

Effects of Endocrine Disrupting Compounds on Fish – What do we know and what don't we know?

MWRD Workshop on Microconstituents and Ecological Impacts
of Biosolids and Effluent Reuse

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Outline of talk

- Background on emerging chemicals of concern
- Federal framework for addressing emerging chemicals
- Collaborative studies
 - Distribution of Chemical Contaminants within a Large Wastewater Treatment Plant and in Downstream Surface Waters (**Calumet**)
 - Pharmaceuticals and Personal Care Products (PPCPs), Hormones, and Alkylphenol Ethoxylates (APEs) in the North Shore Channel of the Chicago River (**NSC**)
- Conclusions and next steps



An AP Investigation: Pharmaceuticals found in Drinking Water - Headlines

- Pharmaceuticals found in drinking water, affecting wildlife and maybe humans
- Pharmaceuticals found in drinking water of 24 major metro areas, 34 say no testing
- Fish, wildlife affected by drug contamination in water
- No standards to handle pharmaceuticals in water
- Tests of Philadelphia's drinking water reveal 56 drugs
- And many more...

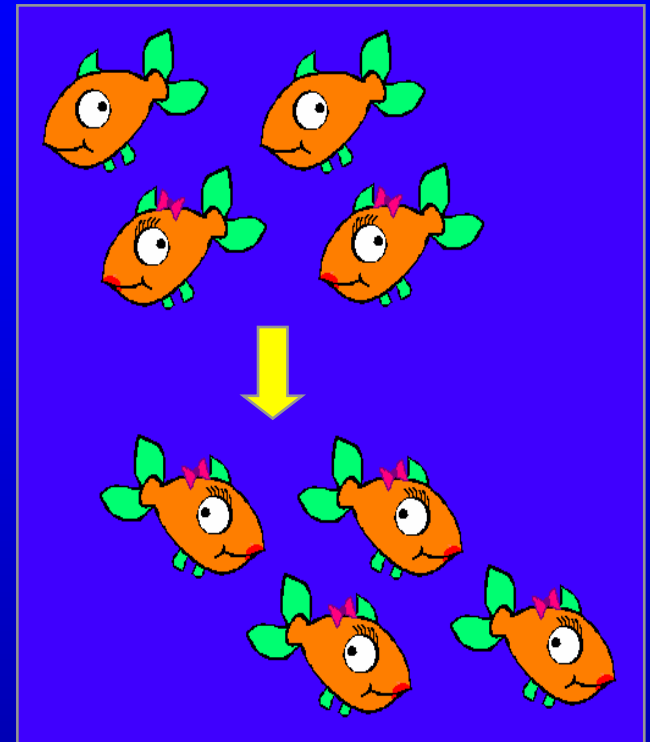
http://hosted.ap.org/specials/interactives/pharma_water_site/index.html





Why are PPCPs (including APEs) of concern?

- Produced and used in large volumes
- May be “pseudo-persistent”
 - ◆ Chronic exposure
- May have biological effects
 - ◆ Therapeutic design
 - ◆ Non-target organisms
- May be endocrine disruptors
 - ◆ alterations to sexual differentiation
 - Boulder Creek
 - Potomac River
 - ◆ reproduction and growth impairments
 - ◆ behavioral effects
- Little known about environmental persistence, fate





Federal framework - Research

- Interagency workgroups
 - Pharmaceuticals in the Environment (PiE)
 - Antimicrobial Resistance (AMR)
 - Endocrine Disrupting Chemicals (EDCs)
- Screening and Testing Programs
 - Bioassays and computational approaches
 - Move towards interpretation and reduction of uncertainty
 - Chemical classes / modes of action / mixtures
- Surveillance
 - Effluent, drinking water, effluent, fish, etc
- Wastewater treatment technologies



Federal framework – Voluntary and P2 efforts

- Great Lakes Binational Toxics Strategy (GLBTS)
- Design for the Environment (DfE)
 - Safer Detergents Stewardship Initiative (SDSI)
- High Production Volume (HPV) Chemical Program
- Chemicals Assessment & Management Program (ChAMP)
 - Security & Prosperity Partnership of North America
- Pharmaceuticals – safe disposal guidance



Federal framework - Regulatory

- Clean Water Act
 - Water quality criteria - human health and aquatic life
 - Effluent guidelines
 - Part 503 Biosolids Rule
- Safe Drinking Water Act
 - Contaminate Candidate List (CCL)
- Toxics Substances Control Act



