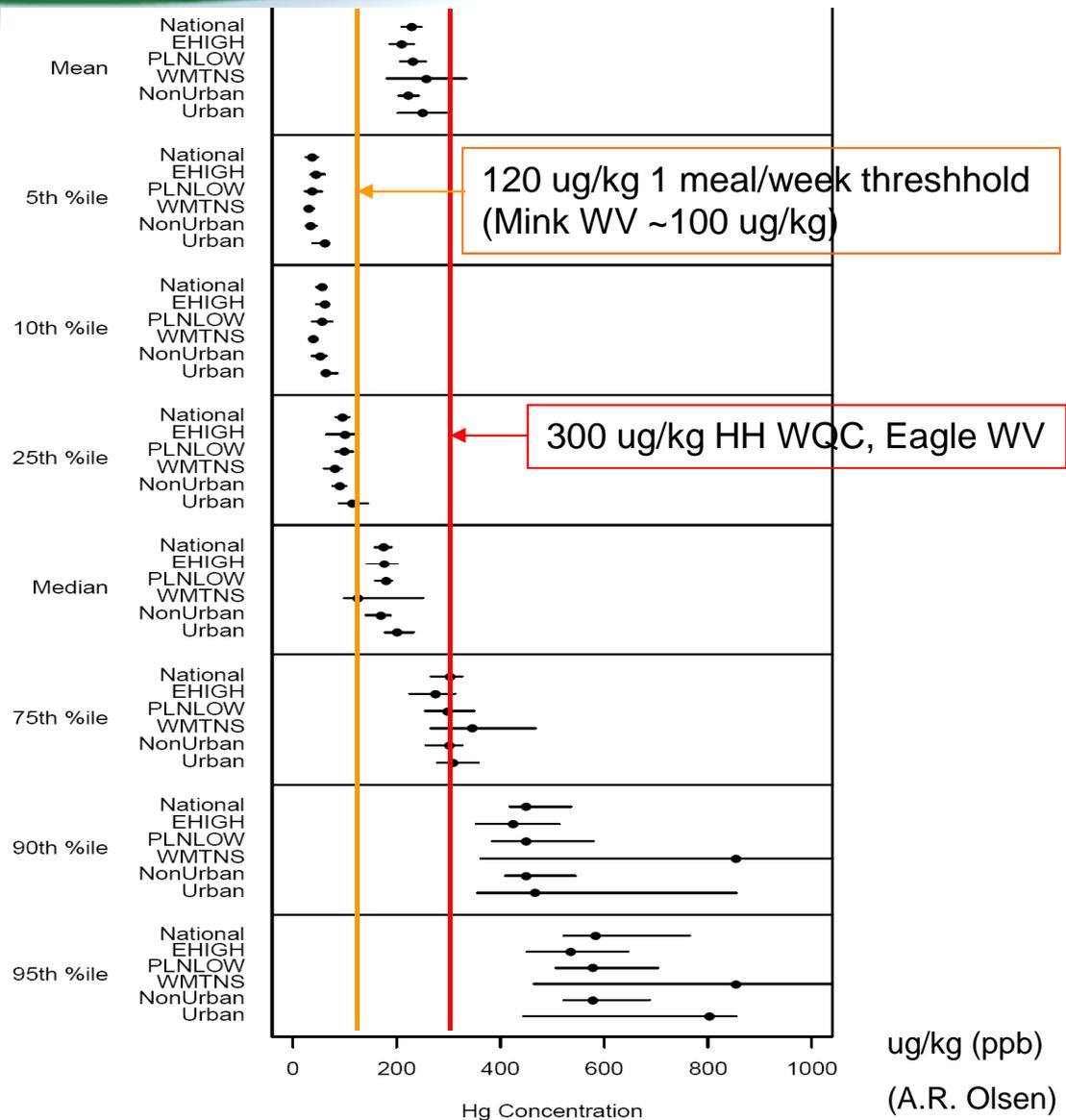
- Reporting today on
 - 50 analytes x 540 sites = 27,000 data points
- Weighted data and means are nationally-representative and representative by:
 - Ecoregion (3); and
 - Urban and Non-urban sub-populations
- Mercury fillet tissue results converted to whole fish values for wildlife impact estimation
- Some unweighted site data depictions and analyses are not nationally representative



Hg Statistics

Statistic *(Hg ww ug/kg)	National <i>n</i> =541	Non- Urban <i>n</i> =379	Urban <i>n</i> =162	EHIGH <i>n</i> =190	PLNLOW <i>n</i> =280	WMTS <i>n</i> =71
River Miles	51,663	40,752	10,911	14,738	29,739	7,186
River km	83,145	40,752	17,559	23,718	47,861	11,564
50th % ile*	175.6	170.5	200.6	176.0	180.1	125.3
95th % ile*	583.6	578.8	803.3	535.2	578.8	854.1
Mean*	228.9	223.3	250.2	210.0	231.4	257.5
Max. *	1,419	1,419	854	854	1,419	1,272

