UNIVERSITY of WISCONSIN
Superior

Baylor University
PyPhD

An educational expedition from the shores of Lake Superior to central Texas

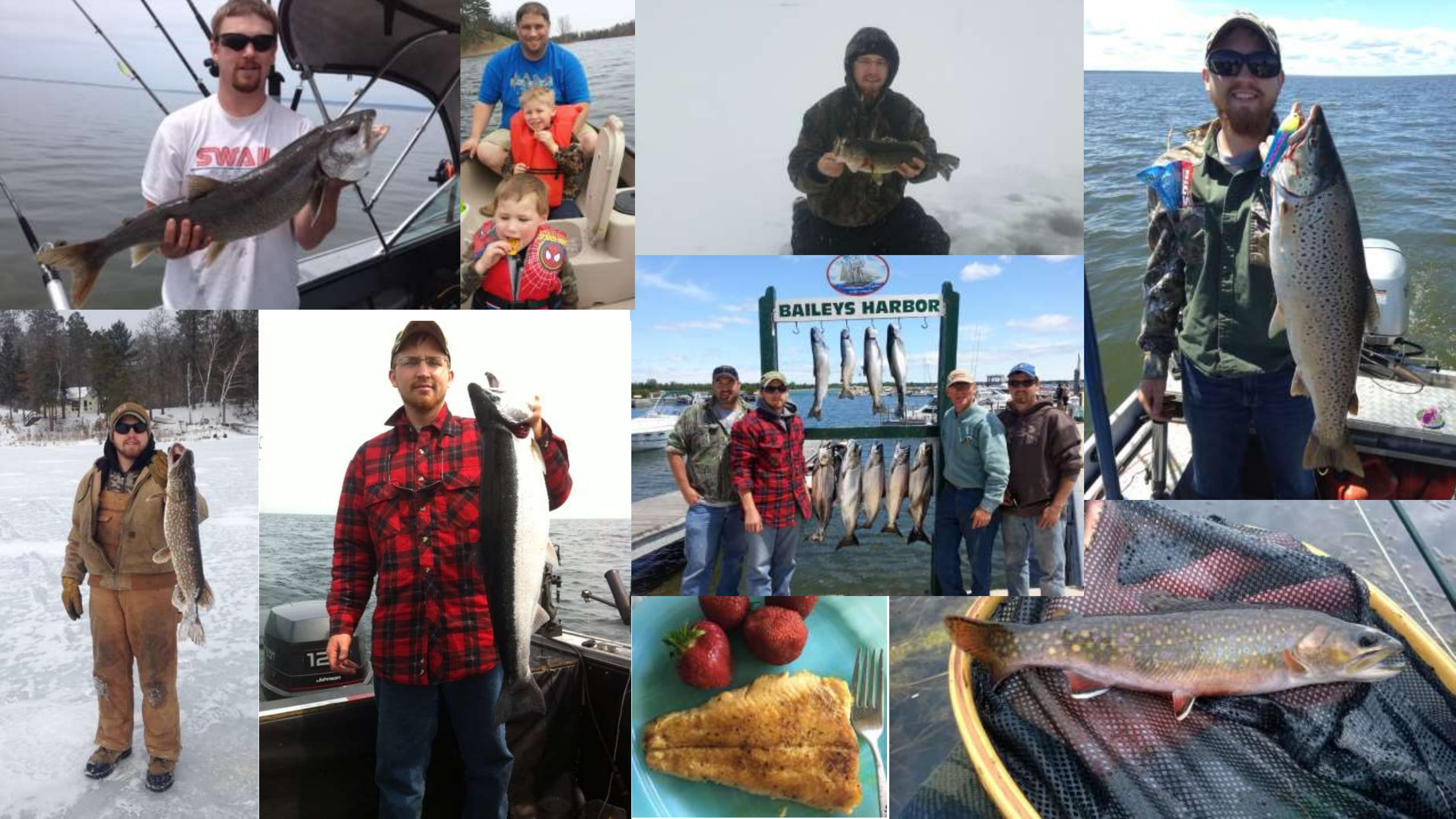
Gavin Saari

PhD Candidate Baylor University

March 9, 2018

BAYLOR | Environmental Science
College of Arts and Sciences
1845

total loss, with crew
stranded boat
20 40 60 80 100 Miles
MINNESOTA
Lake Superior
ONTARIO
Thunder Bay
Leafield
Scottish Hero (loc. unknown)
Turret Chief
L.C. Waldo
Keweenaw Bay
William Nottingham
Duluth
Superior
Henry B. Smith
Huronic
Major
F.A. Hartwell
Whitefish Bay
Sault Ste. Marie
Marquette
J.T. Hutchinson
St. Marys River
Meaford
MICHIGAN
Plymouth
Halsted
Louisiana
Lake Huron
Georgian Bay
Isaac M. Scott
Thunder Bay
A.E. Stewart
John A. McGean
J.M. Jenks
WISCONSIN
Green Bay
Lake Michigan
Matoa
Argus
Howard M. Hanna Jr.
Regina
Saginaw Bay
D.O. Mills
James Carruthers
Hydrus
Wexford
Bay City
Matthew Andrews
Charles S. Price
Northern Queen
H.A. Hawgood
Lake Ontario
Milwaukee
Waukesha
St. Clair River
Buffalo
Lightship 82
C.W. Elphicke
NEW YORK
Saxona
Lake St. Clair
Detroit
W.G. Pollock
IOWA
Detroit River
Victory
Fulton
Lake Erie
Erie
Chicago
G.J. Grammer
Donaldson
Toledo
Sandusky
Lorain
Cleveland
PENNSYLVANIA
ILLINOIS
INDIANA
OHIO