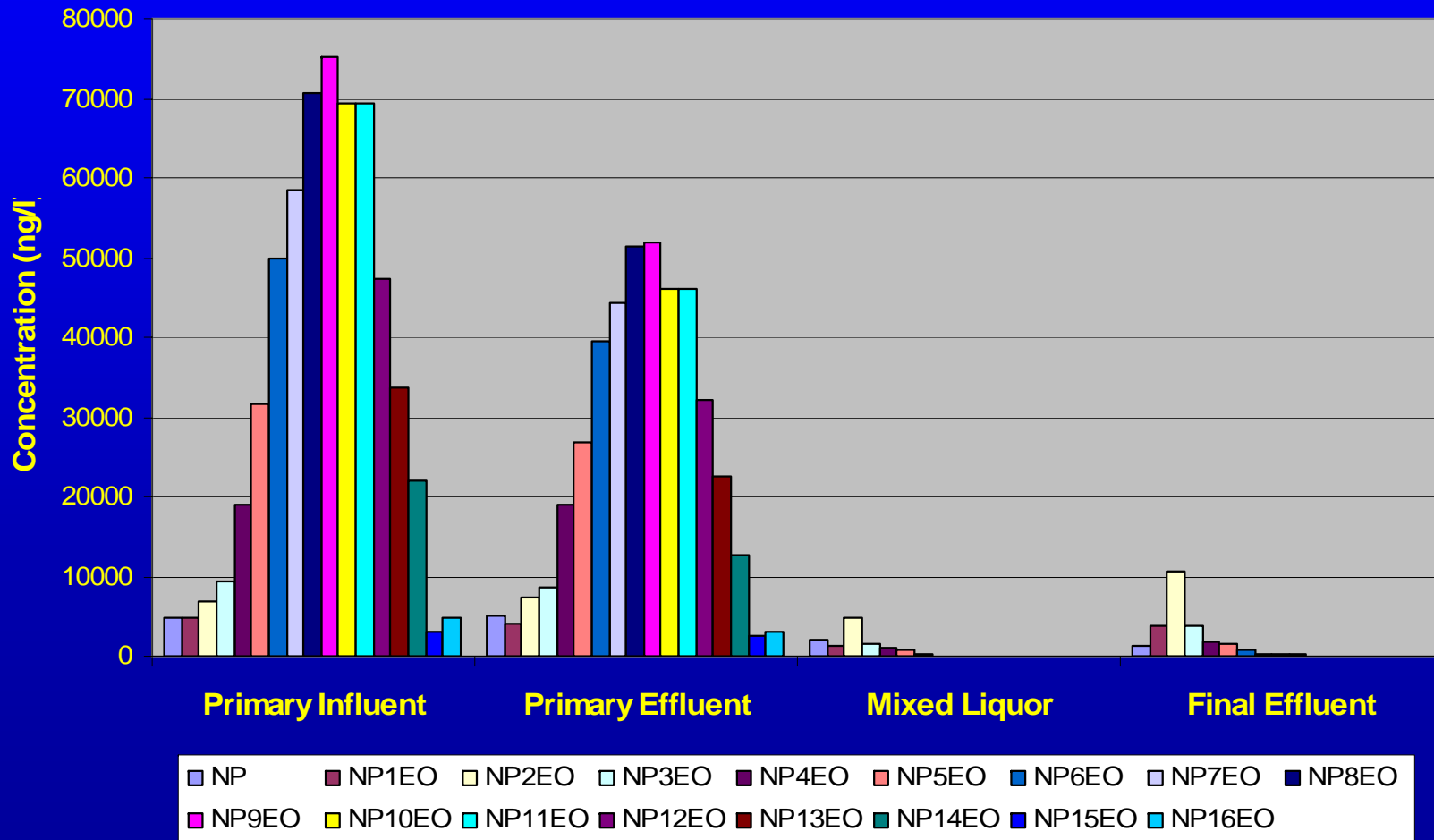
What do we know?

- Wastewater treatment plant can be effective at reducing many of these compounds
 - However, many of these compounds are still released into the environment in measurable amounts (biosolids and effluent)



NPEOs are reduced through the treatment process

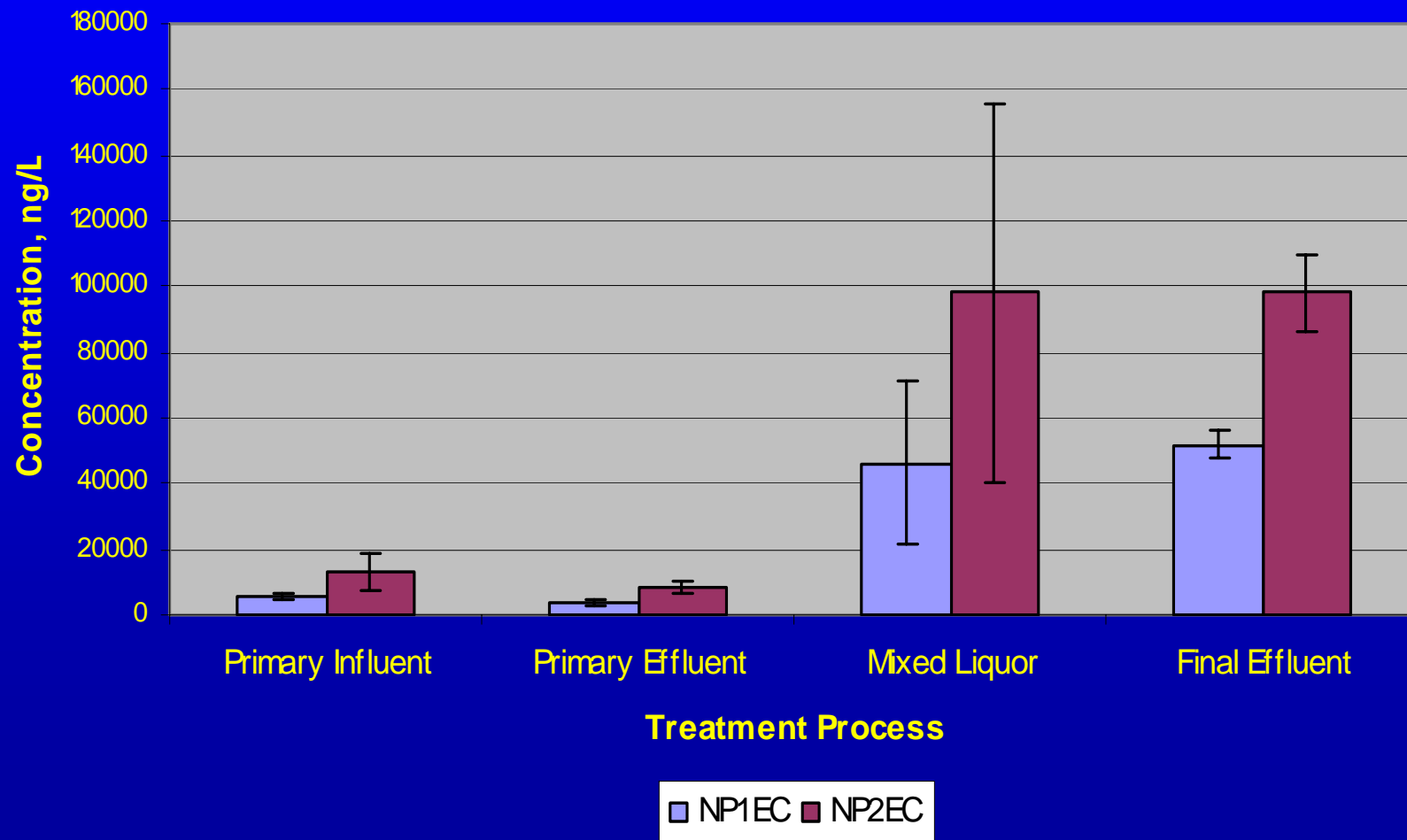
Nonylphenol Ethoxylates in the Calumet WRP