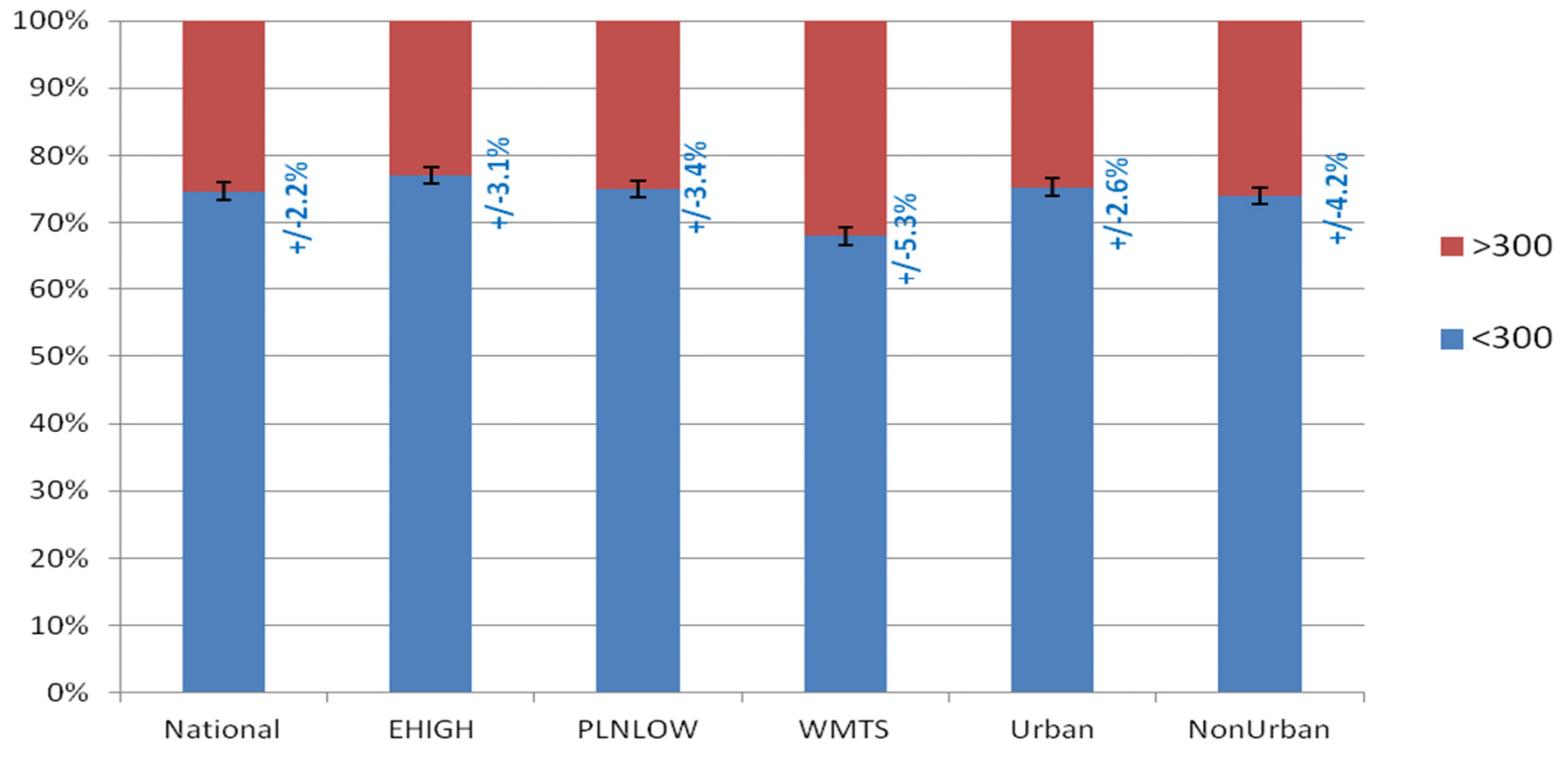
Hg Percentile Data by subgroup





Hg subpopulations

Percentages of Samples in Subgroups <300 ug/kg and >300 ug/kg Hg
Standard error bars indicated





Mercury (Hg) Results

- All (100%) of the 541 fish fillet samples analyzed for Hg content >3.33 ug/kg (ppb) quantitation limit for the method.
- Weighted values for 137/541 samples (25.4%) exceeded the EPA HHWQC for Hg of 300 ug/kg, = 13,071 river miles (21,154 km)/ 51,663 miles (83,143 km) of sampled U.S. rivers (compare with 48.9% of lakes in NFLTS).
- Risk to piscivorous avian species (eagle) are similar to risks for humans at 300 ug/kg (@two meals per month level), whereas mink are more at risk than the avian species (and humans) @ the HH 1 meal per week (fillet) threshold of 120 ug/kg.
- No statistically-significant differences between non-urban/urban sites and among eco regions (EHIGH, PLNLOW, WMTS).
- Apparent higher 95th %ile, mean, and % of sites exceeding HHWQC in WMTS likely attributable to natural localized Hg source (geothermal area/Hg mining history).



Focus of organics analysis is on PCBs, PBDEs, Chlordane, and DDT, Dieldrin

PCBs

National Data

- Detected 505/540 sites = 93.5%
- National Mean = 32.7 ug/kg
- %>Screening Value (12ug/kg) = 48.0%

Non Urban Sites (n=377)

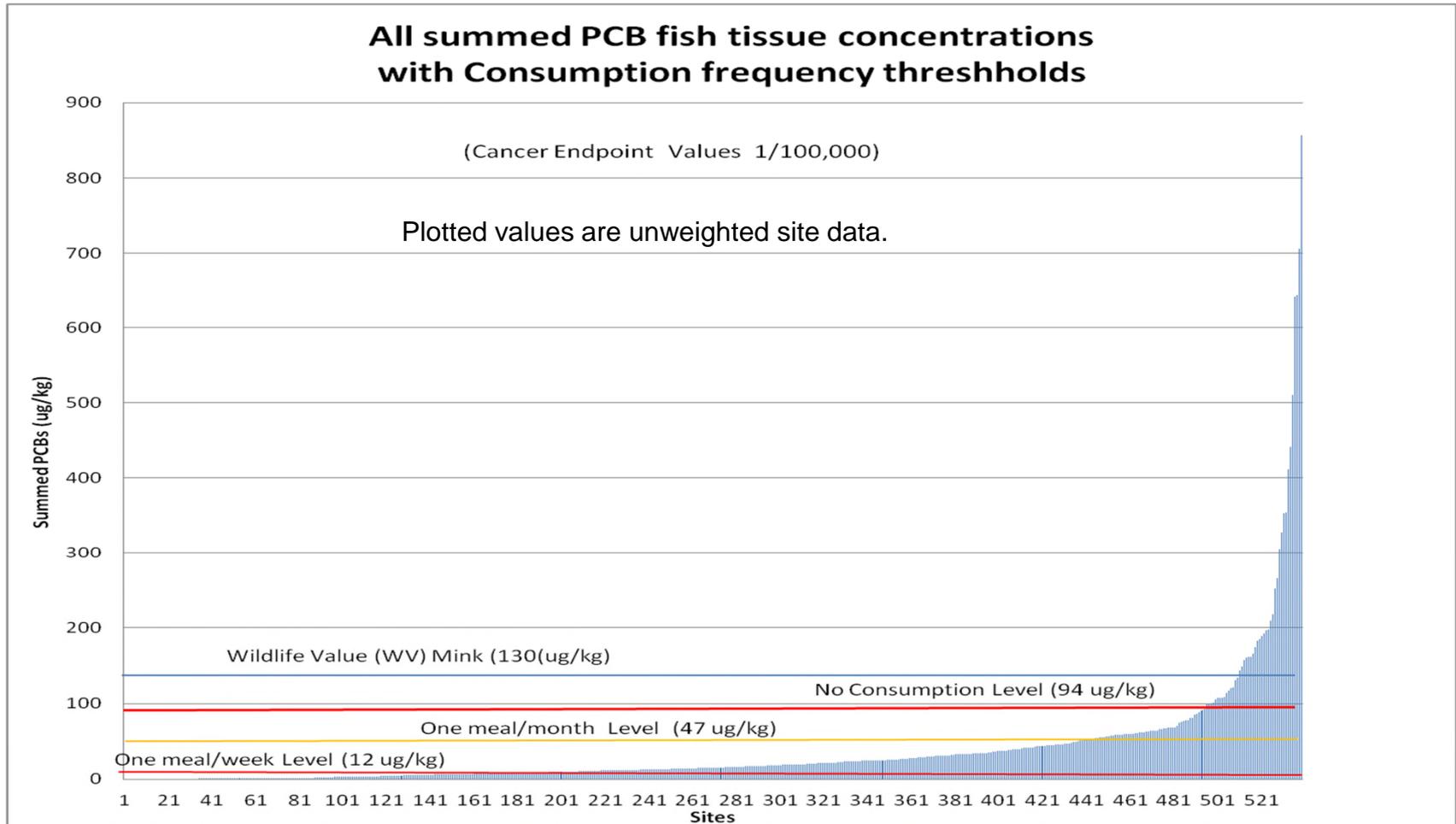
- Detects Non-urban = 343
- Max Non-urban = 411.5 ug/kg=ppb
- Mean Non-urban = 26.9 ug/kg
- %>Screening value= 42.0%