BAILEYS HARBOR

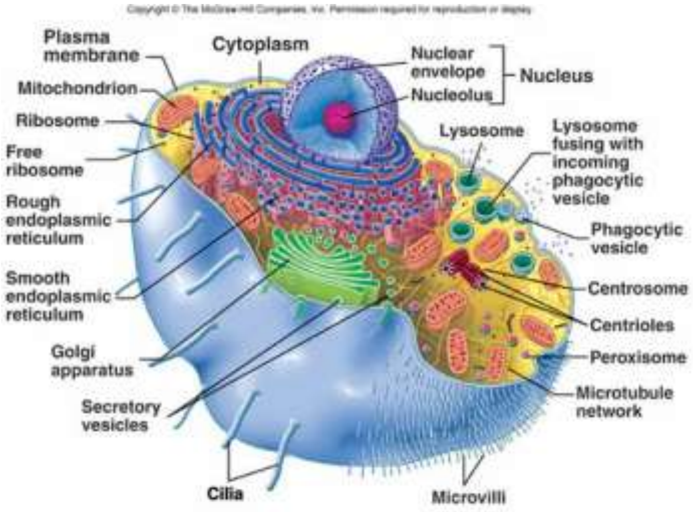
Bachelor of Science

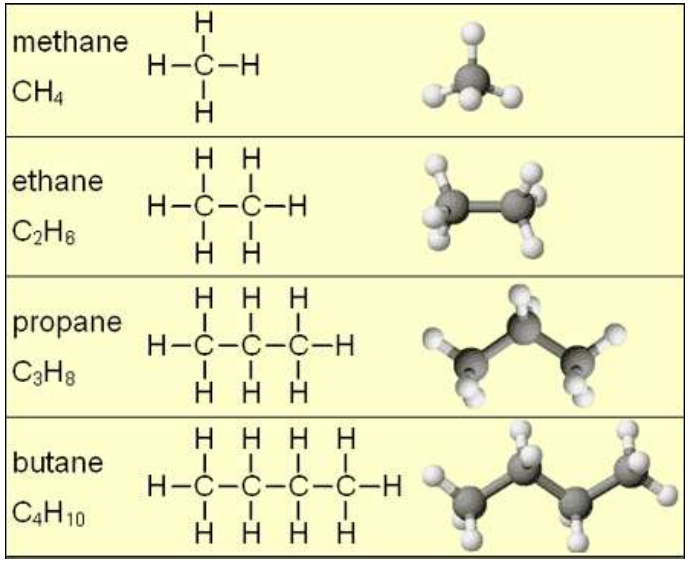
Biology Major
Chemistry Minor

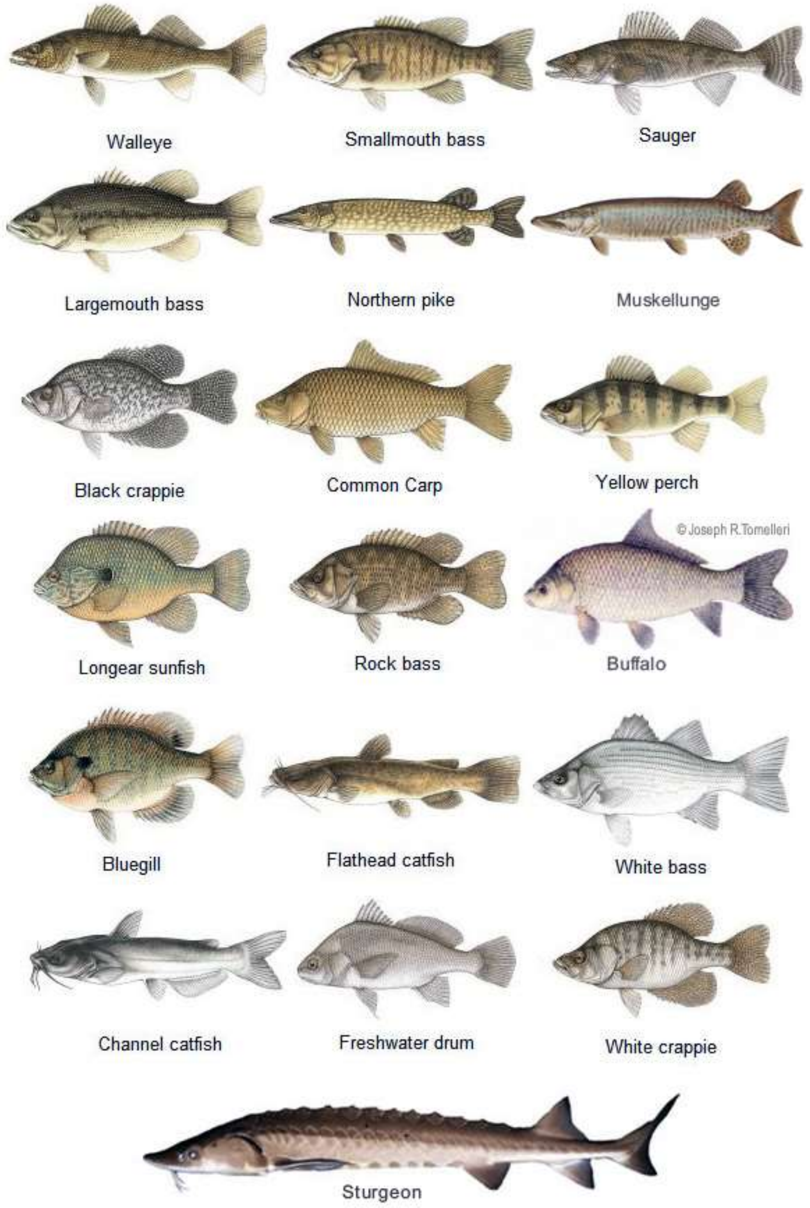
Core/Elective Classes

Genetics
Ecology
Cell Biology
Limnology
Animal Physiology
Ichthyology
Fish Population Ecology and Management

General Chemistry I
General Chemistry II
Organic Chemistry I and II
Spectroscopy
Water Chemistry







Core/Elective Classes

Genetics
Ecology
Cell Biology
Limnology
Animal Physiology
Ichthyology
Fish Population Ecology and
 Management

General Chemistry I
General Chemistry II
Organic Chemistry I and II
Spectroscopy
Water Chemistry

58-foot all-steel retired tug boat
Research equipment
Hydraulic sediment dredge and fish trawling

Lake Superior Research Institute

- News and Events
- Directory
- Services Provided
- Research Projects
- Publications
- Forms and Documents
- Employment
- Contact Us
- Photos
- Site Map and Search

Lake Superior Research Institute

The Lake Superior Research Institute (LSRI) was created in 1967 and formally recognized by the University of Wisconsin's Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Expertise

- Analytical chemistry
- Aquatic invasive species monitoring and outreach
- Benthic and zooplankton taxonomy
- Habitat restoration
- Microbiology
- Sediment and aquatic toxicology
- Quality assurance and data management

