

Emerging Issues - Challenges on the Horizon We Have Not Addressed Yet

Jone Corrales, Ph.D.
Department of Environmental Science
Baylor University, Waco, Texas USA

Bayou Preservation Association, 12 October 2016

Emerging Issues - Challenges on the Horizon We Have Not Addressed Yet

'Pharmaceuticals In the Environment'

Jone Corrales, Ph.D.
Department of Environmental Science
Baylor University, Waco, Texas USA

Bayou Preservation Association, 12 October 2016

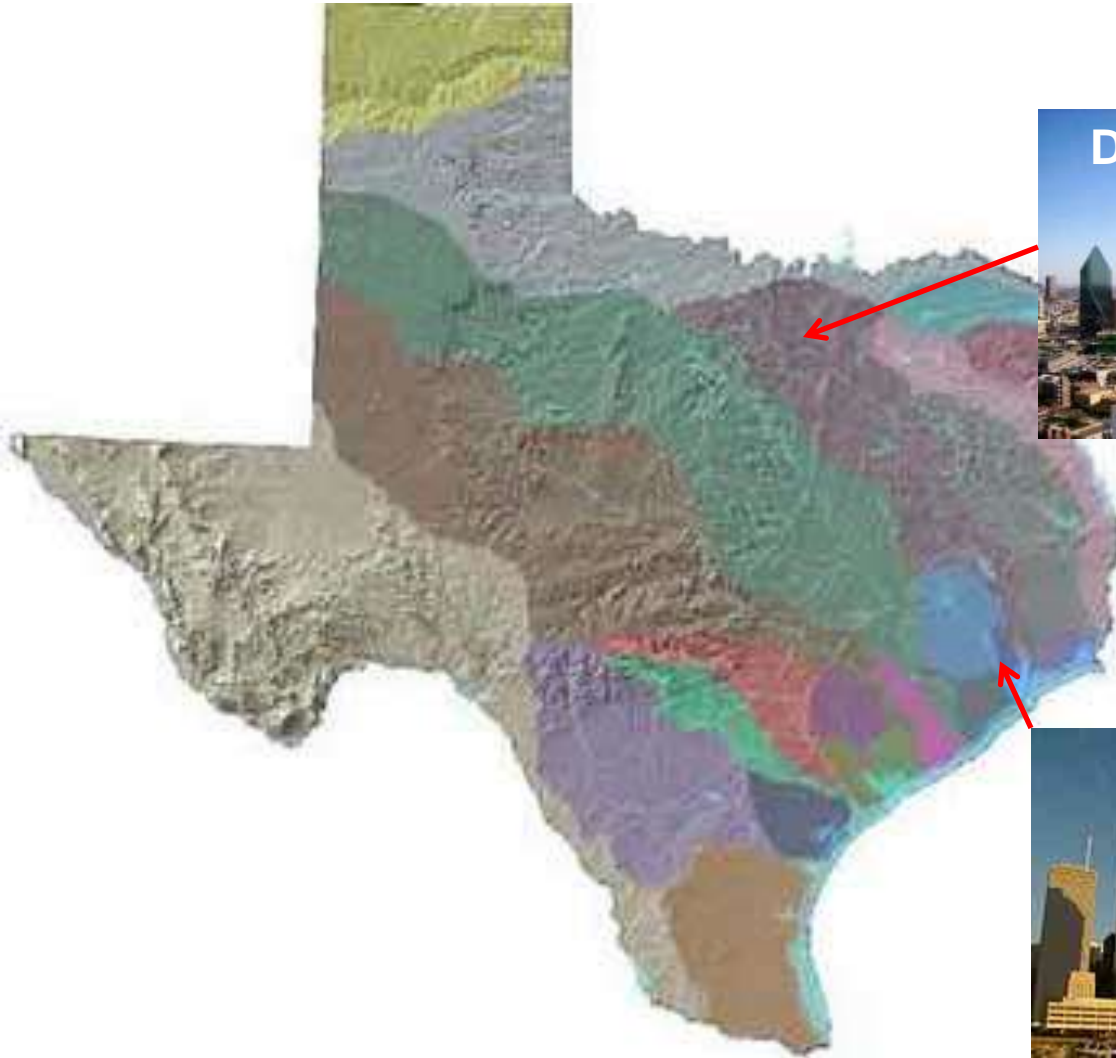
More People Now Live in Cities than Ever Before...



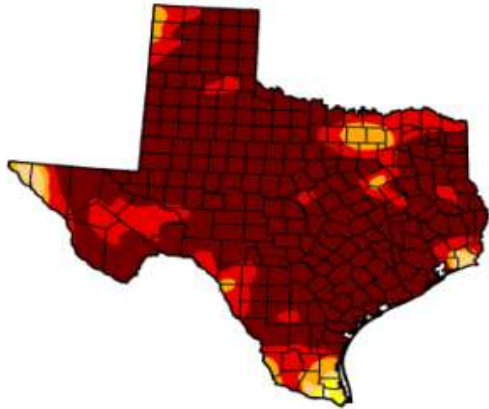
By 2050:

- World population reaches 9.6 bil (UN)
- 70% of all people will live in urban areas (UN)
- Water needs and consumption will continue to increase
- Consumer product and other chemical use is concentrated in cities...






Fast Growing Metros...



The Urban Water Cycle is the New Normal



August 2011

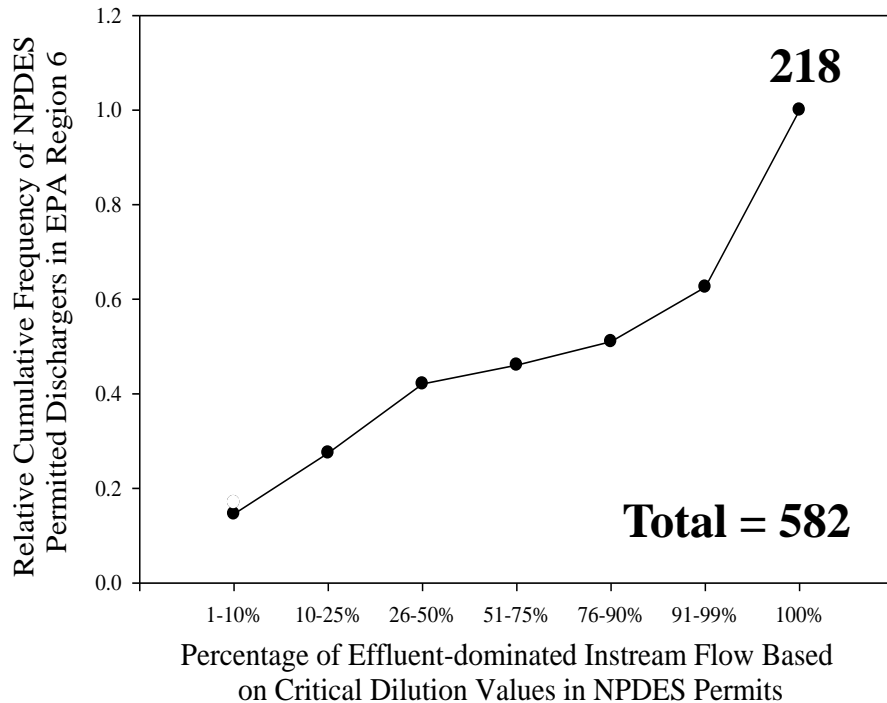
-  D0 - Abnormally Dry
-  D1 Drought - Moderate
-  D2 Drought - Severe
-  D3 Drought - Extreme
-  D4 Drought - Exceptional



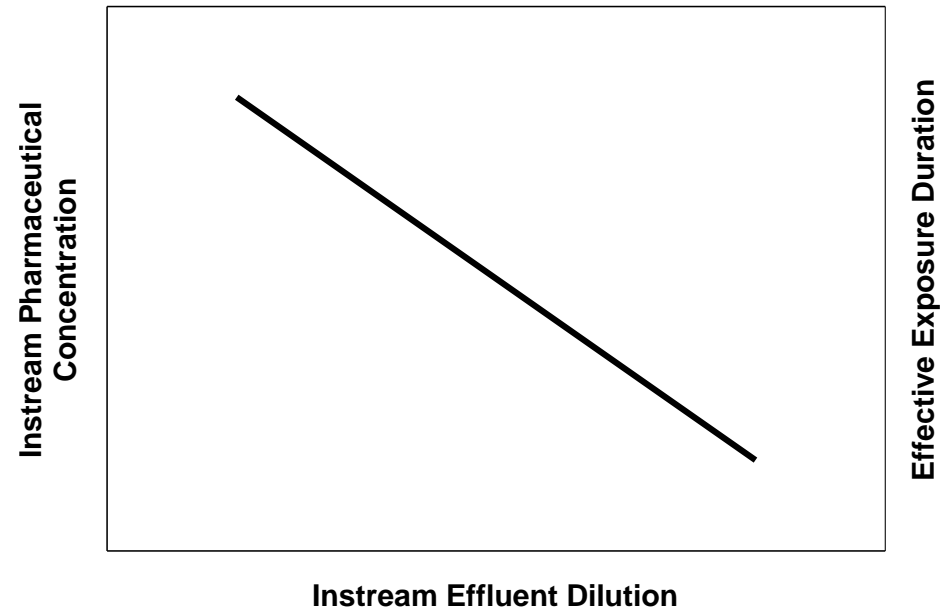
Bryan W. Brooks

River flows from reclaimed wastewater discharges

Effluent-dominated & dependent systems: worst case scenarios for chemical exposure?