Urban Sites (n=163)

- Detects Urban = 162
- Max Urban = 856.5 ug/kg
- Mean Urban = 54.2 ug/kg
- %>Screening value= 69.8%



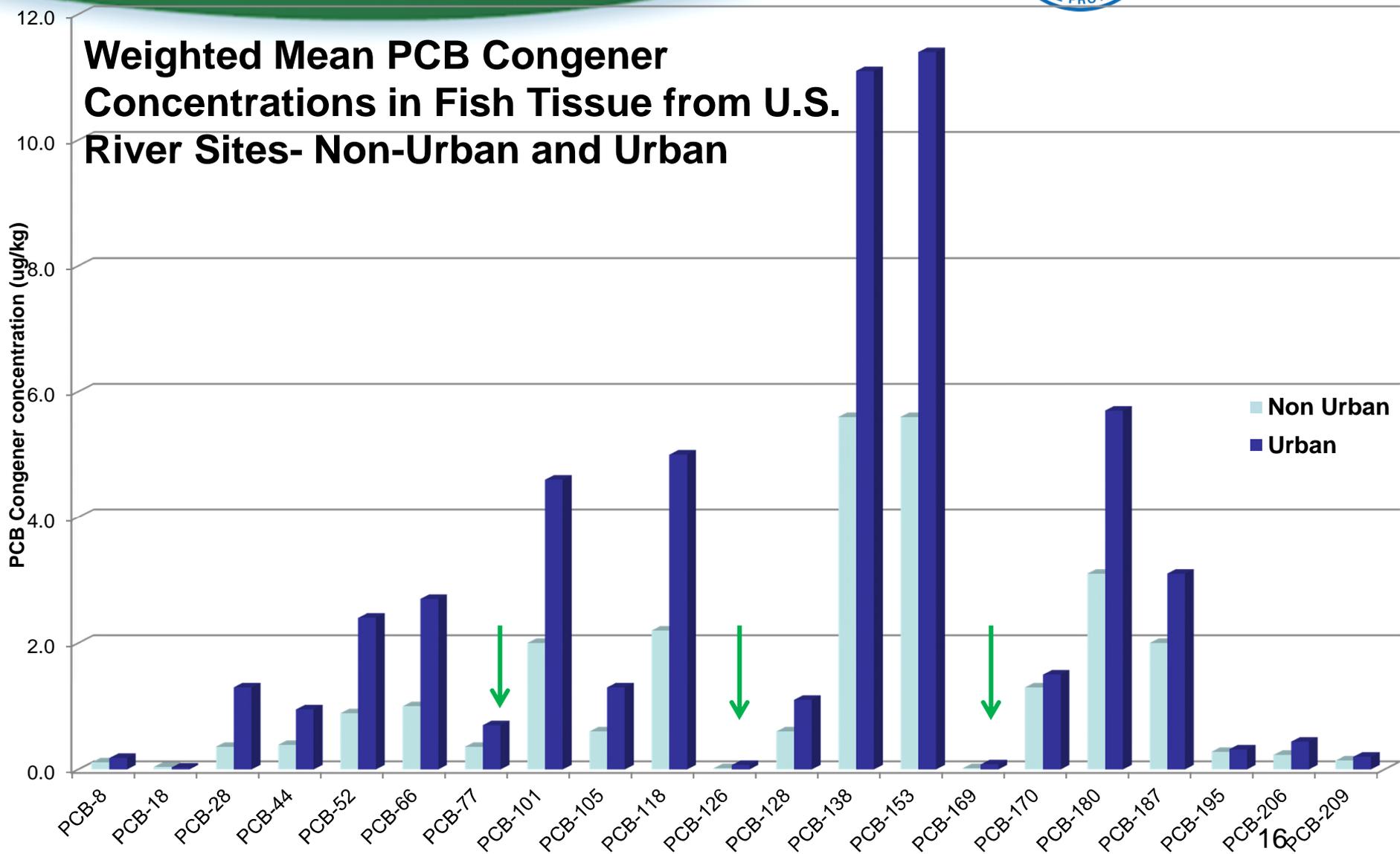
Summed PCBs (21 of 209 congeners) in Fish Tissue Samples



Note: Unweighted site data



Weighted Mean PCB Congener Concentrations in Fish Tissue from U.S. River Sites- Non-Urban and Urban





PBDEs

National Data

- Detected 497/540 sites = 92.0%
- National Mean = 11.6 ug/kg
- 1 Urban Site exceeded 210 ug/kg SV

Non Urban Waters (n=377)