APPLY | SCHEDULE A VISIT | REQUEST INFORMATION

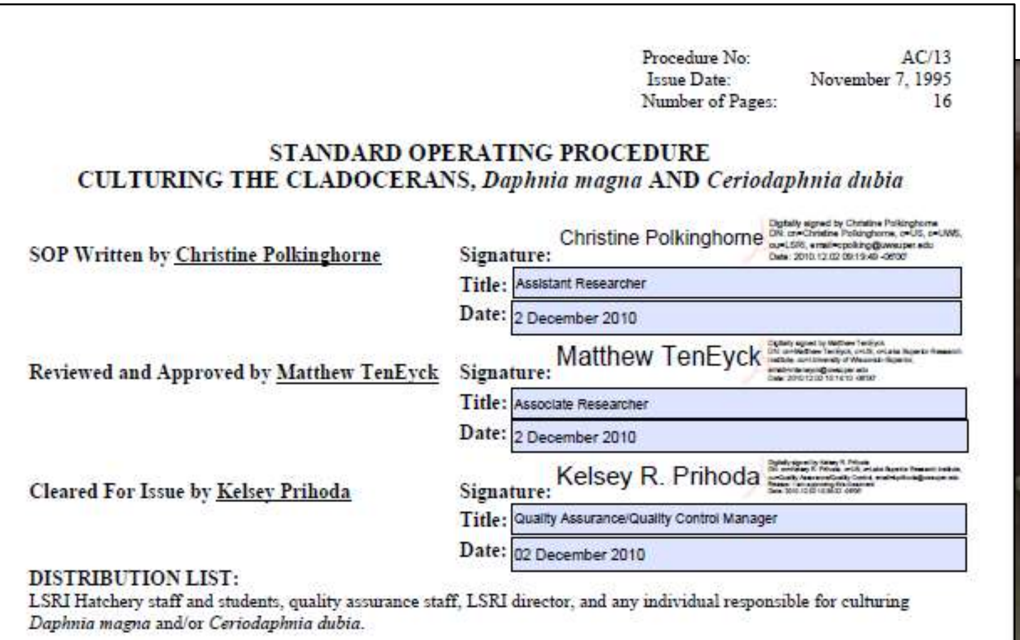
Lake Superior Research Institute (LSRI)

General lab procedures/techniques

Standard Operating Procedures (SOPs)

Culturing standard model organism

Reference toxicity tests (KCl)- healthy organisms?



Procedure No: AC/13
Issue Date: November 7, 1995
Number of Pages: 16

STANDARD OPERATING PROCEDURE
CULTURING THE CLADOCERANS, *Daphnia magna* AND *Ceriodaphnia dubia*

SOP Written by Christine Polkinghorne — Signature: Christine Polkinghorne
Digitally signed by Christine Polkinghorne DN: cn=Christine Polkinghorne, c=US, o=UWS, ou=LSRI, email=cpolking@uwsuper.edu Date: 2010.12.02 09:19:49 -06'00'
Title: Assistant Researcher
Date: 2 December 2010

Reviewed and Approved by Matthew TenEyck — Signature: Matthew TenEyck
Title: Associate Researcher
Date: 2 December 2010

Cleared For Issue by Kelsey Prihoda — Signature: Kelsey R. Prihoda
Title: Quality Assurance/Quality Control Manager
Date: 02 December 2010

DISTRIBUTION LIST:
LSRI Hatchery staff and students, quality assurance staff, LSRI director, and any individual responsible for culturing *Daphnia magna* and/or *Ceriodaphnia dubia*.