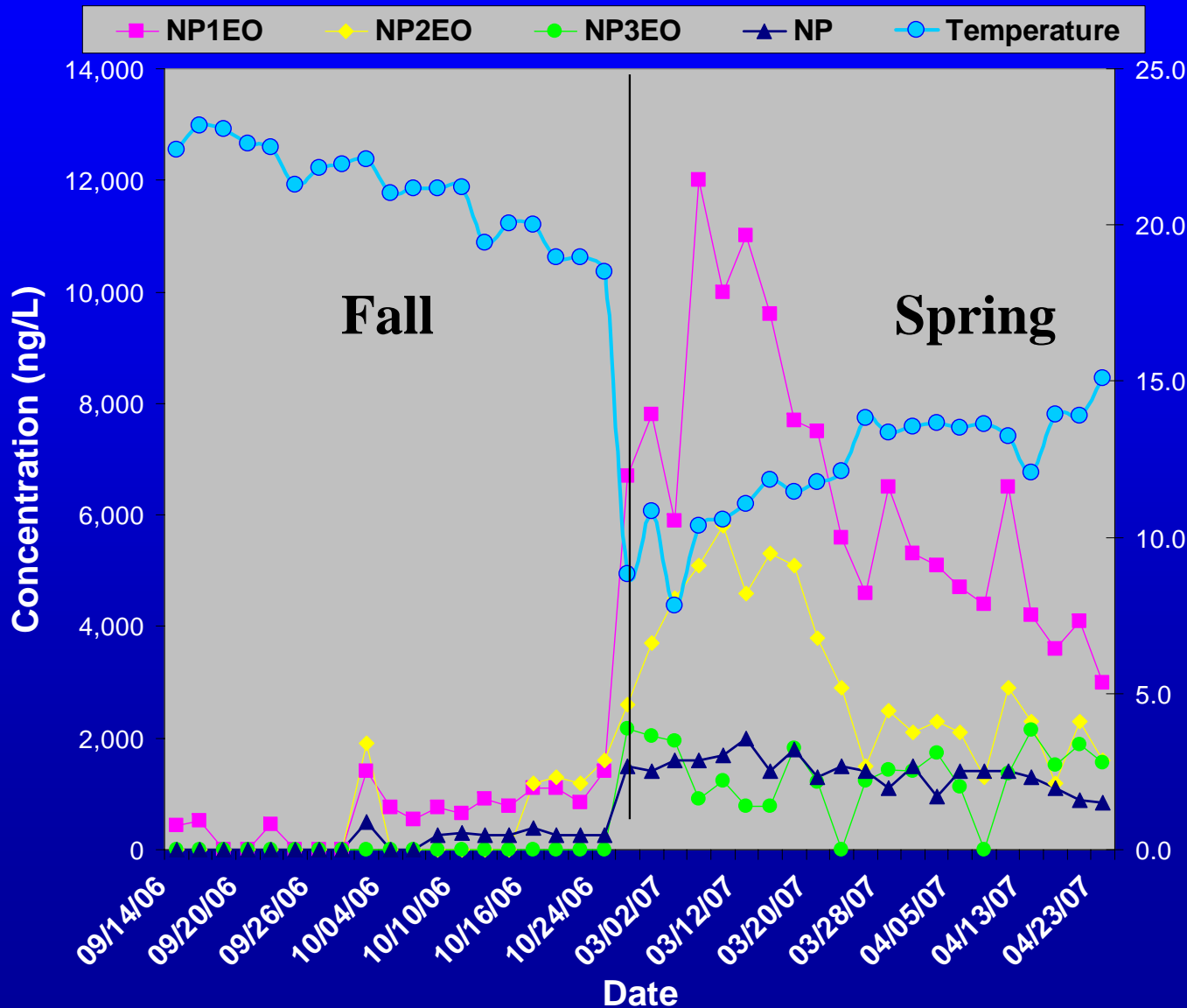
However, NPECs are formed in the treatment process