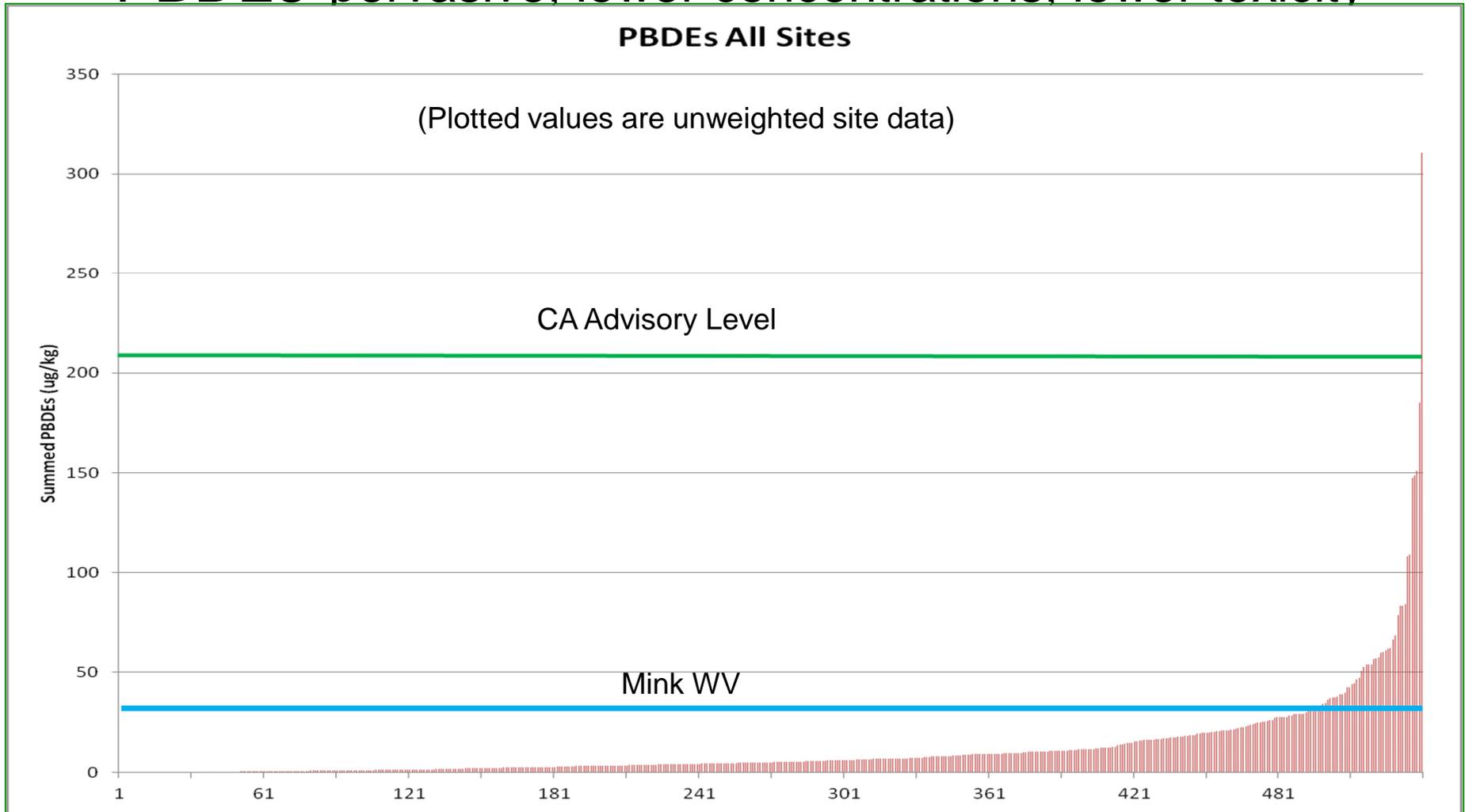
- Detects Non-urban = 340
- Max Non-urban = 151.1 ug/kg=ppb
- Mean Non-urban = 8.6 ug/kg

Urban Waters (n=163)

- Detects Urban = 157
- Max Urban = 310.7 ug/kg
- Mean Urban = 22.5 ug/kg

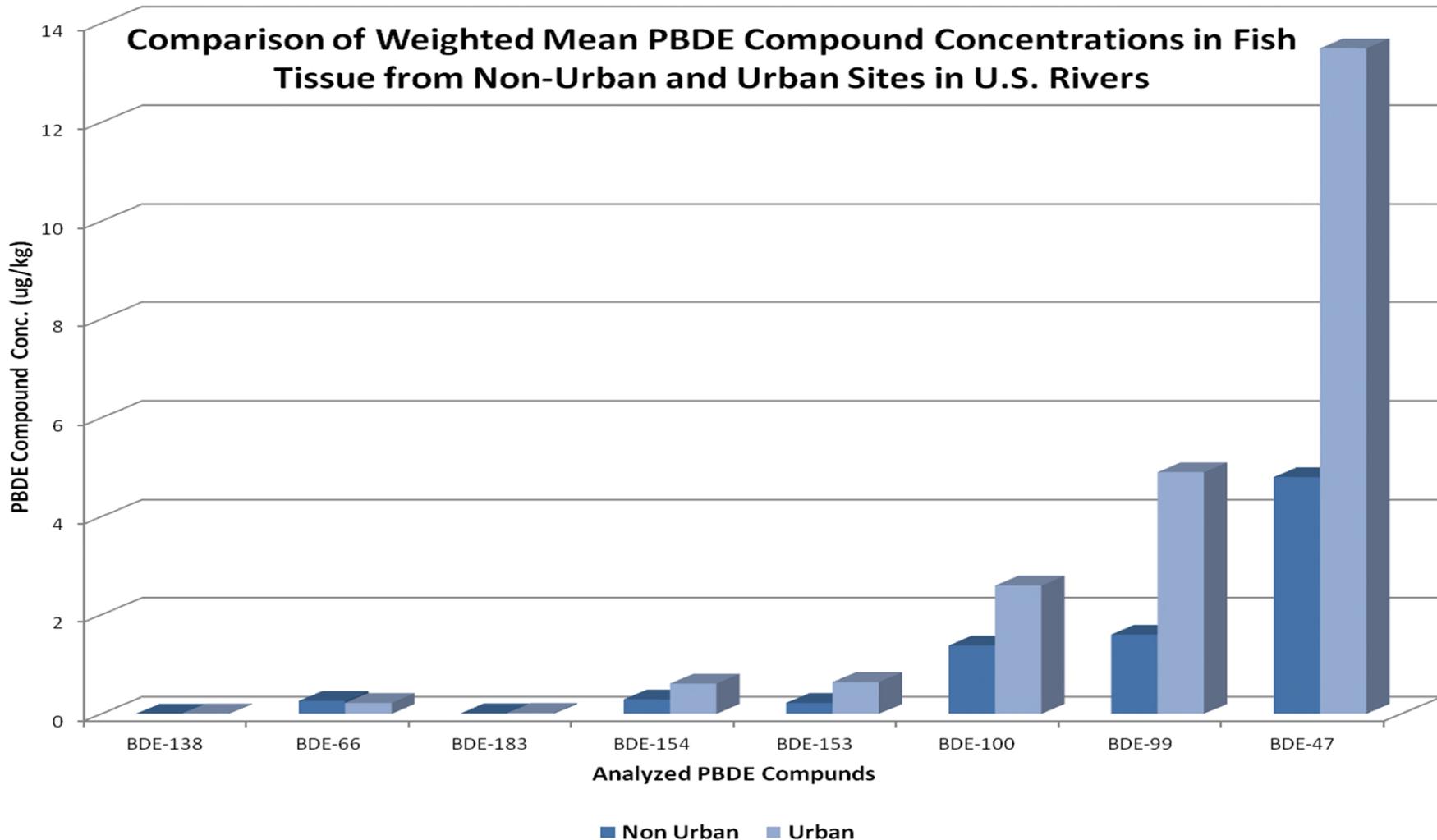


PBDEs-pervasive, lower concentrations, lower toxicity





Comparison of Weighted Mean PBDE Compound Concentrations in Fish Tissue from Non-Urban and Urban Sites in U.S. Rivers