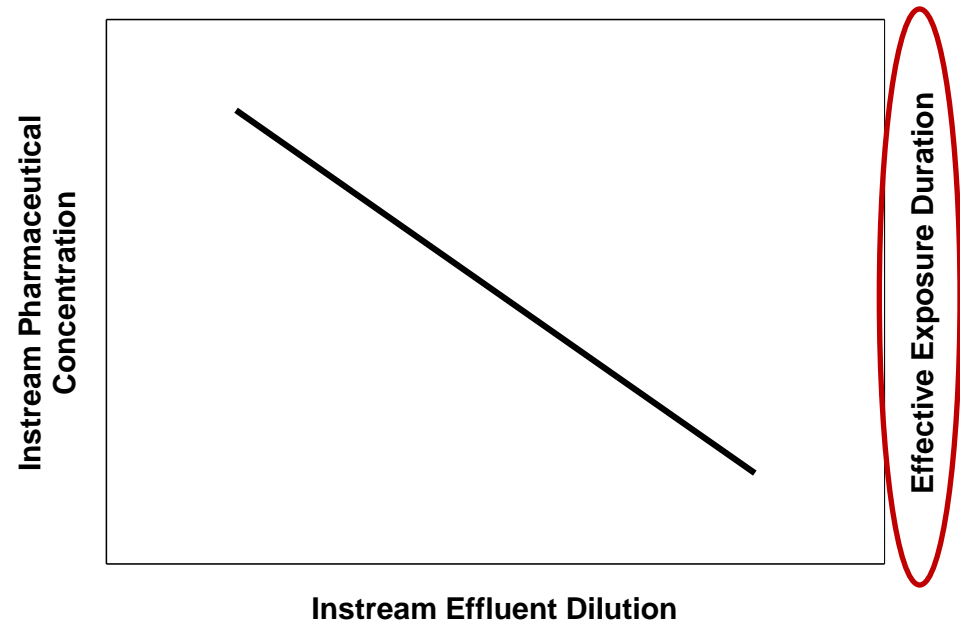


Brooks et al 2006. *Hydrobiologia*



Ankley, Brooks, Huggett, Sumpter. 2007. *ES&T*

Effluent-dominated & dependent systems: worst case scenarios for chemical exposure?



Effective Exposure Duration:
Increases when introduction rates from effluent discharge exceed a chemical's rate of degradation.

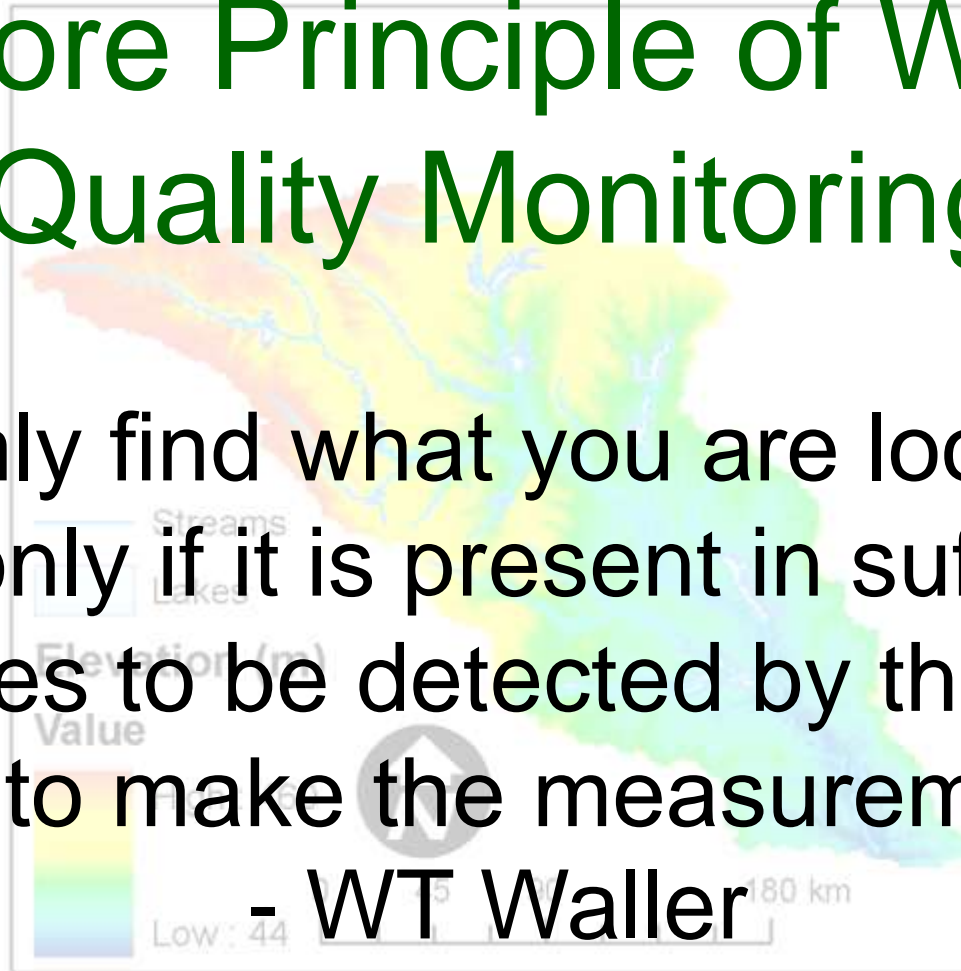


Ankley, Brooks, Huggett, Sumpter. 2007. *ES&T*

A Core Principle of Water Quality Monitoring

“You only find what you are looking for
and only if it is present in sufficient
quantities to be detected by the device
used to make the measurements.”

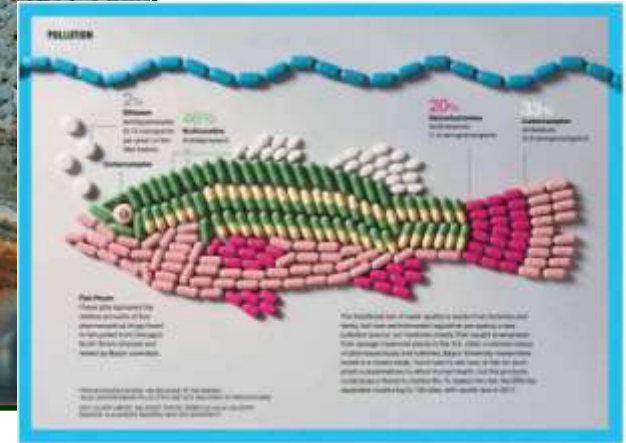
- WT Waller



FIELD & STREAM
THE WORLD'S LEADING OUTDOOR MAGAZINE




Fish on Prozac? How depressing!
Antidepressant ingredient detected in Texas lake water



November 2003:
March 2008:
February 2013:


“Fish on Prozac”
“AP Probe Finds Drugs in Drinking Water”
“Anxiety Drugs Affect Fish, Too”



NAUTILUS

ISSUES BLOG

NEWSLETTER SUBSCRIBE



CULTURE : PHARMACOLOGY

Blissed-Out Fish on Prozac

Why we can't get our water supply free of drugs.

BY ADAM PIORE
ILLUSTRATION BY YUKO SHIMIZU

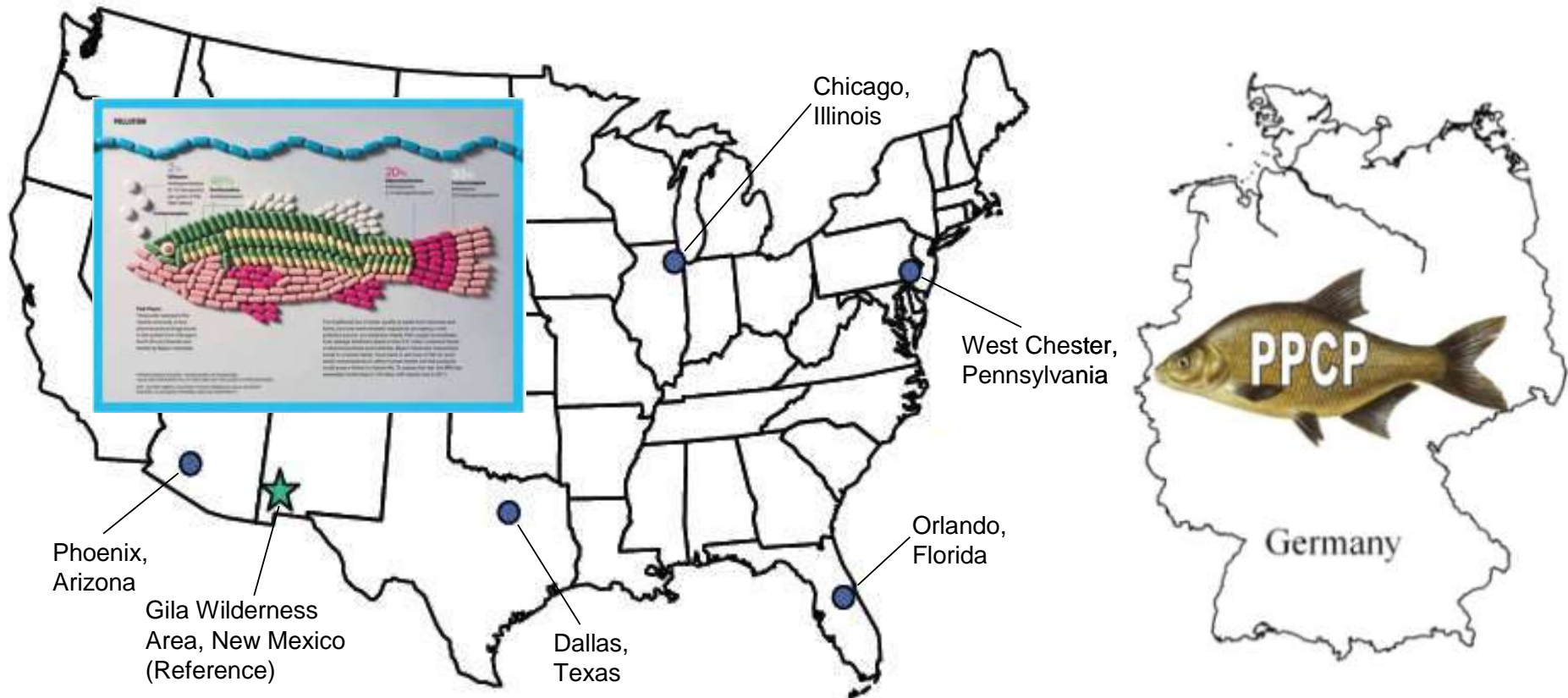
COMMENT FACEBOOK TWITTER

Jeffrey Hawkins Writer likes to say that the average drop of water entering the Mississippi River headwaters north of Minnesota will be used 11 times before it reaches the Gulf of Mexico. That drop might irrigate crops, flow through wastewater treatment plants, pour out of residential taps, move through digestive systems, arc into toilet