Nonylphenol Carboxylates in the Calumet WRP





Seasonality of Observed NPE Concentrations



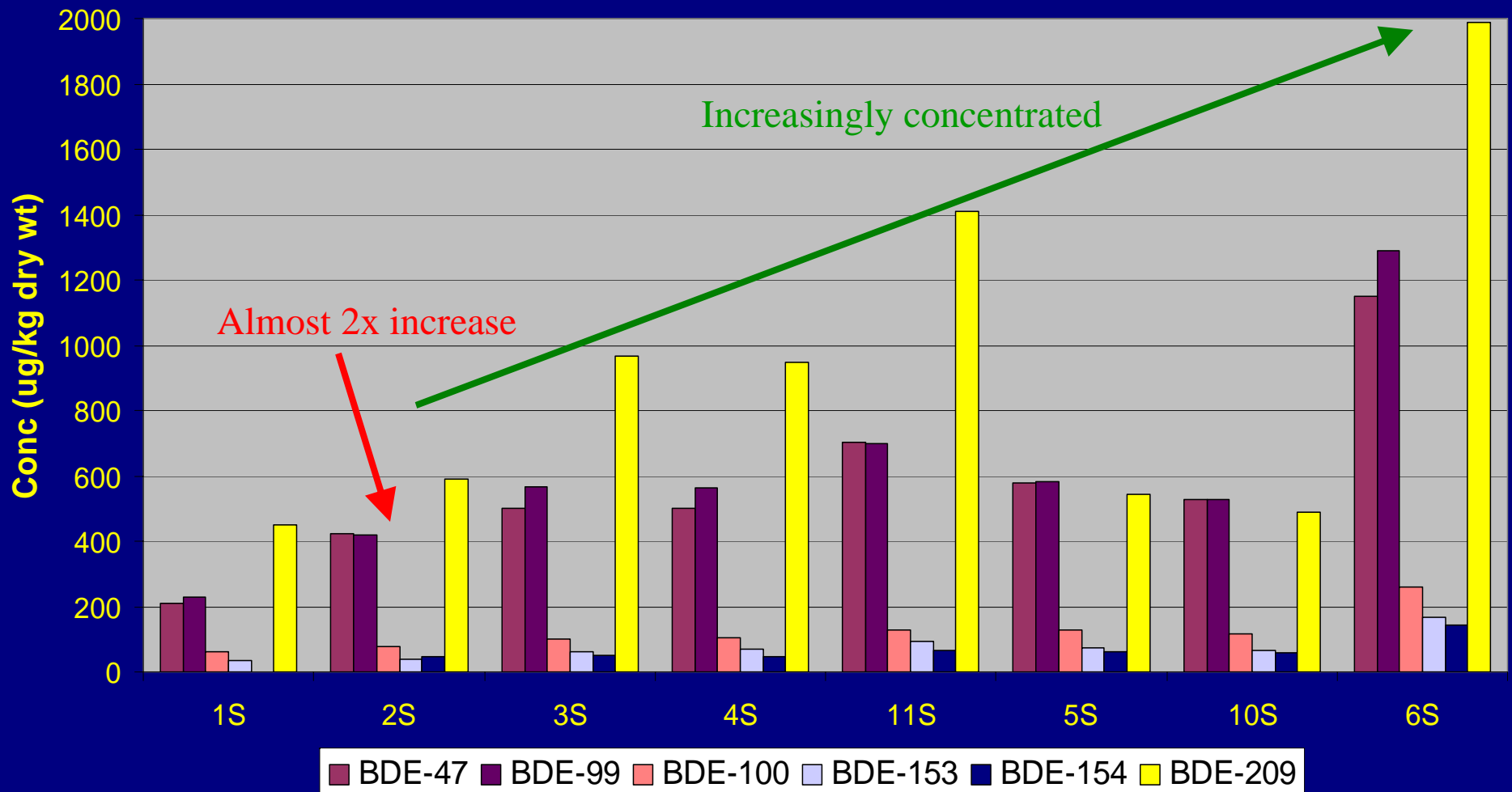
- Conc. ↑ as temps. ↓

- NP levels below toxicity based criteria for aquatic life



The wastewater treatment process is also effective at removing PBDEs from effluent

PBDEs in Sludge at CWRP





What do we know? (cont.)

- Many of these chemicals can be found in the environment
 - Effluent
 - Streams
 - Great Lakes
 - Biosolids
 - Fish and other aquatic organisms



Pharmaceuticals in effluent present at...