Total Chlordane and Summed DDT(s)

Total Chlordane

Detected 481/540 locations = 88.5%

National Mean = 6.3 ug/kg

Non Urban Waters (n=377)

- Detects Non-urban = 325
- Max Non-urban = 87.1 ug/kg
- Mean Non-urban = 5.1 ug/kg

Urban Waters (n=163)

- Detects Urban = 153
- Max Urban = 311.4 ug/kg
- Mean Urban = 10.8 ug/kg

Summed DDT

Detected 533/540 locations = **98.7%**

National Mean = 13.8 ug/kg

Non Urban Waters (n=377)

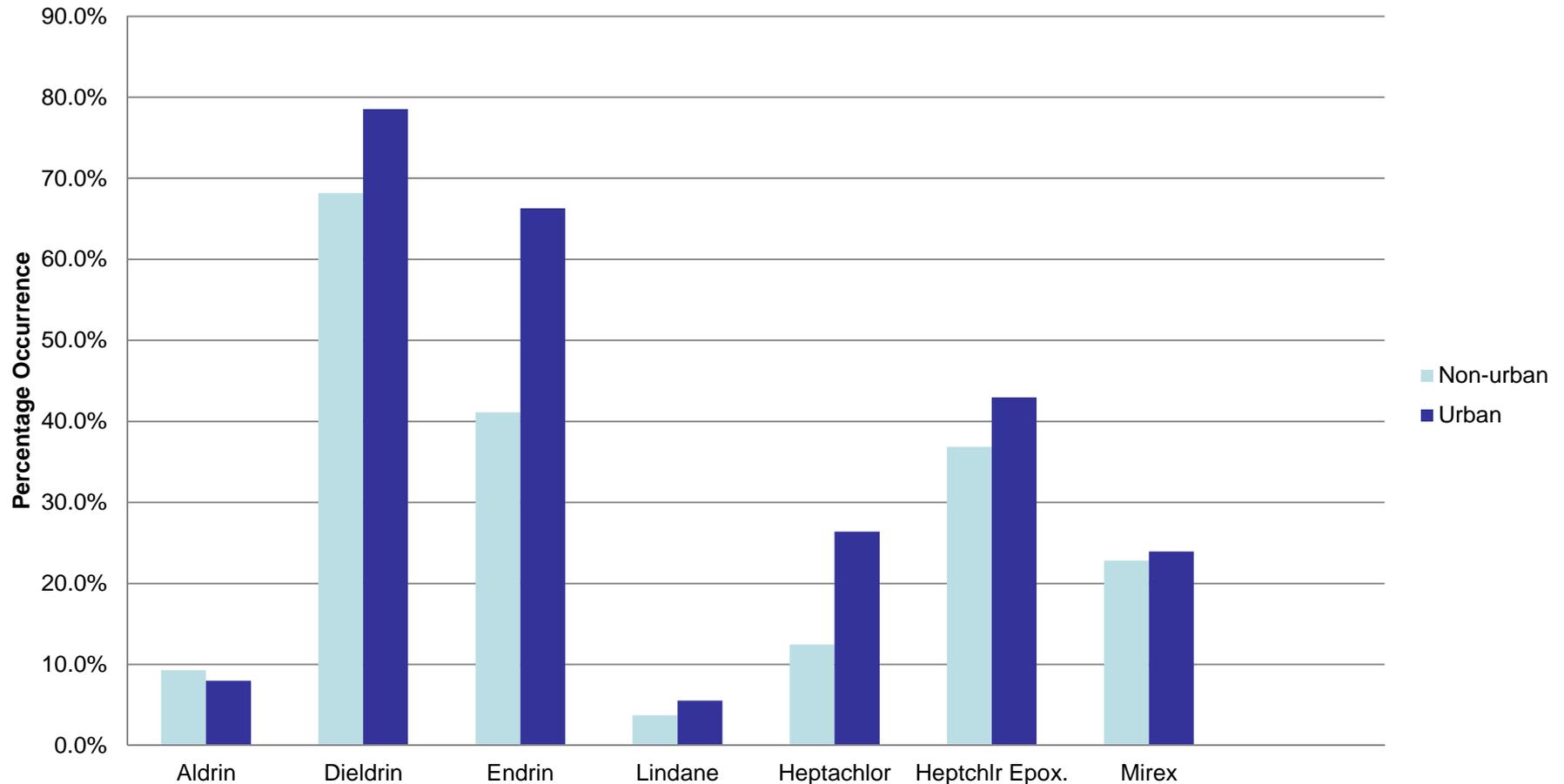
- Detects Non-urban = 370
- Max Non-urban = 170.3 ug/kg
- Mean Non-urban = 12.3 ug/kg

Urban Waters (n=163)

- Detects Urban = 163
- Max Urban = 294.3 ug/kg
- Mean Urban = 19.0 ug/kg



Percentage Detections of Other Organic Pesticide Compounds in Fish Tissue Samples from Non-Urban and Urban Sites





Human health screening values (SVs)- I meal/week

<u>Compound*</u>	<u>Non-cancer SV</u>	<u>Cancer SV</u>
Chlordane (total)	1200	67
Dieldrin	120	1.5
DDT (summed)	120	69
PCBs (summed)	47	12
PBDEs (summed)	210 [@]	NA

(*ug/kg wet weight)

- U.S. EPA (2000) Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories; Volume 2 Risk Assessment and Fish Consumption Limits; Third Edition EPA 823-B-00-008 Office of Water, Washington DC

[@]California sport fish advisory level



Wildlife risk values (WVs)

<u>Compound*</u>	<u>Mink WV</u>	<u>Kingfisher WV</u>
Chlordane	830	4.5
Dieldrin	20	360
DDT (total)	360	155
PCBs (total)	130	440
PBDEs@	32	13 (Kestrel)

(*ug/kg wet weight)

**Lazorchak, J.M.et al. 2003. CONTAMINATION OF FISH IN STREAMS OF THE MID-ATLANTIC REGION: AN APPROACH TO REGIONAL INDICATOR SELECTION AND WILDLIFE ASSESSMENT. Environ Tox Chem. 22,3*

@Canadian Environmental Protection Act, 1999 Federal Environmental Quality Guidelines Feb. 2013