ISSUE 007
WASTE
EXPLORE THIS ISSUE

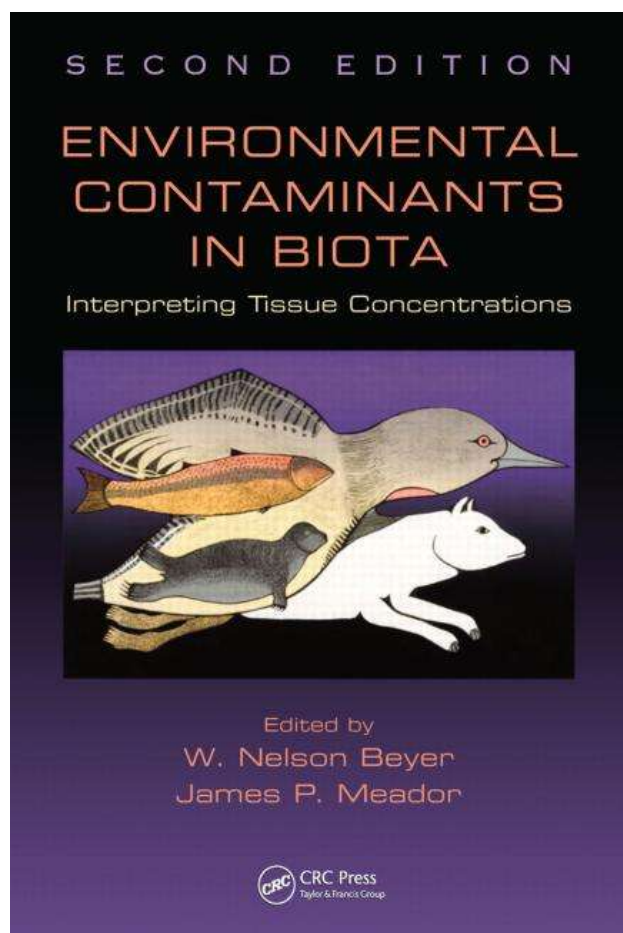
INTRODUCTION

US EPA National Pilot Study of PPCPs in Fish



Similar study for German Environment Agency's ESB

What about Coastal Systems?



8 Active Pharmaceutical Ingredients and Aquatic Organisms

*Christian G. Daughton
Bryan W. Brooks*

CONTENTS

8.1	Introduction to Pharmaceutical Ingredients and Aquatic Organisms	282
8.2	Exposure	283
8.2.1	Background	283
8.2.2	Sources/Origins Leading to Exposure	289
8.2.3	Exposure Variables	291
8.2.4	Some General Perspectives and Background Regarding Aquatic Tissue Levels of APIs	291
8.2.5	Predictive Modeling	294
8.2.6	Overview of Fish Tissue and Other Residue Data for APIs	295
8.2.6.1	SSRIs/SNRIs (Selective Serotonin and Serotonin-Norepinephrine Reuptake Inhibitors)	296
8.2.6.2	NSAIDs (Nonsteroidal Anti-inflammatory Drugs)	298
8.2.6.3	Lipid Regulators	299
8.2.6.4	β -Blockers	299
8.2.6.5	Fungicides	300
8.2.6.6	Macrocyclic Lactones	300
8.2.6.7	Steroids	300
8.2.6.8	Antibiotics: Informing Environmental Exposure with Data from Use of Veterinary Aquaculture Drugs	304
8.2.6.9	Carbamazepine (CBZ)	305
8.2.6.10	Triclosan (and Methyl Triclosan) and Triclocarban	305
8.2.6.11	Miscellaneous APIs	307
8.2.6.12	API Disinfection By-Products (DBPs) and Metabolites	308
8.2.7	Uptake by Aquatic Plants and Aerial Invertebrates	308
8.2.8	Multianalyte Studies	309
8.2.9	Summary of Published Data	311
8.3	Factors Influencing Exposure	318
8.3.1	General Considerations	318

What about Coastal Systems?

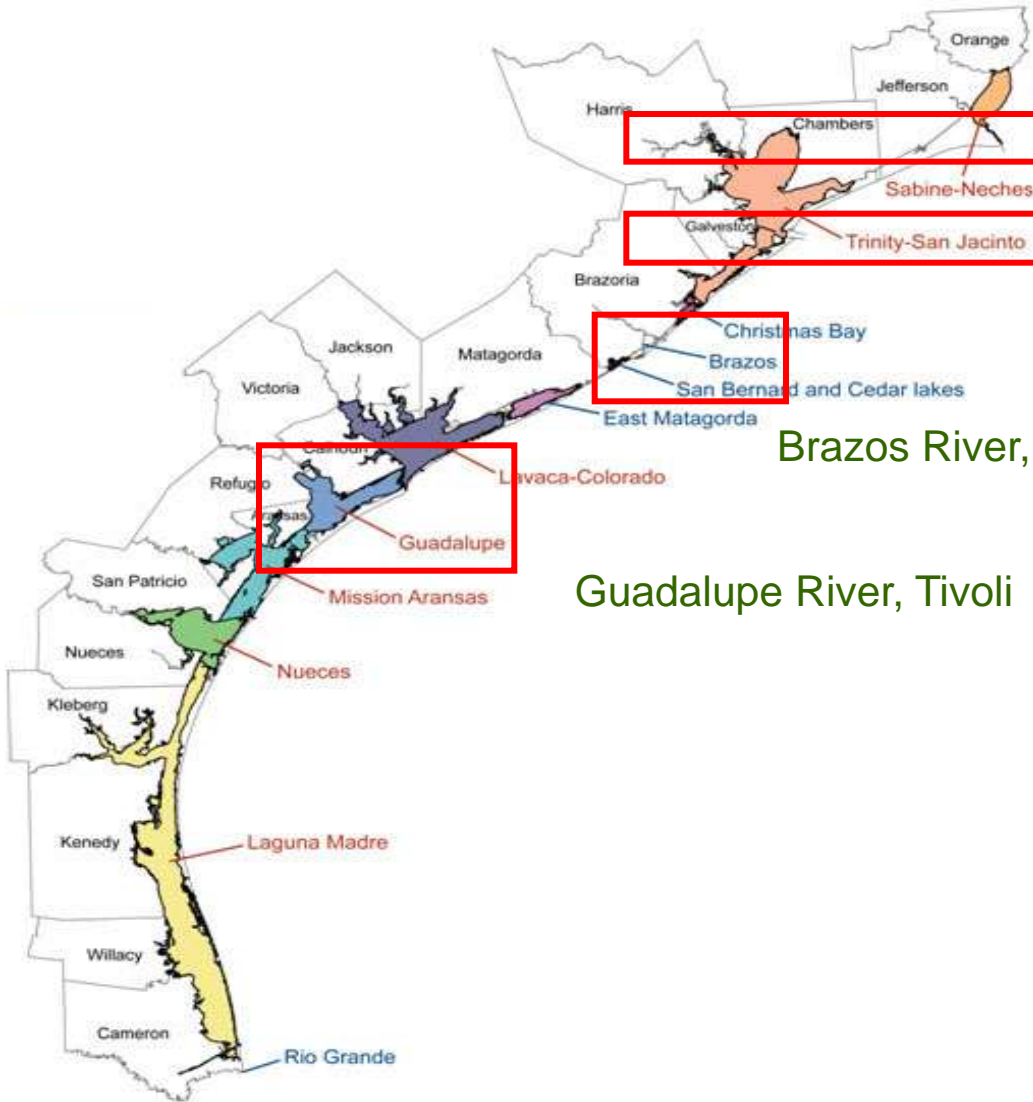
Determining Pharmaceutical Loadings to Select Texas Coastal Systems and Associated Risks to Aquatic Life



Research Objectives:

1. To determine the seasonal hydrologic loading of targeted pharmaceuticals to select Texas coastal systems.
2. To determine the bioaccumulation and trophic transfer of pharmaceuticals in select Texas coastal systems.
3. To predict risks of pharmaceutical exposure to fish residing in select Texas coastal systems.