High ppt to ppb levels (> 500 ng/L)

lisinopril
valsartan
hydrochlorothiazide
ibuprofen-2-hydroxy
gemfibrozil

Mid ppt levels (100 - 500 ng/L)

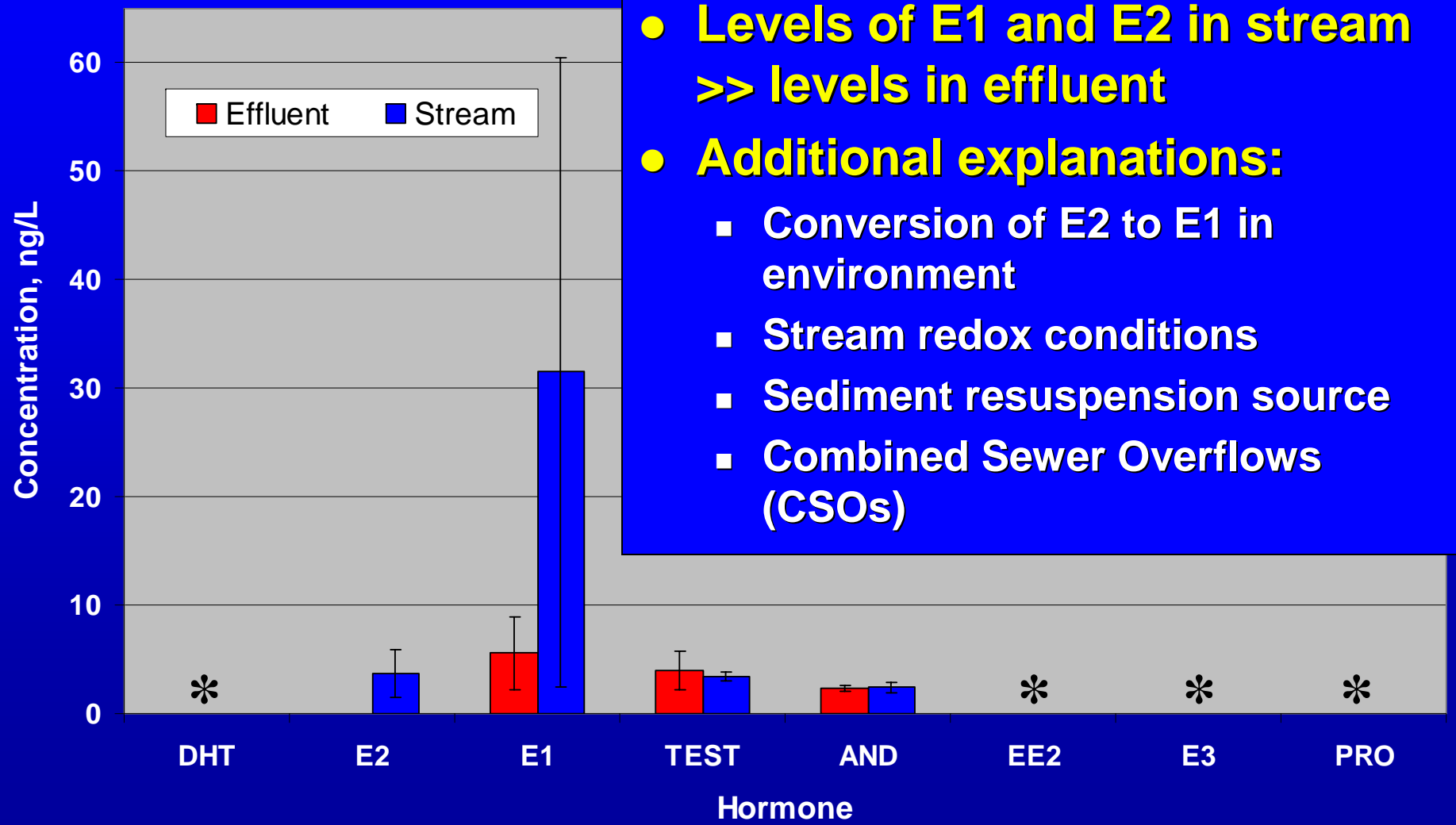
atenolol
metoprolol
diltiazem
furosemide
ciprofloxacin
carbamazepine
trimethoprim
ibuprofen

Low ppt levels (<100 ng/L)

amphetamine
hydrocodone
triamterene
enaliprilat
enalipril
propranolol
diltiazem-desmethyl
verapamil
norverapamil
amlodipine
sulfamethoxazole
promethazine
paroxetine
amitriptyline
benztropine
norfluoxetine
fluoxetine
sertraline-desmethyl
sertraline