Lake Superior Research Institute- model organisms

Green Algae- *Selenastrum capricornutum*

Zooplankton- *Brachionus calyciflorus*

https://www.youtube.com/watch?v=FRZ64_lZf_8

Lake Superior Research Institute- model organisms

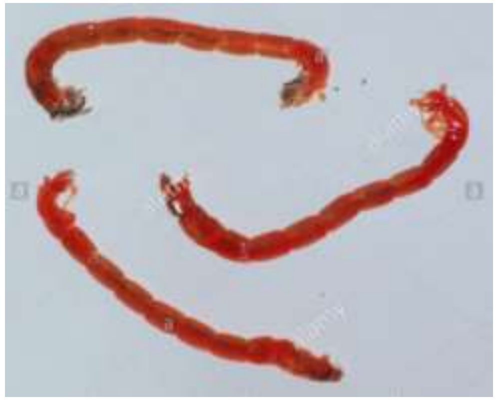
Waterflea- *Daphnia magna*

Waterflea- *Ceriodaphnia dubia*

Zooplankton- *Eucyckops sp*

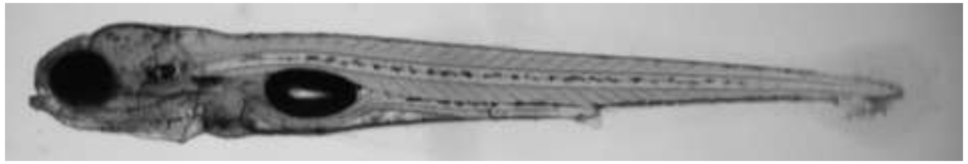
Freshwater shrimp- *Hyalella Azteca*

Aquatic worm- *Lumbriculus vatirgatus*



Bloodworm- *Chironomus dilutus*

Lake Superior Research Institute- Toxicity Testing



UNIVERSITY of WISCONSIN Superior

Lake Superior Research Institute

Procedure No: AT/19
Revision No. 2: October 30, 2015
Page 1 of 5

STANDARD OPERATING PROCEDURE

CONDUCTING A 28-DAY BIOACCUMULATION SEDIMENT TOXICITY TEST WITH THE OLIGOCHAETE, *LUMBRICULUS VARIEGATUS*

SOP Written by Christine Polkinghorne — **Signature:** Christine N. Polkinghorne
Title: Associate Researcher
Date: 30-Oct-2015

Reviewed and Approved by Matthew TenEyck — **Signature:** Matthew TenEyck
Title: Assistant Scientist
Date: 30-Oct-2015

Cleared For Issue by Kelsey Prihoda — **Signature:** Kelsey Prihoda
Title: Quality Assurance Manager
Date: 16-Nov-2015

Freshwater Ballast Testing Facility and Other Projects

Ballast Water Treatment

- Four 50,000 gl tanks
- Follow ships and sample ballast water at ports

Chemical monitoring in fish tissue, wild rice, and mussels

Effects of Pollutants to aquatic organisms

Survey of native and invasive plants


6201
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
MID-CONTINENT ECOLOGY DIVISION
DULUTH

U.S. Environmental Protection Agency (EPA) Mission: to protect human health and the environment

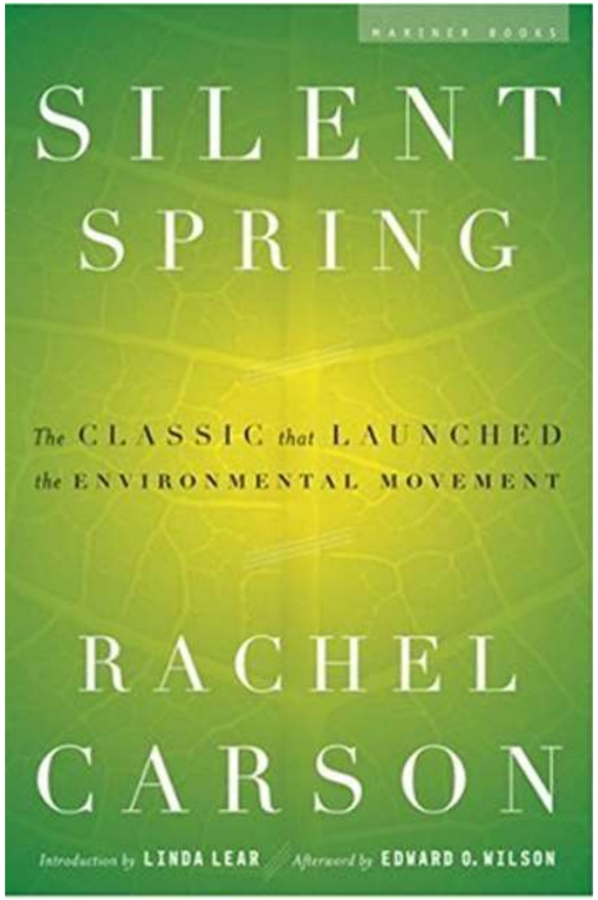
Mid-Continent Ecology Division (MED)- National Health and Environmental Effects Research Laboratory (Duluth, MN)