Texas Sea Grant Study Sites



Buffalo Bayou

Dickinson Bayou

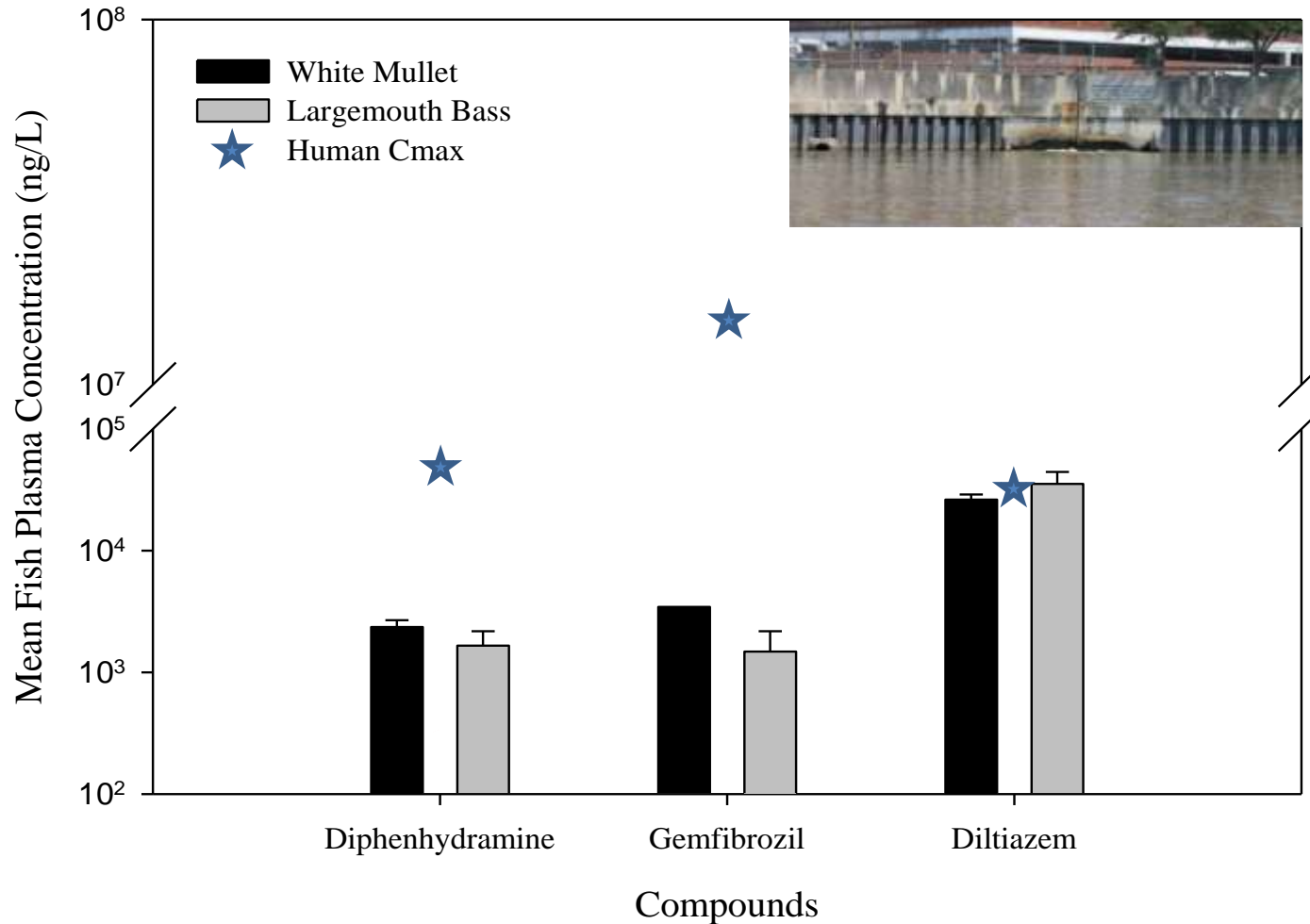
Brazos River, Lake Jackson

Guadalupe River, Tivoli

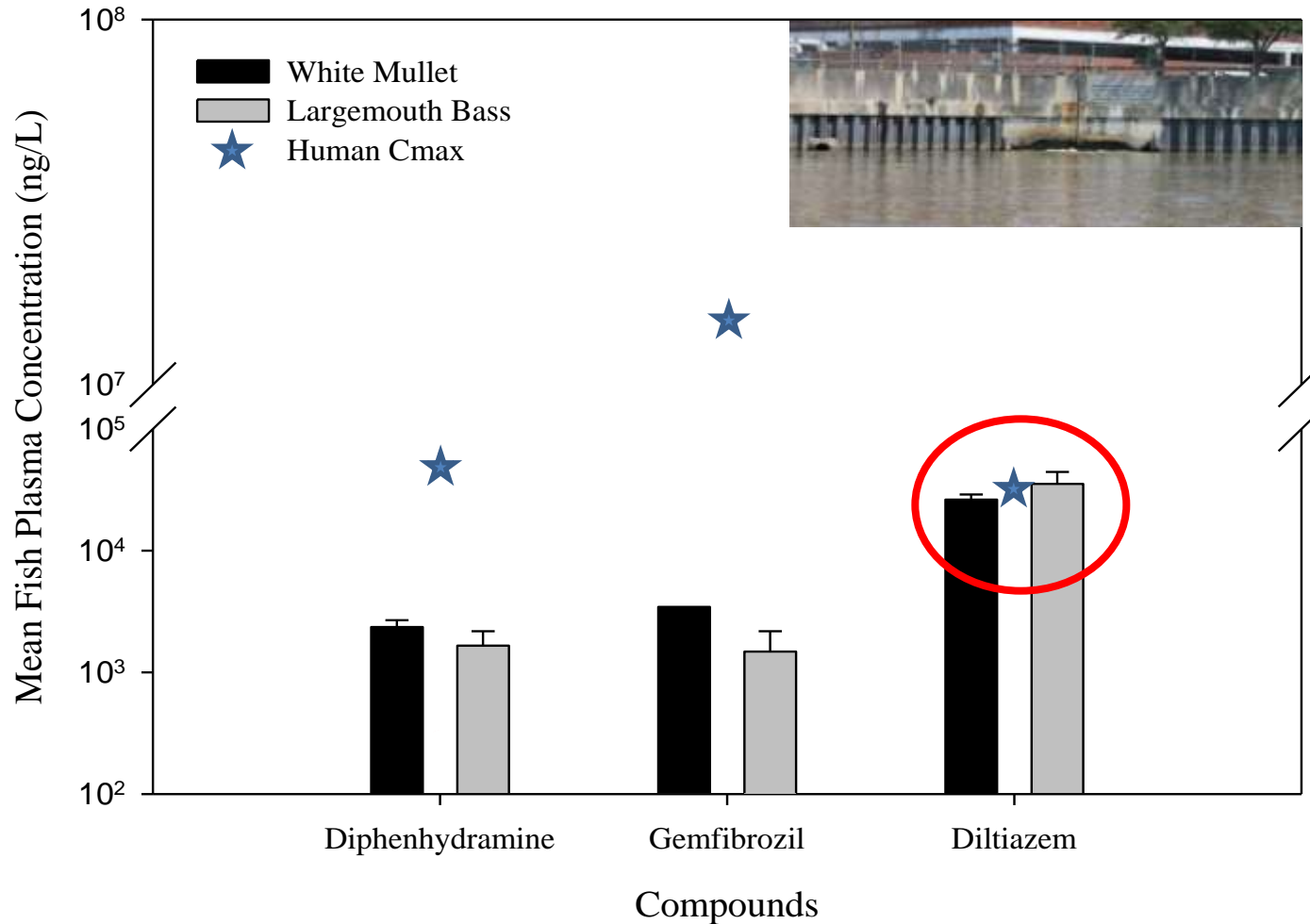


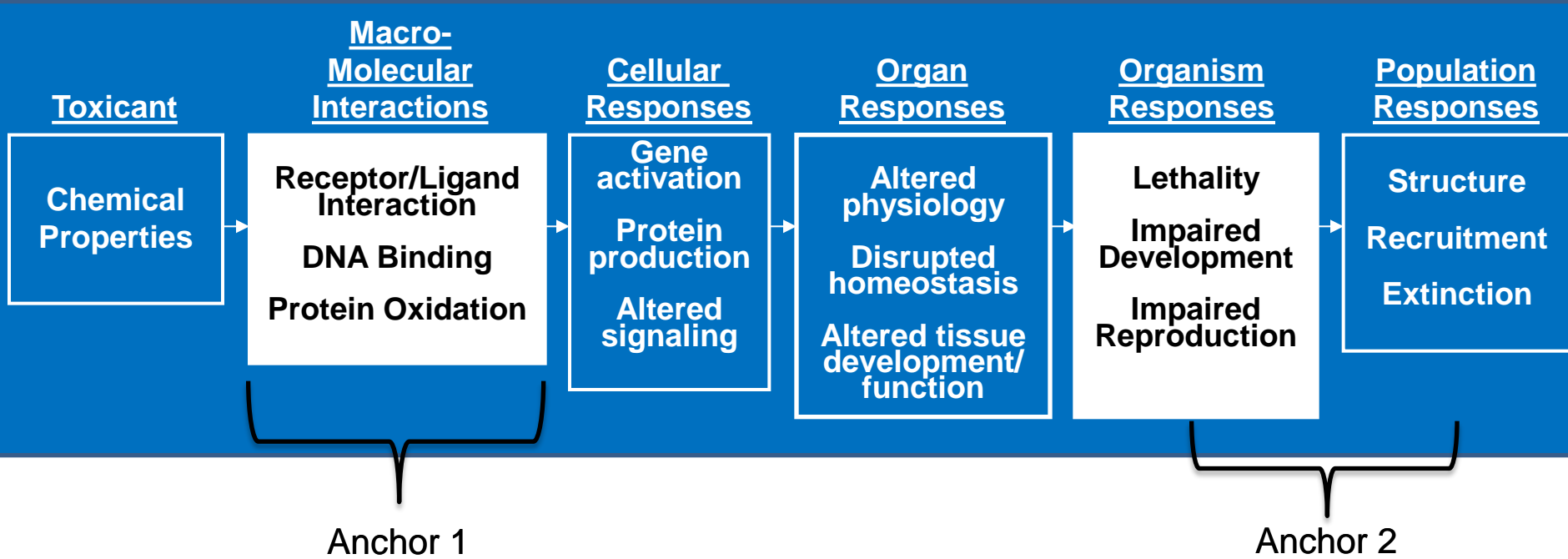
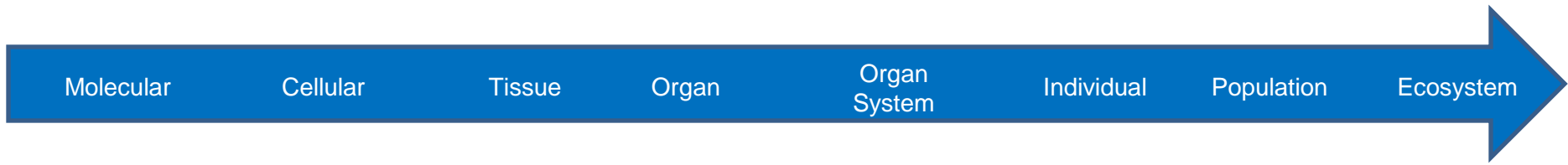
Anti-hypertension	Atenolol(- d_7)	Psychostimulant	Methylphenidate(- d_9)
	Propranolol(- d_7)	Antihistamine	Diphenhydramine(- d_3)
	Diltiazem(- d_3)	Anti-Seizure	Carbamazepine(- d_{10})
Analgesic	Codeine(- d_3)	Anticoagulant	Warfarin(- d_3)
	Acetaminophen(- d_4)	Benzodiazepine	Diazepam(- d_5)
Antibiotic	Sulfamethoxazole(- d_4)	Parasiticide	Ivermectin (Abamectin)
	Trimethoprim(- d_9)	Antidepressant	Fluoxetine(- d_6)
	Erythromycin(- $^{13}\text{C}, d_3$)		Sertraline(- d_3)
Anti-inflammatory	Celecoxib(- d_4)		Paroxetine(- d_6)
	Diclofenac(- d_4)	Antidepressant metabolites	Norfluoxetine(- d_6)
Antilipemic	Gemfibrozil(- d_6)		Desmethylsertraline(- d_4)
Stimulant	Caffeine(- d_9)	Artificial sweetener	Sucralose(- d_6)