Hormones in Effluent and Stream

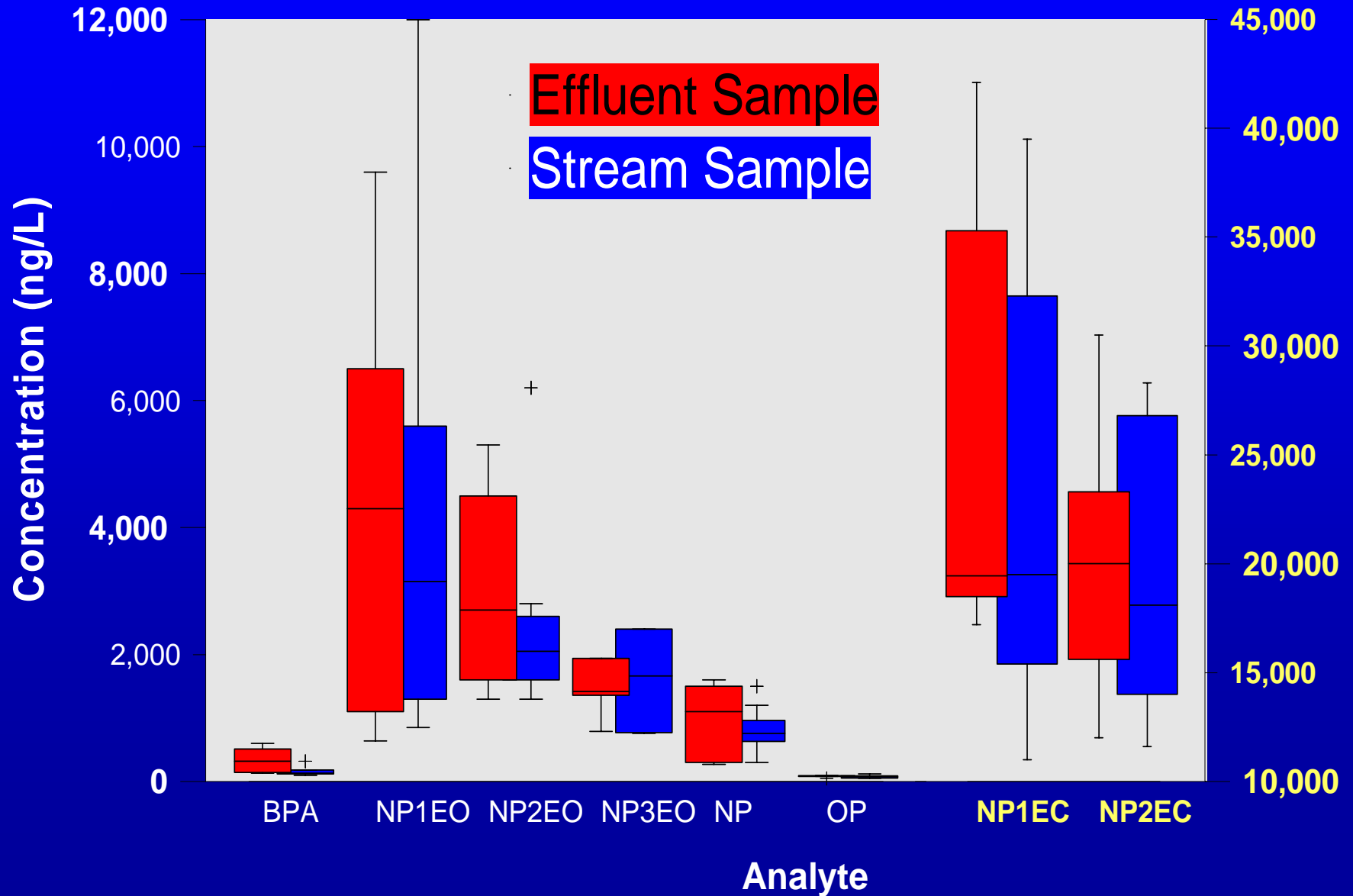


- Levels of E1 and E2 in stream >> levels in effluent
- Additional explanations:
 - Conversion of E2 to E1 in environment
 - Stream redox conditions
 - Sediment resuspension source
 - Combined Sewer Overflows (CSOs)

* - below reporting limit of 2 ng/L



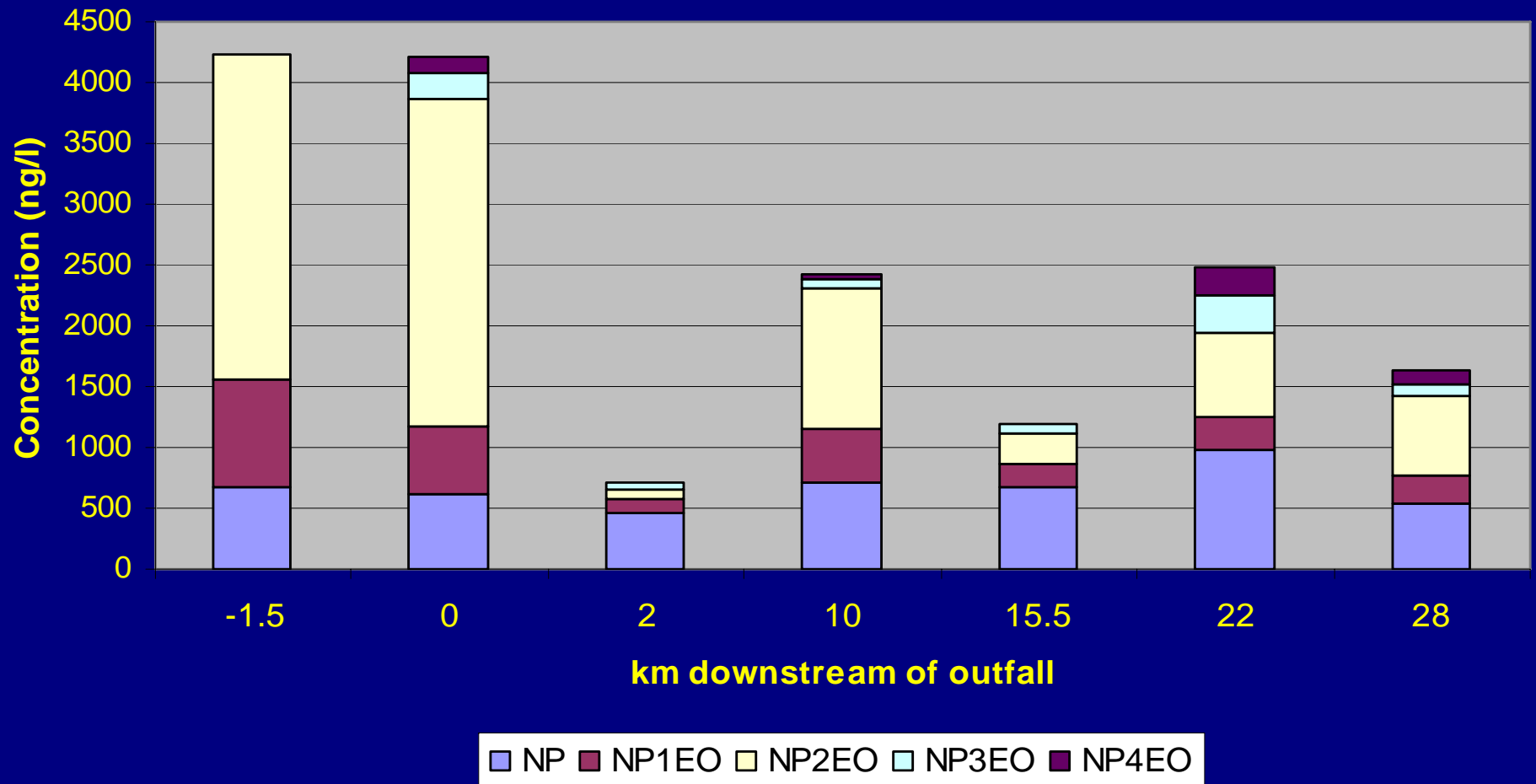
Many compounds persist downstream of outfall