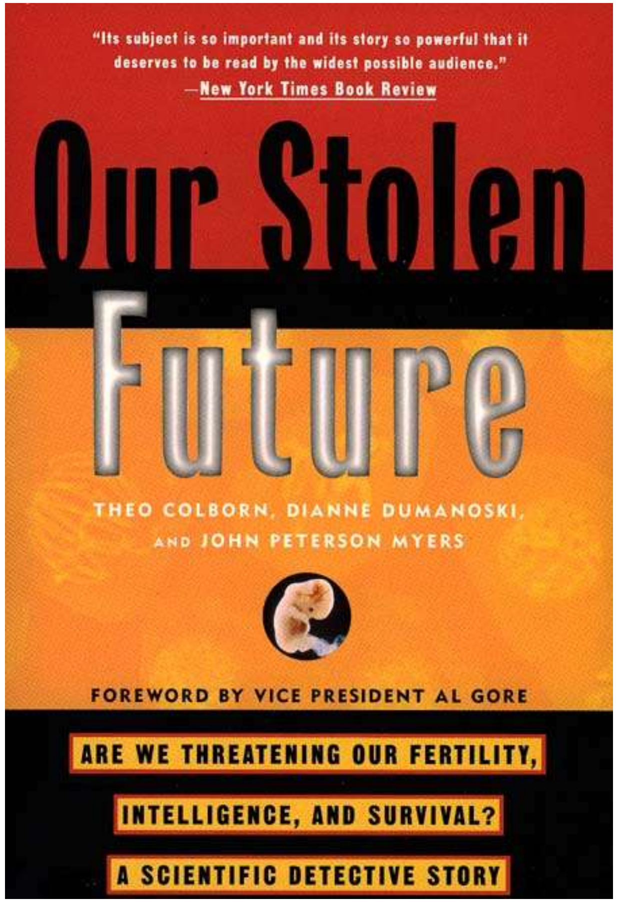
- Forecast the effects of pollutants on the integrity of watersheds and freshwater ecosystems
- Characterize adverse outcome pathways of toxic exposure at multiple scales and levels of biological organization
- Link environmental condition to human health and well being

1990's - scientists proposed that certain chemicals might be disrupting the endocrine systems of humans and wildlife

Congress passed Food Quality Protection Act with amended the Federal Food, Drug, and Cosmetic Act and the Safe Drinking Water Act (1996)

What should we do? Screen pesticide chemicals for potential produced effects similar to those by the female hormones (estrogen) in humans and screen other chemicals for all types of endocrine effects





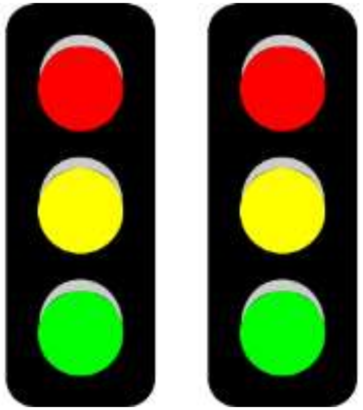
ToxCast™- 2007- High Throughput Assays (HTA) and Computational Tools

Expose cells and proteins to chemicals…changes in biological activity?
~1800 chemicals and ~700 HTAs

Toxicology Testing in the 21st Century (Tox21)

Collaboration between EPA, NIH, and FDA
10,000 chemicals; 50 quantitative HTAs

Effects of chemicals on cellular, molecular, and biochemical processes



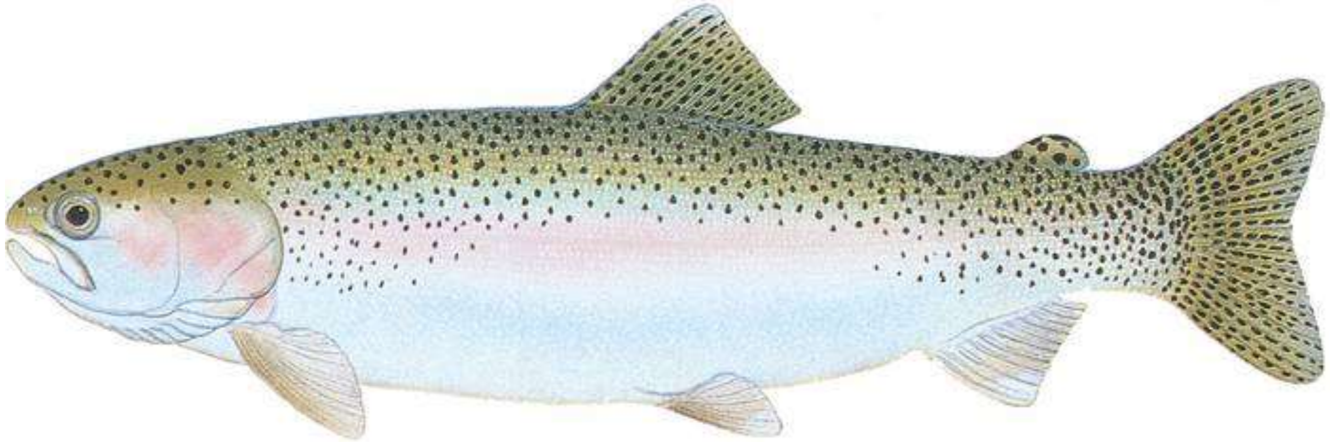
Biologist- Student Contractor for the U.S. EPA