Diltiazem in Fish Plasma Exceeds Human Dose



Diltiazem in Fish Plasma Exceeds Human Dose

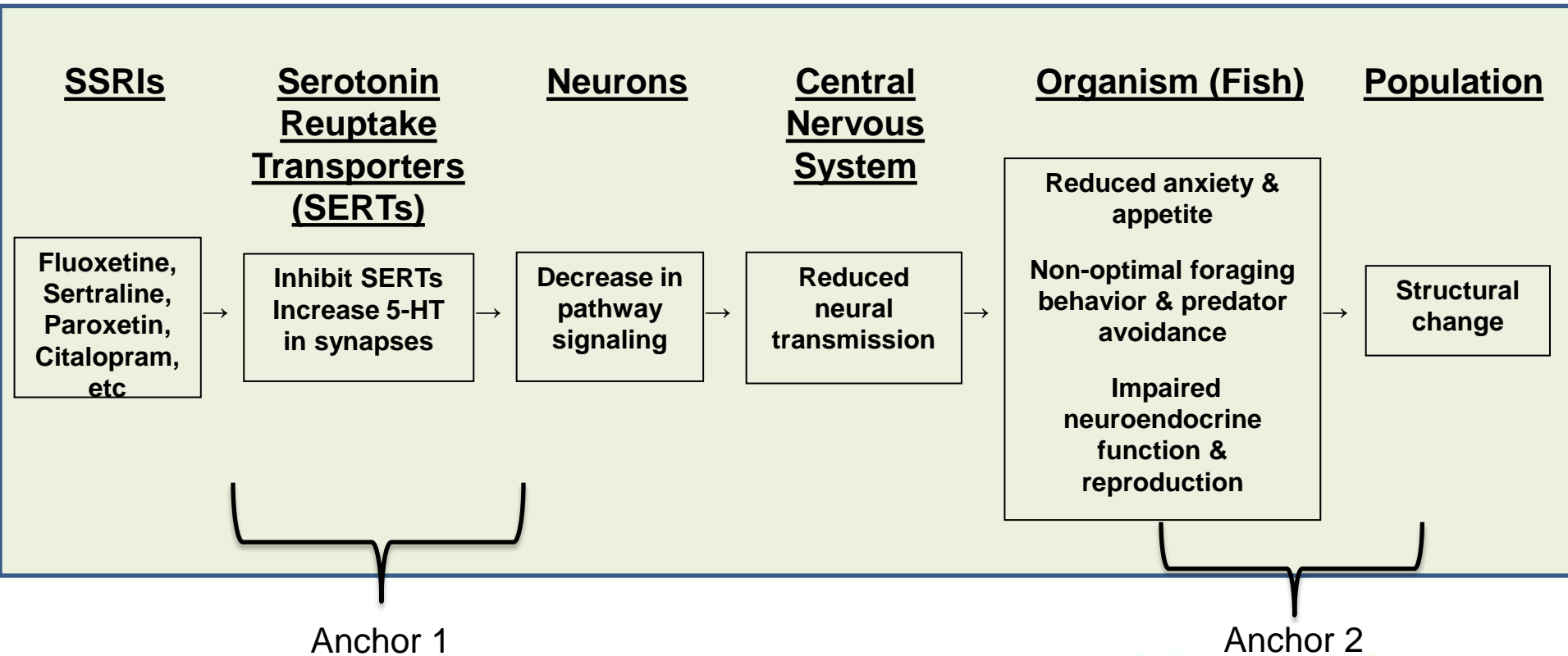




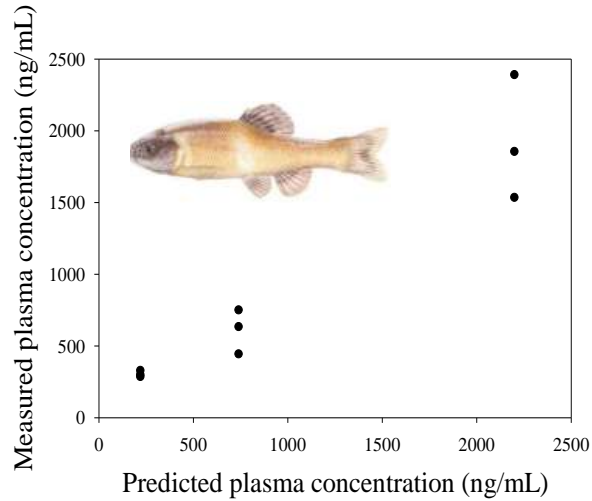
www.epa.gov/ncct/



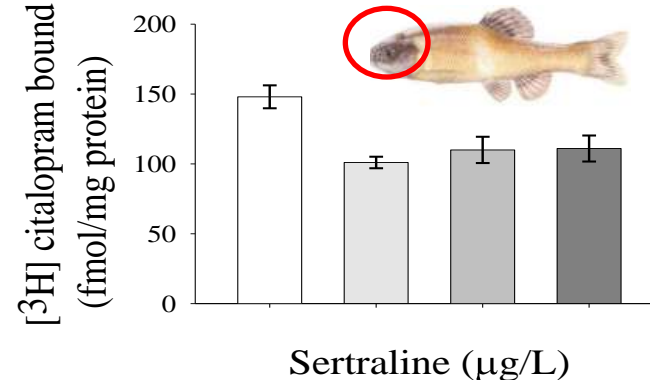
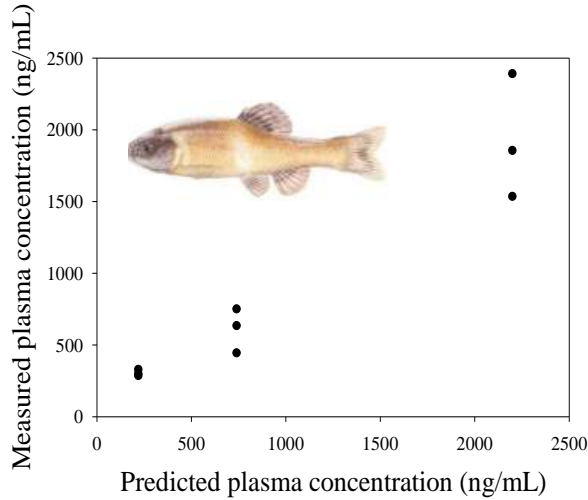
Adverse Outcome Pathway Selective Serotonin Reuptake Inhibitors



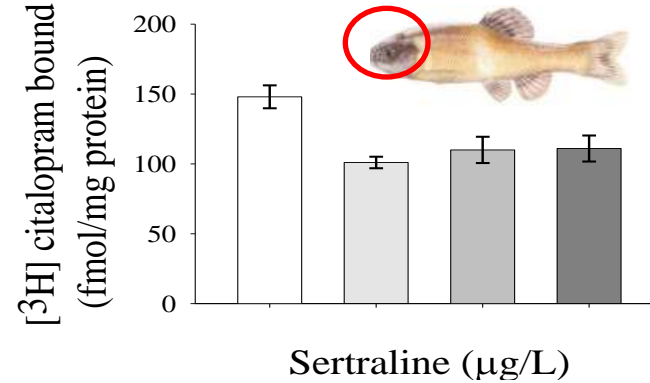
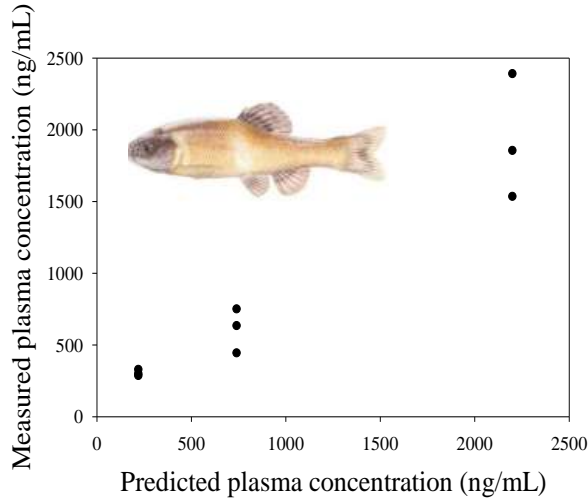
Antidepressant uptake, CNS binding, anxiety behavior