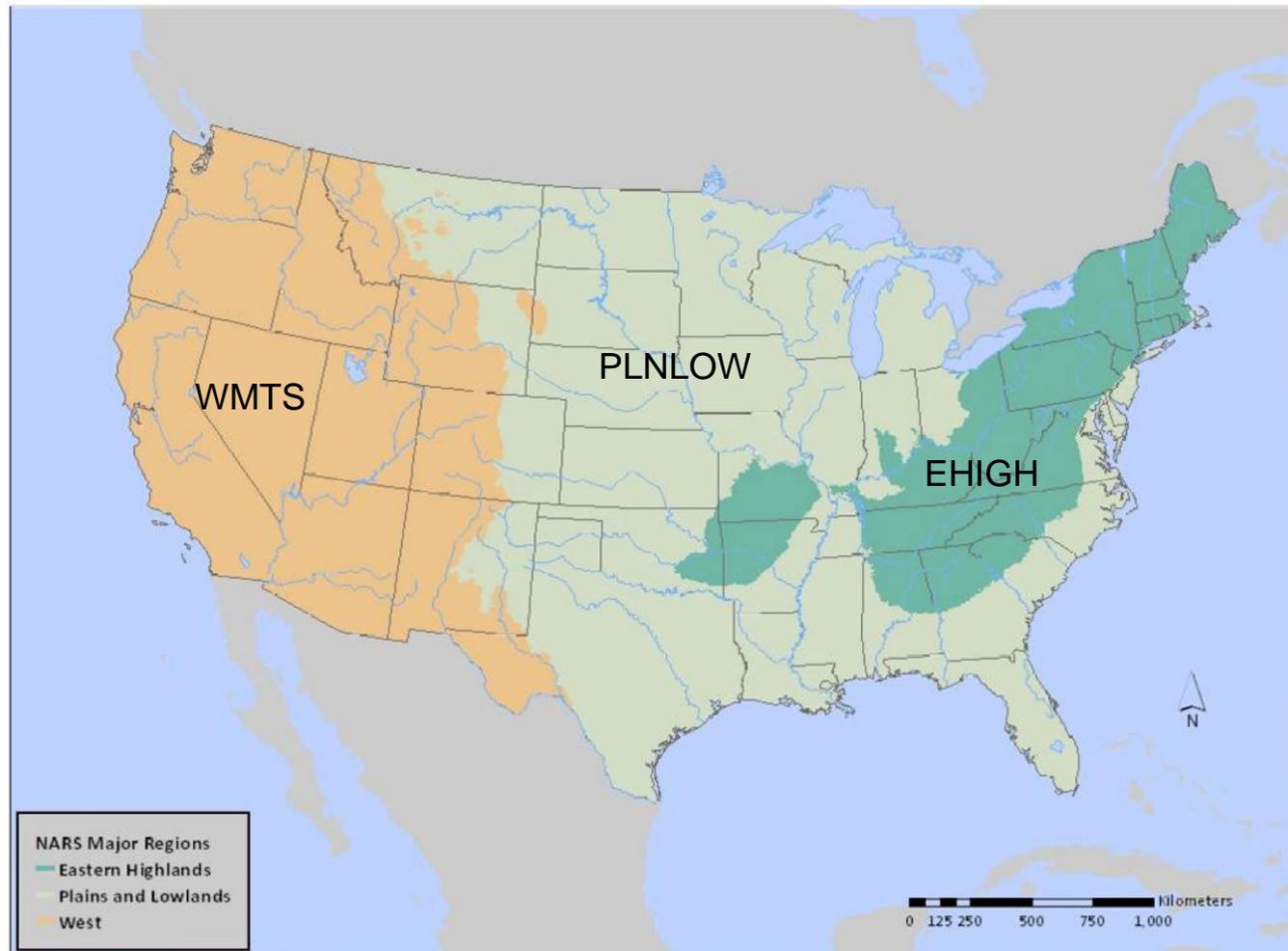
Time for some statistics: Weighted Data: Fish Tissue Concs. in Non-urban vs. Urban Sites

Compound Family	Mean Conc.(ug/kg)		Median Conc.(ug/kg)		St. Dev.(ug/kg)	
	<u>Non Urb.</u>	<u>Urban</u>	<u>Non Urb.</u>	<u>Urban</u>	<u>Non Urb.</u>	<u>Urban</u>
PCBs	26.9	54.2	8.6	23.8	51.7	120.6
PBDEs	8.6	22.5	3.6	8.0	14.3	42.8
Total Chlordane	5.1	10.8	1.6	2.7	10.3	35.4
DDTs	12.3	19.0	5.7	9.5	19.3	30.9
Dieldrin	2.6	3.8	0.4	1.0	7.1	12.3