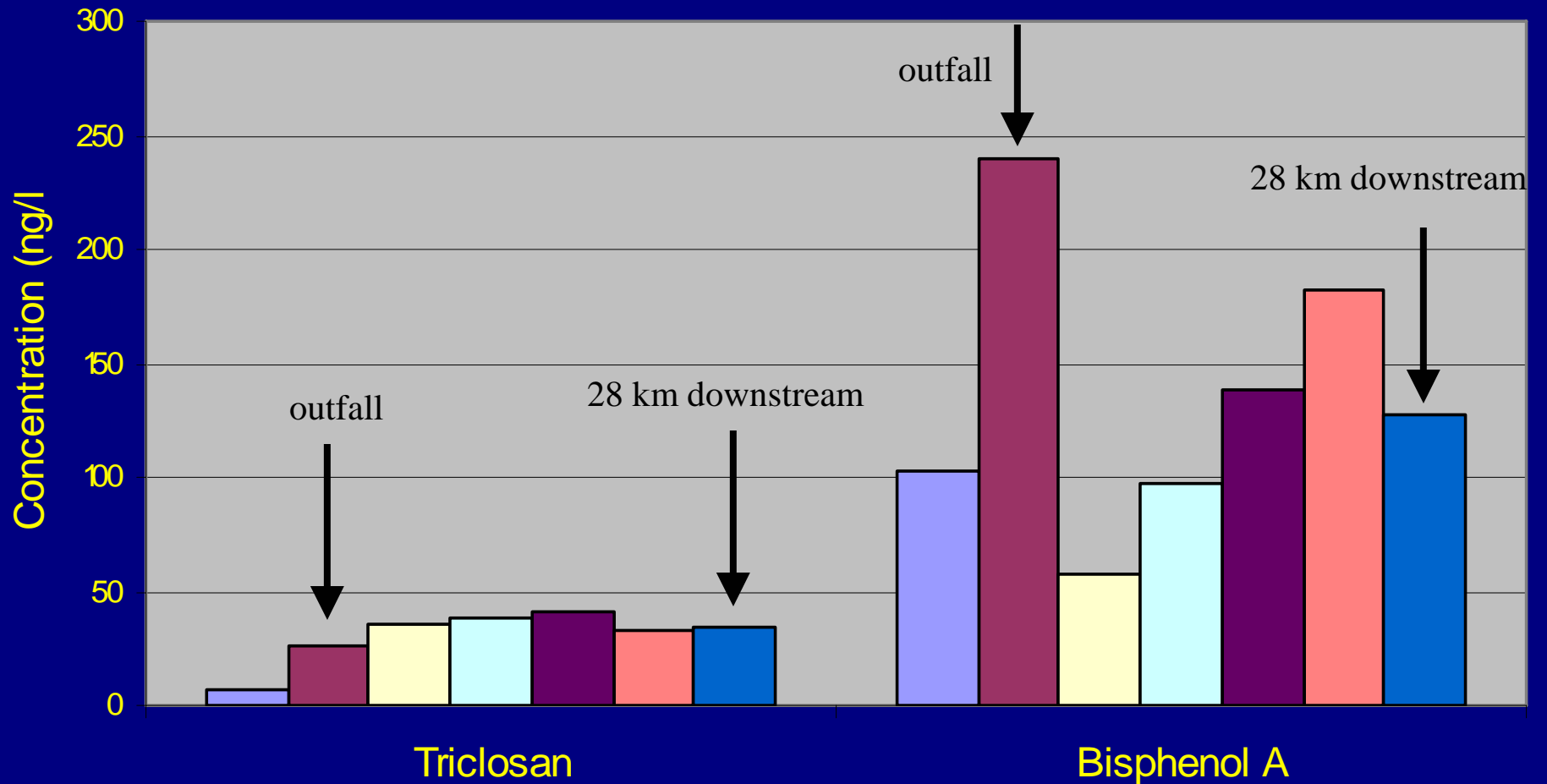


They can even persist well downstream of outfall

Nonylphenol and its Ethoxylates in the Cal-Sag Channel



Downstream Persistence in the Cal-Sag





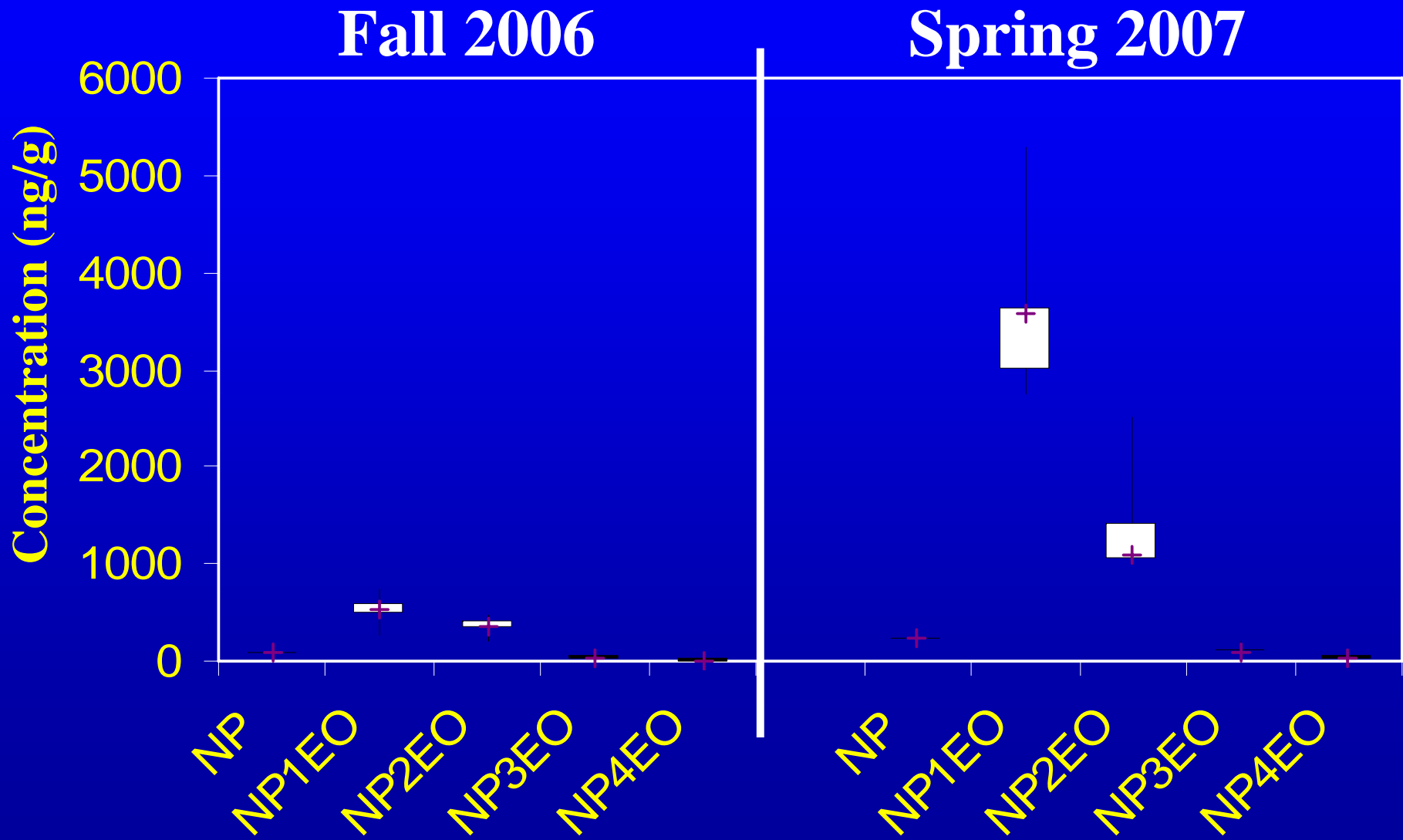
Pharmaceutical Chemicals Detected in EPA Pilot Study & Fillet and Liver Tissue from NSC

Detected Chemicals & Method Detection Limits (MDLs)	Use	National Composites with Detection (N=30)		Detections in NSC (N=6)	
		Fillet	Liver	Fillet	Liver
Carbamazepine (1.86 ppb)	Anti-seizure	6	6	6	6
Diltiazem (0.26ppb)	Anti-hypertension	8	16	5	6
Diphenyldramine (0.26ppb)	Antihistimine	18	23	6	6
Fluoxetine (12.41ppb)	Antidepressant	0	11	0	3
Gemfibrozil (24.82ppb)	Antilipemic	0	8	0	0
Norfluoxetine (15.31ppb)	Fluoxetine metabolite	12	26	2	6
Sertaline (17.29ppb)	Antidepressant	12	23	6	6

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APEs in NSC Large Mouth Bass



*Clifford P. Rice, Nuria Lozano, Agricultural Research Service, USDA, Beltsville, MD



What don't we know?

- Effects of the mixtures?
 - We detected 10s to 100s of compounds (there are probably 1000s of others)
 - Presence of compounds that are not currently measured (screening studies)?
 - No standards or criteria
- Significance of effects on entire population?
- Importance of other modes of action?
- Human Health impacts?



Conclusions

- Collaboration is KEY!
- Sampling and analytical capability are challenges
- Many compounds are removed significantly from treatment plants
 - But still end of in the environment in detectable amounts
- Effluent (and streams) contain a wide mixture of compounds
 - Persistent exposure to aquatic life
- Other possible sources
- Emerging concern that we've just begun to investigate





Questions?



Thank You!

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