Antidepressant uptake, CNS binding, anxiety behavior

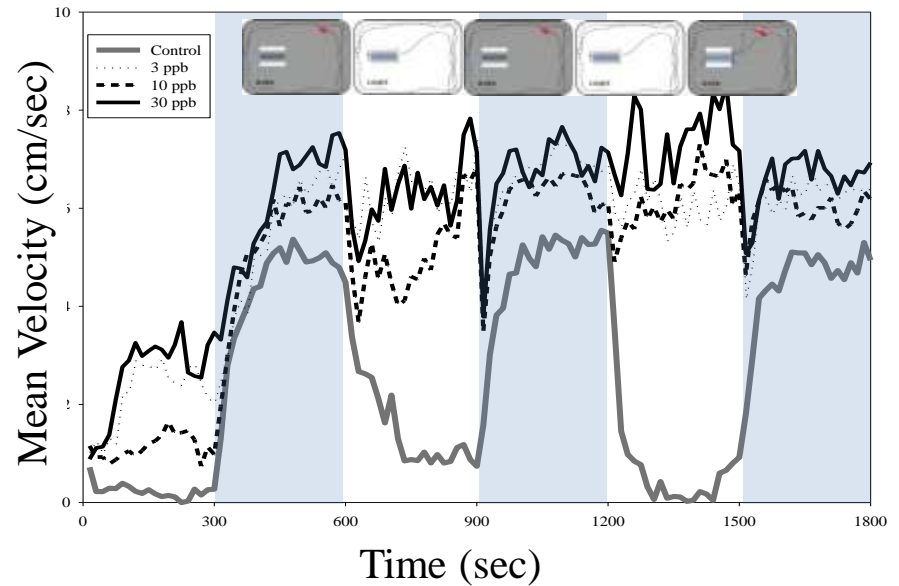
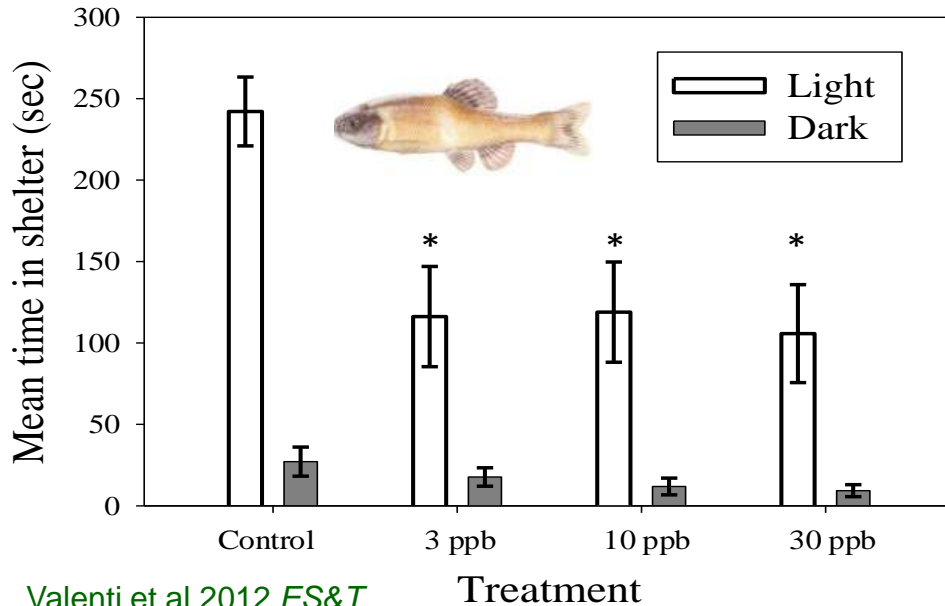
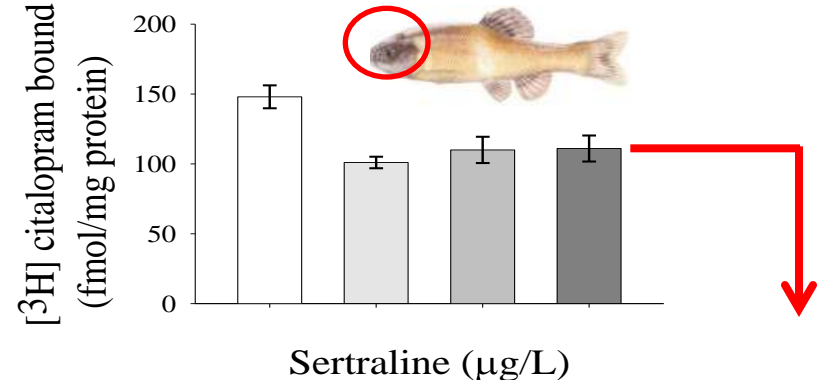
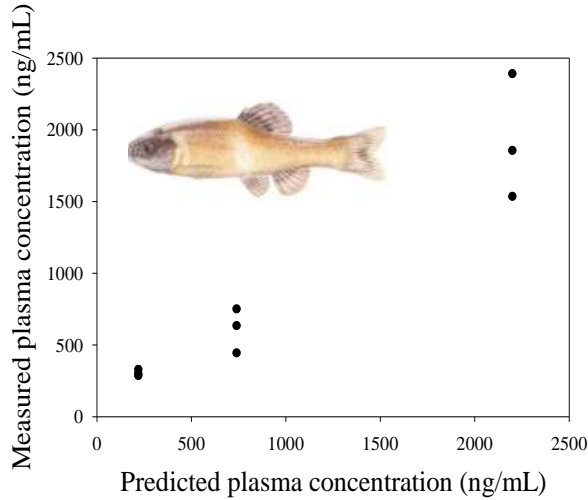


Antidepressant uptake, CNS binding, anxiety behavior



Does it Affect Fish?

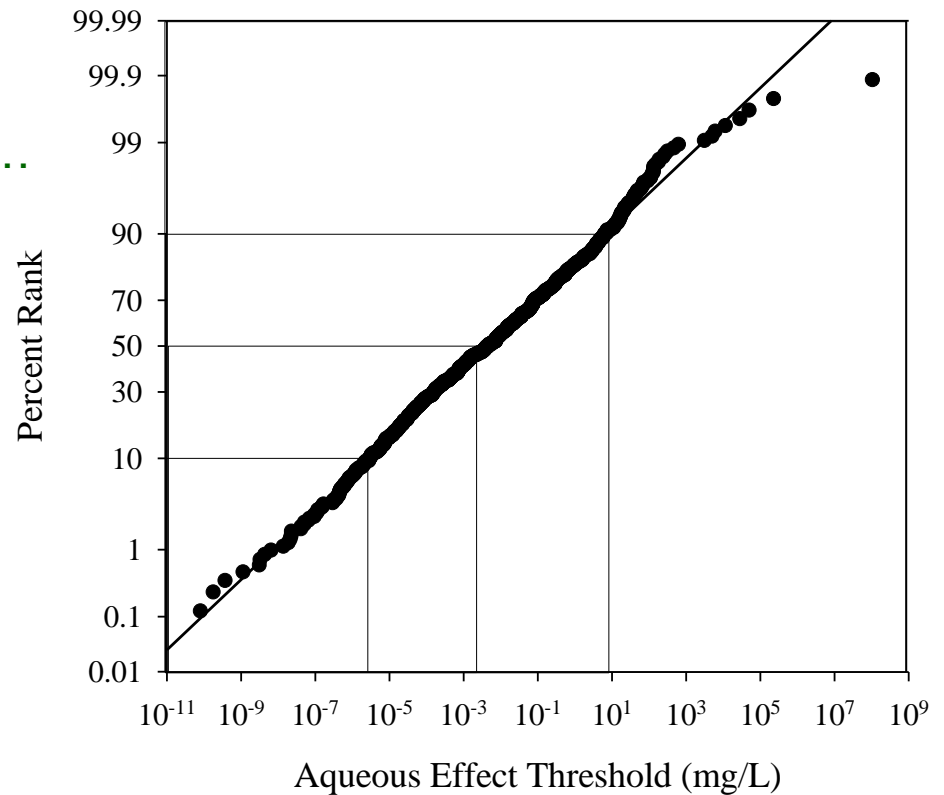
Antidepressant uptake, CNS binding, anxiety behavior



Predicting Surface Water Concentrations Leading to Human Therapeutic Doses in Fish

Building on Fish Plasma, PBPK Models...

A surface water concentration leading to a plasma concentration in fish above the mammalian therapeutic value is predicted to be at or below the environmentally relevant concentration of 29 ng/L for 10% of all drugs.