Bold = greater in non-urban vs urban comparison



NARS Major Ecoregions





Significance of Differences Between Subgroups

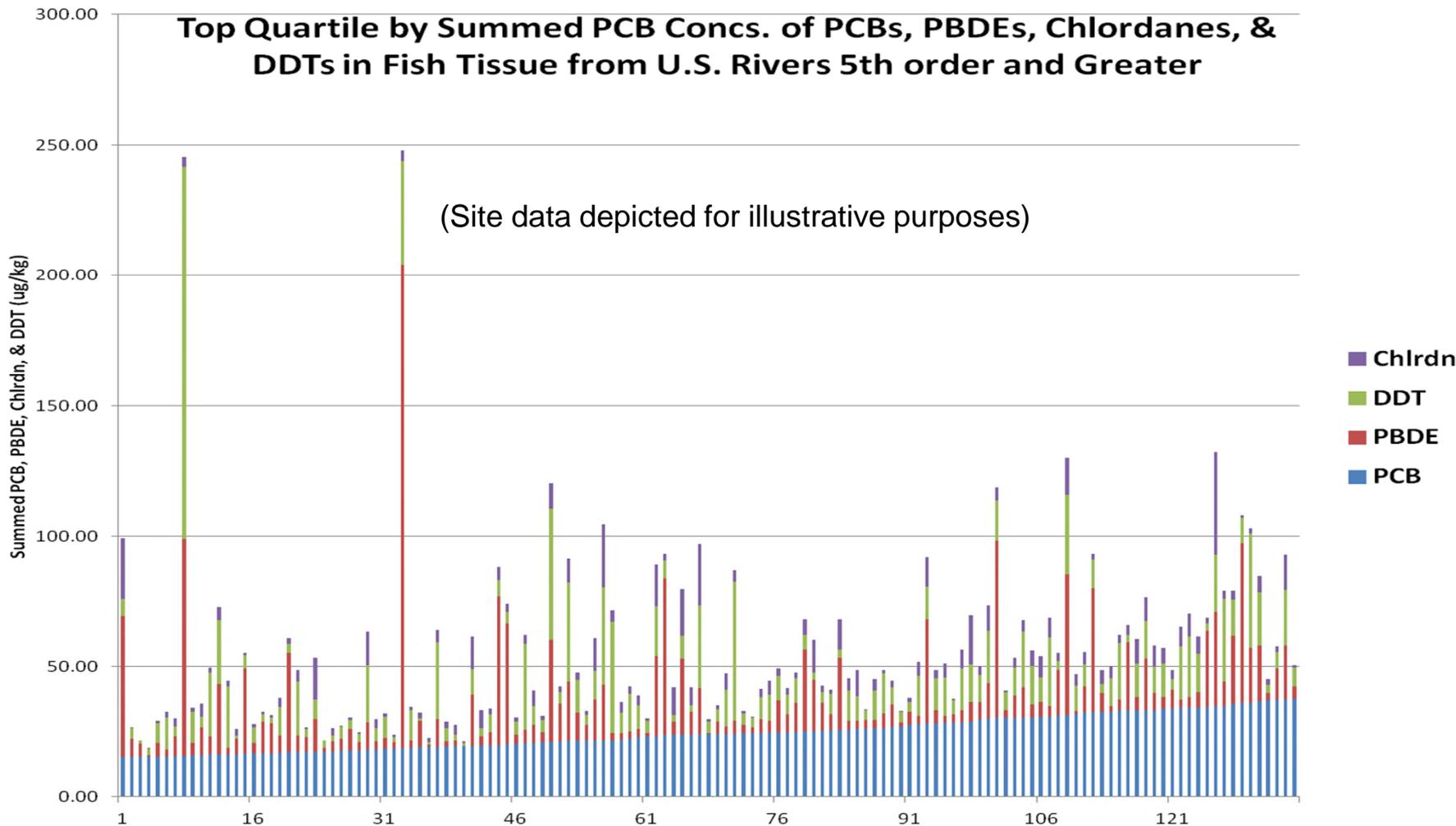
Compound Family	Non-urban/Urban		EHIGH/ PLNLOW		EHIGH/ WMTS		PLNLOW/ WMTS	
	<u>Greater mean</u>	<u>P value</u>						
PCBs Urb. EHIG	Urban	<u>0.006</u>	EHIGH	<u>0.032</u>	EHIGH	<u><0.001</u>	PLN LOW	<u>0.0015</u>
PBDEs No E-R diff.	Urban	<u><0.001</u>	EHIGH	0.1	Same	None	WMTS	0.365
Chlordanes less WMTS	Urban	0.107	PLN LOW	0.2	EHIGH	<u><0.001</u>	PLN LOW	<u><0.001</u>
DDTs Urb.PLNLOW	Urban	<u>0.017</u>	PLN LOW	<u><0.001</u>	WMTS	0.67	PLN LOW	0.7
Dieldrin less WMTS	Urban	0.36	PLN LOW	<u><0.001</u>	EHIGH	<u><0.001</u>	PLN LOW	<u><0.001</u>

Comparisons based on Z-Tests using calculated weighted means and standard errors



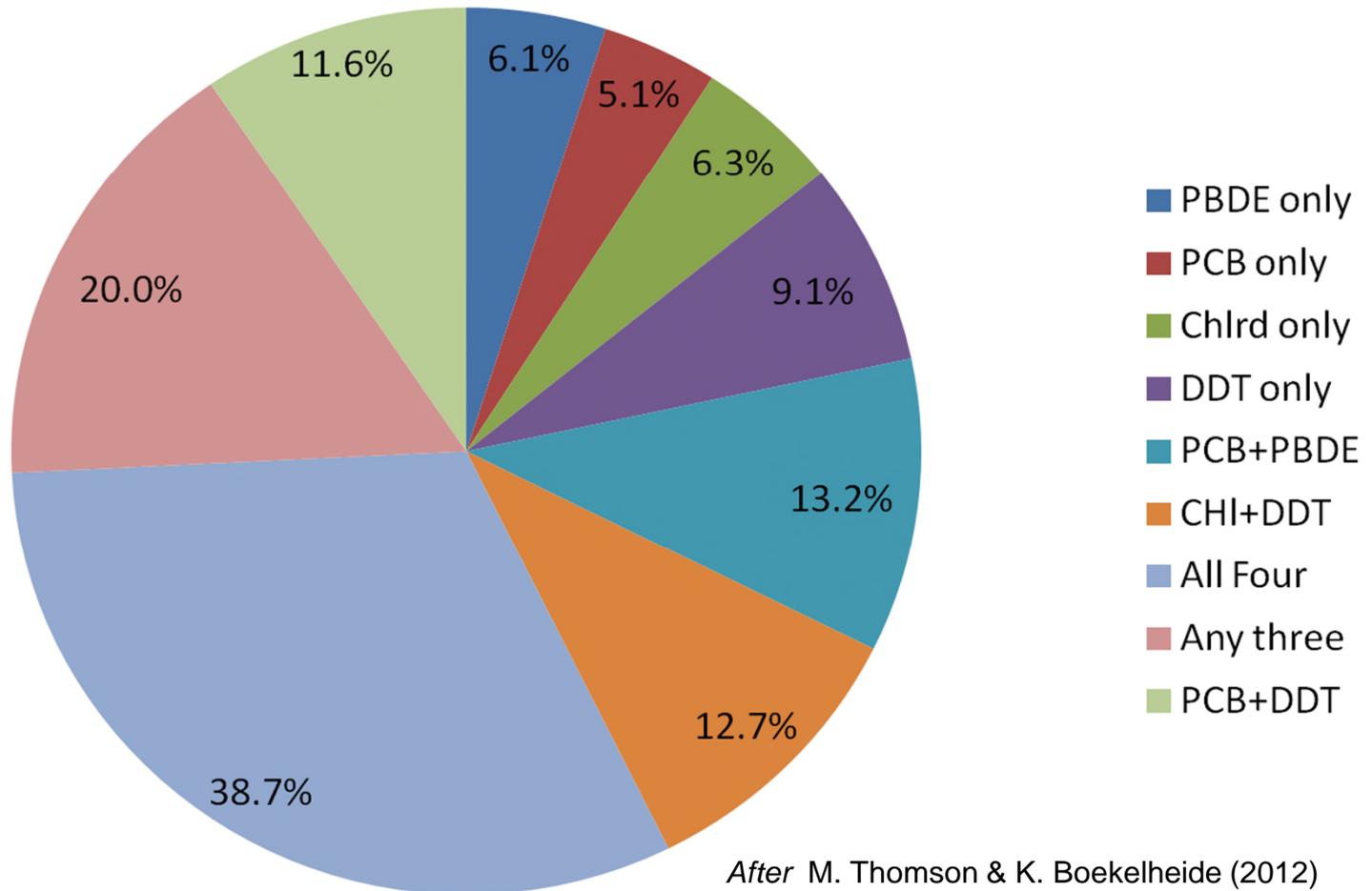
Top Quartile by Summed PCB Concs. of PCBs, PBDEs, Chlordanes, & DDTs in Fish Tissue from U.S. Rivers 5th order and Greater