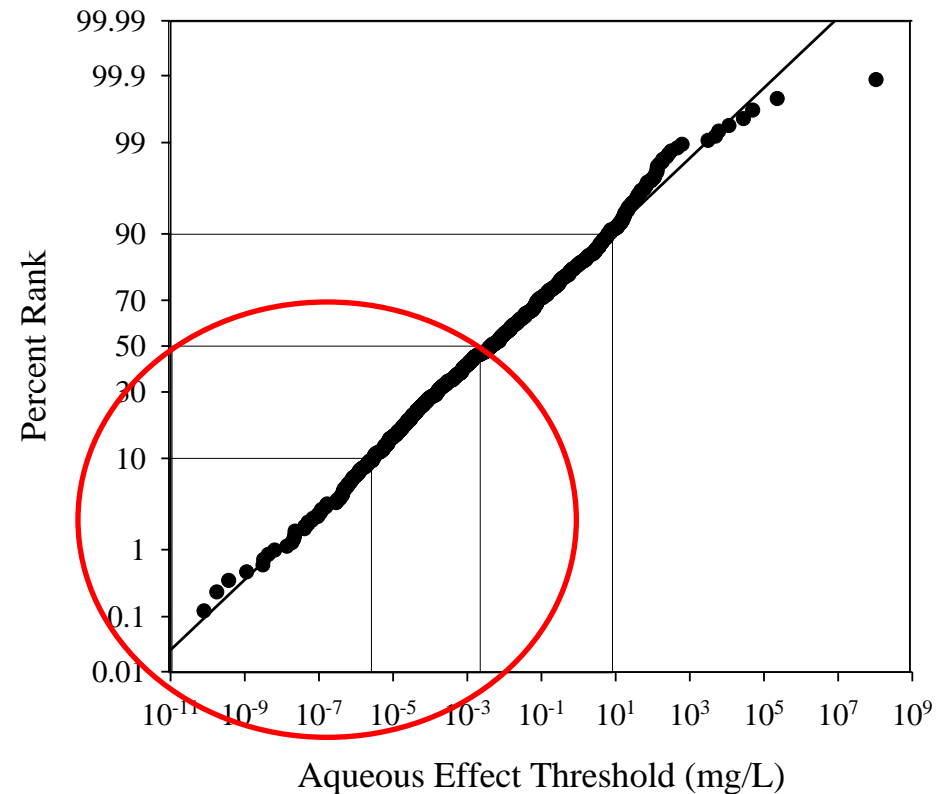


Predicting Surface Water Concentrations Leading to Human Therapeutic Doses in Fish

Building on Fish Plasma, PBPK Models...

A surface water concentration leading to a plasma concentration in fish above the mammalian therapeutic value is predicted to be at or below the environmentally relevant concentration of 29 ng/L for 10% of all drugs.

We are focusing our future studies on these medicines.



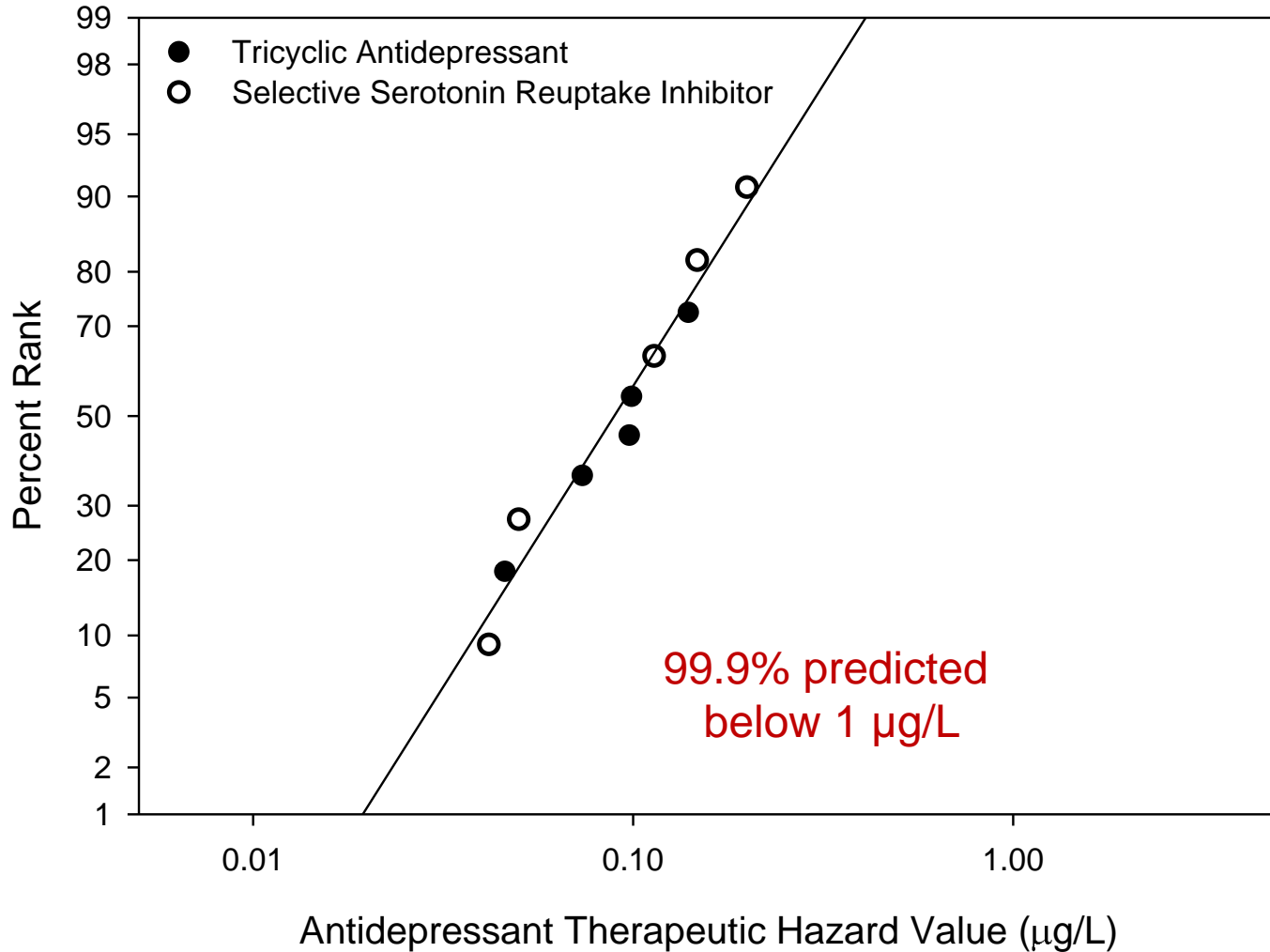
$$\text{THV} = C_{\text{max}} / \text{Log } P_{\text{Blood:Water}}$$

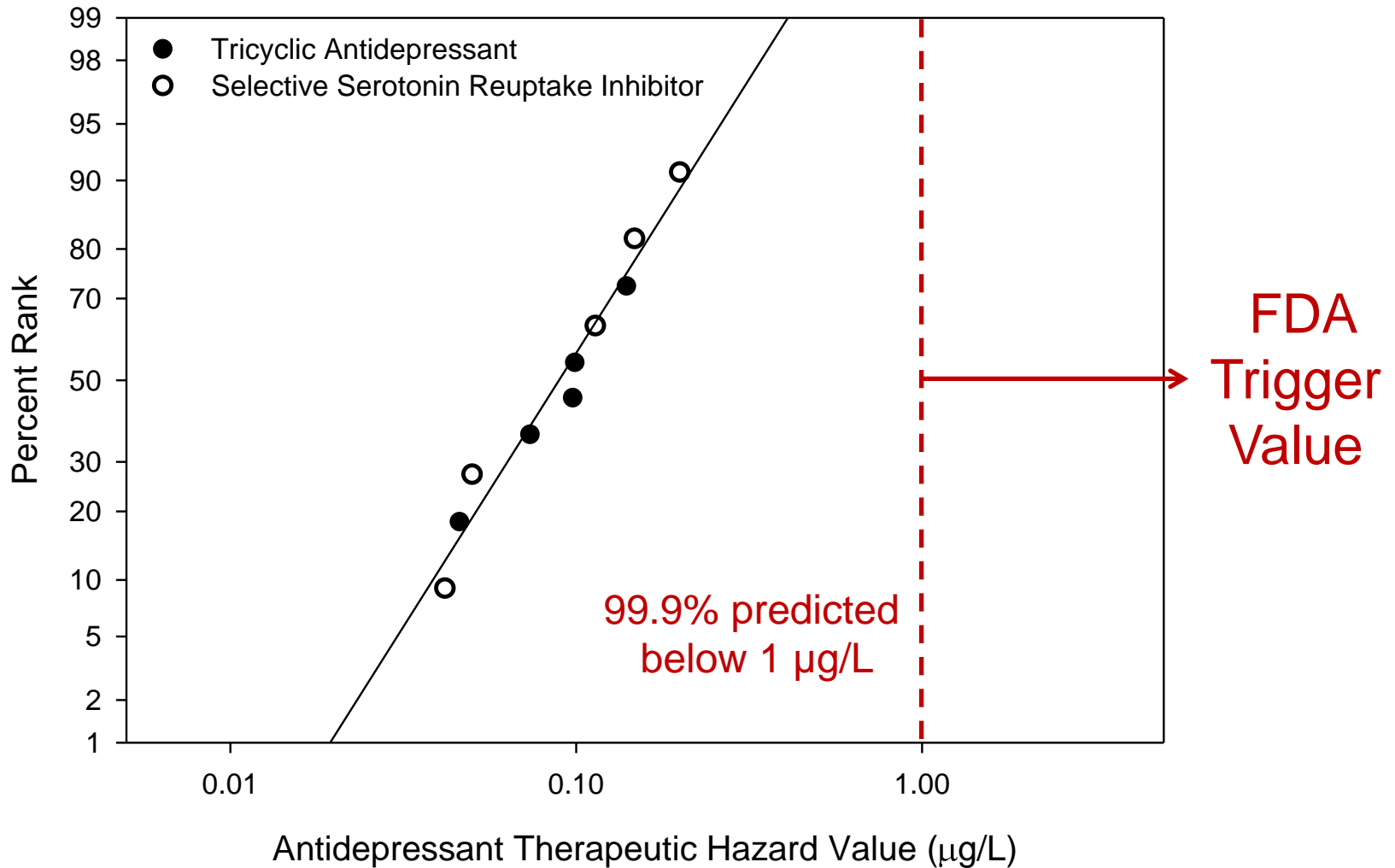
The THV represents an aqueous concentration of a drug that, if exceeded, would be expected to result in a therapeutic effect in fish.

$$\text{THV} = C_{\text{max}} / \text{Log } P_{\text{Blood:Water}}$$

The THV represents an aqueous concentration of a drug that, if exceeded, would be expected to result in a therapeutic effect in fish.

$$\text{Therapeutic Hazard Ratio (THR)} = \text{Measured Environmental Concentration} / \text{THV}$$





So, where/how should they be monitored?