(Site data depicted for illustrative purposes)





Co-occurrence of Total PCBs, PBDEs, Chlordanes, and DDTs in Fish Tissue at Concs. above Median Values



After M. Thomson & K. Boekelheide (2012)



Synthesis 1- National Organics Data

- Dieldrin, chlordane, DDT, PCBs and PBDEs are pervasive in fish tissue samples collected from U.S. rivers-detects in fish tissue average 88.8% of river miles.
- The extent to which these compounds exceed risk-based screening values varies (weighted national data):
 - **PCBs 48% of sites**
 - PBDEs 0.26% (1 Site)
 - Summed DDTs 2.3% of sites
 - Total Chlordane 0.56% of sites
 - **Dieldrin 31.2% of sites**
- Extent of effect depends on conc. and SV or WV



Organics Synthesis 2

- Unlike Hg concentrations, **PCBs, PBDEs, and DDT** compounds occur at concentrations that **are significantly higher in fish from urban sites** nationally than from non-urban sites.
- **PCBs concs. are highest in EHIGH**, significantly higher in the PLNLOW and EHIGH ecoregions than in the WMTS.
- There is no significant difference in PBDE concentrations in fish tissue among eco-regions*
- **DDT concentrations are significantly elevated in PLNLOW relative to EHIGH, but not to WMTS**(CA ag?)
- Chlordane concentrations in fish tissue are significantly higher in samples from the PLNLOW and EHIGH than WMTS. No difference between non-urban and urban sites.
 - *(Previous analysis of POTWs in urban locations –SETAC 2012)



Conclusions

- **Monitoring of fish tissue for assessment and for fish consumption advisories continues to be important for organic compounds as well as Hg**
- **Individual compounds seldom occur alone in fish tissue. Therefore, the presence and effects of any of these or other contaminants must be viewed in the context of co-occurring compounds**
- **Any new persistent organo-halogen compounds add to the existing overall organo-halogen burden in fish tissue potentially consumed by humans and wildlife.**

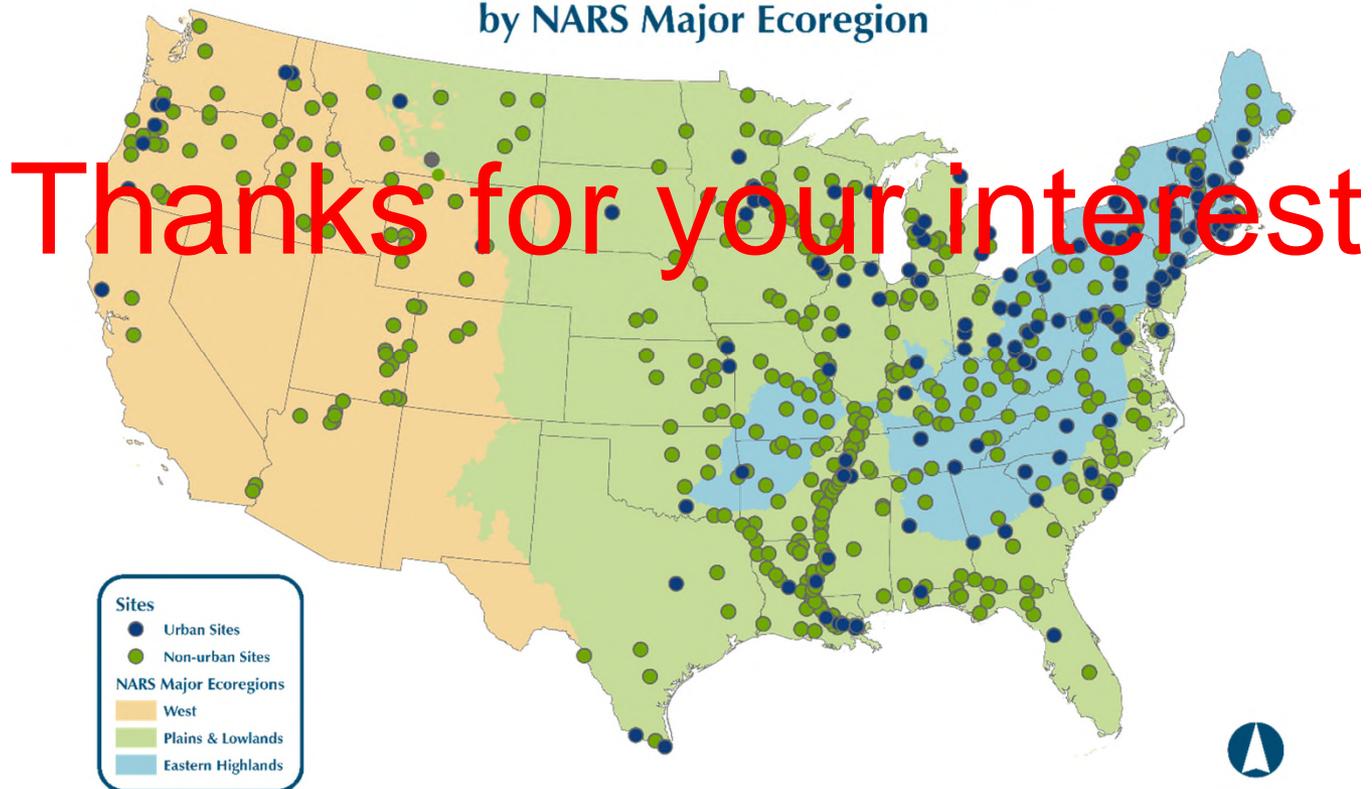


Acknowledgements

- This assessment was the product off the combined efforts of many:
 - Sampling was conducted by state, federal agency, and contractor crews
 - The NRSA is operated by our colleagues in the EPA Office of Wetlands, Oceans, and Watersheds, and
 - The EPA Office of Research and Development, Western Ecology Division, are responsible for the sample design and for derivation of nationally- representative descriptive statistics
 - Mission support from Tetra Tech, CSC, and other contractors



National Rivers and Streams Assessment Urban and Non-urban Sampling Locations by NARS Major Ecoregion



U.S. EPA Office of Water