- Analytical methods for PPCPs vary
- Robust approaches are critical, yet costly
- Surface water grab samples are most common
- Biomonitoring (e.g., fish) is largely uncommon



And, how can decisions be informed?

- PPCPs challenge existing assessment paradigms
 - Representative, integrative studies of diverse landuses and inputs (e.g., municipal discharge, onsite systems, manufacturing, runoff from biosolids) are lacking
 - Ecology, Chemistry and Toxicology must inform Risk Management
 - Biological thresholds → Select appropriate mitigation
1. Prioritize PPCPs of concern. 2. Target areas for study; and 3. Translate surface water quality monitoring to support risk based decision making



And, how can decisions be informed?

- PPCPs challenge existing assessment paradigms
- Representative, integrative studies of diverse landuses and inputs (e.g., municipal discharge, onsite systems, manufacturing, runoff from biosolids) are lacking

- Ecology, Chemistry and Toxicology must inform Risk Management
 - Biological thresholds → Select appropriate mitigation
- 1. Prioritize PPCPs of concern. 2. Target areas for study; and 3. Translate surface water quality monitoring to support risk based decision making



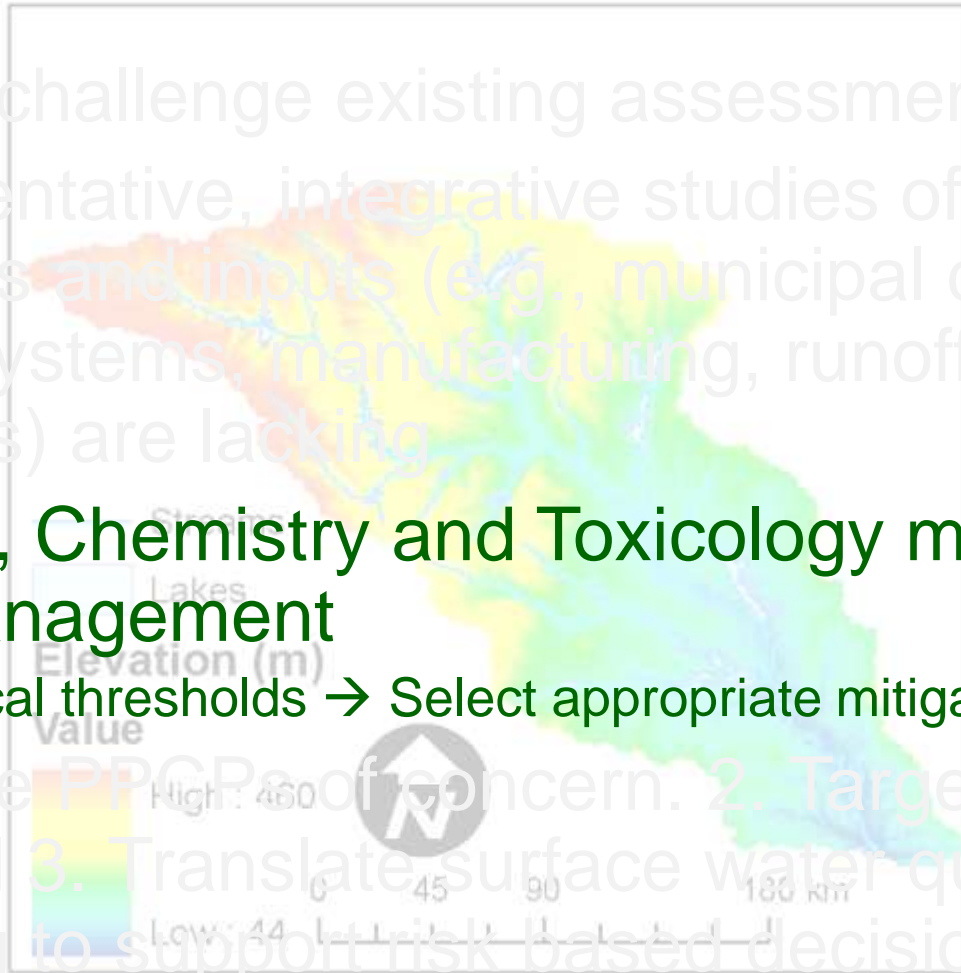
And, how can decisions be informed?

- PPCPs challenge existing assessment paradigms
- Representative, integrative studies of diverse landuses and inputs (e.g., municipal discharge, onsite systems, manufacturing, runoff from biosolids) are lacking

- **Ecology, Chemistry and Toxicology must inform Risk Management**

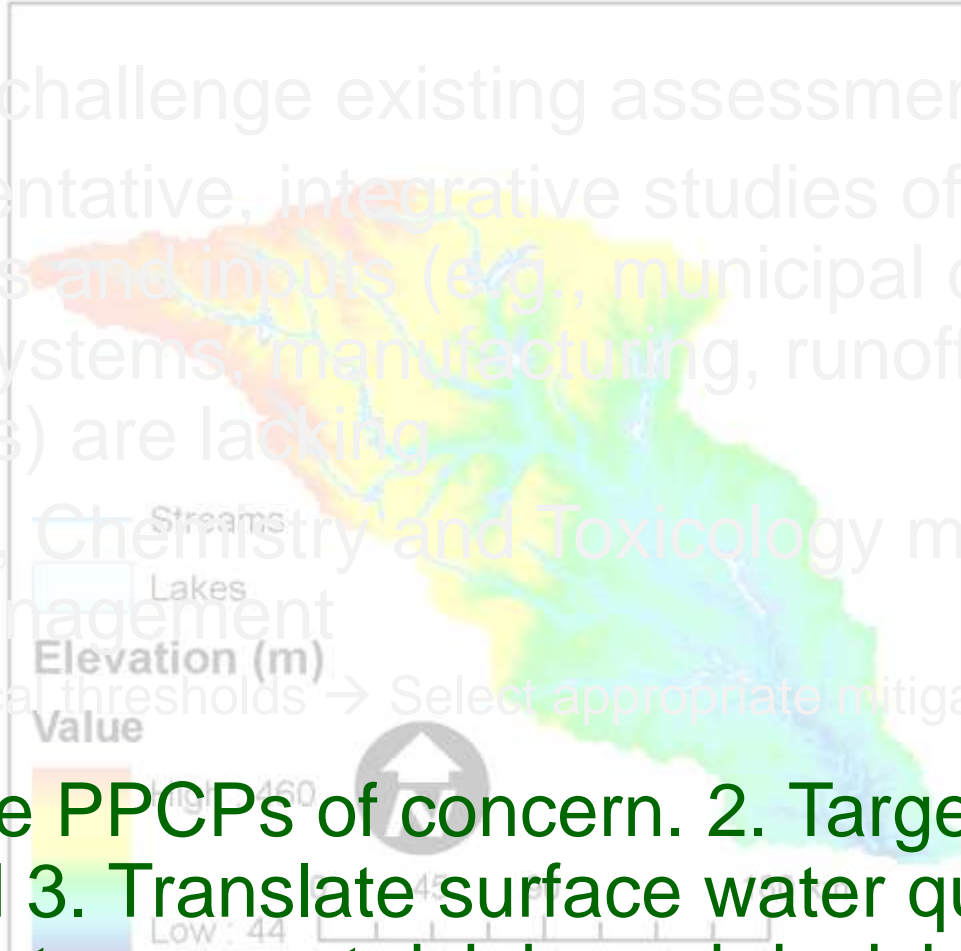
- Biological thresholds → Select appropriate mitigation

1. Prioritize PPCPs of concern.
2. Target areas for study;
- and 3. Translate surface water quality monitoring to support risk based decision making



And, how can decisions be informed?

- PPCPs challenge existing assessment paradigms
- Representative, integrative studies of diverse landuses and inputs (e.g., municipal discharge, onsite systems, manufacturing, runoff from biosolids) are lacking
- Ecology, Chemistry and Toxicology must inform Risk Management
 - Biological thresholds → Select appropriate mitigation



1. Prioritize PPCPs of concern. 2. Target areas for study; and 3. Translate surface water quality monitoring to support risk based decision making

We propose using THR values during surface water quality monitoring across gradients within and among urban estuaries to identify locations for more intensive study and potential restoration activities.

We also propose development of an environmental specimens bank of edible fish and shellfish collected across gradients within and among urban estuaries, and archived for evaluation through time to identify status and trends of CEC accumulation.

Perhaps this effort could be coordinated through the various National Estuary Programs.

We propose using THR values during surface water quality monitoring across gradients within and among urban estuaries to identify locations for more intensive study and potential restoration activities.

We also propose development of an environmental specimens bank of edible fish and shellfish collected across gradients within and among urban estuaries, and archived for evaluation through time to identify status and trends of CEC accumulation.

Perhaps this effort could be coordinated through the various National Estuary Programs.

We propose using THR values during surface water quality monitoring across gradients within and among urban estuaries to identify locations for more intensive study and potential restoration activities.

We also propose development of an environmental specimens bank of edible fish and shellfish collected across gradients within and among urban estuaries, and archived for evaluation through time to identify status and trends of CEC accumulation.

Perhaps this effort could be coordinated through the various National Estuary Programs.

- Texas Sea Grant
- TCEQ - Houston (Linda Broach, Marty Kelly)
- EPA ORD – Duluth MN (John Nichols, Russ Erickson)
- Baylor University
 - Department of Environmental Science
 - Center for Reservoir & Aquatic Systems Research
- Research Team
 - Dr. Bryan Brooks
 - Dr. Kevin Chambliss
 - Bruce Byars
 - Melissa Mullins
 - Bowen Du
 - Kristin Connors
 - Casan Scott
 - Samuel Haddad
 - Chris Breed
 - Valerie Toteu-Djomte