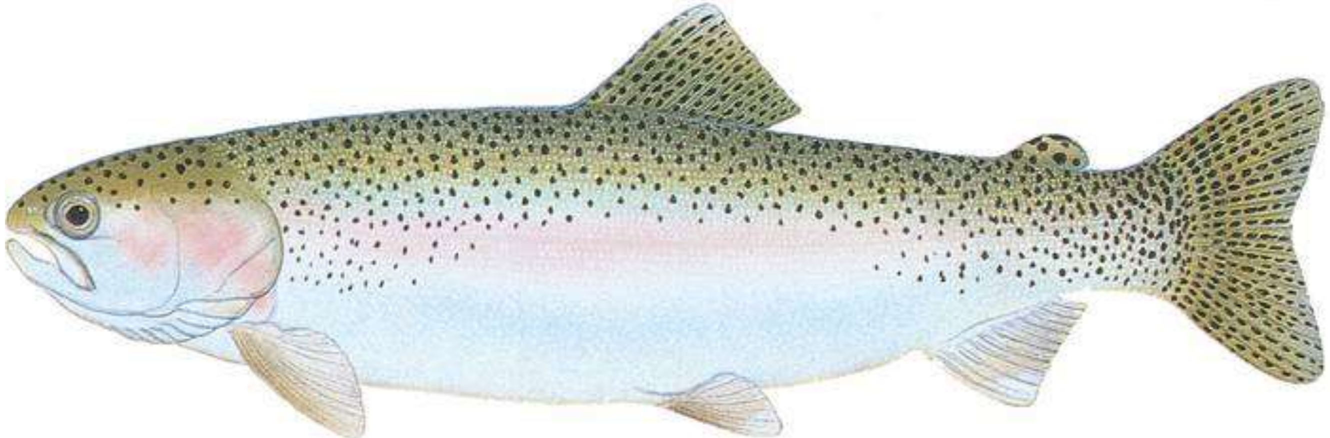
Environ. Sci. Technol. **2004**, *38*, 6333–6342

Use of Trout Liver Slices To Enhance Mechanistic Interpretation of Estrogen Receptor Binding for Cost-Effective Prioritization of Chemicals within Large Inventories

PATRICIA K. SCHMIEDER,[*,†]
MARK A. TAPPER,[†] JEFFREY S. DENNY,[†]
RICHARD C. KOLANCZYK,[†]
BARBARA R. SHEEDY,[†]
TALA R. HENRY,[‡] AND
GILMAN D. VEITH[§]

U.S. EPA, ORD, NHEERL, Mid-Continent Ecology Division, 6201 Congdon Boulevard, Duluth, Minnesota 55804, U.S. EPA, Office of Water/OST, 1299 Pennsylvania Avenue NW, Washington, DC 20460, and International QSAR Foundation to Reduce Animal Testing, Two Harbors, Minnesota 55616





Graduate School- Baylor University

BAYLOR | Environmental Science
College of Arts and Sciences

PERGAMON

Chemosphere 52 (2003) 135–142

www.elsevier.com/locate/chemosphere

Waterborne and sediment toxicity of fluoxetine to select organisms

Bryan W. Brooks [a,b,*], Philip K. Turner [a], Jacob K. Stanley [a], James J. Weston [c],

Short communication

Aquatic ecotoxicology of fluoxetine

Bryan W. Brooks [a,1,*], Christy M. Foran [b], Sean M. Richards [c,2], James Weston [d], Philip K. Turner [a], Jacob K. Stanley [a], Keith R. Solomon [c], Marc Slattery [d], Thomas W. La Point [a]

Fish on Prozac (and Zoloft): Ten years later

CrossMark

Bryan W. Brooks *

Department of Environmental Science, Institute of Biomedical Studies, Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, TX, USA

Graduate School- Baylor University

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)

- Consumer product and other chemical use is concentrated in cities…

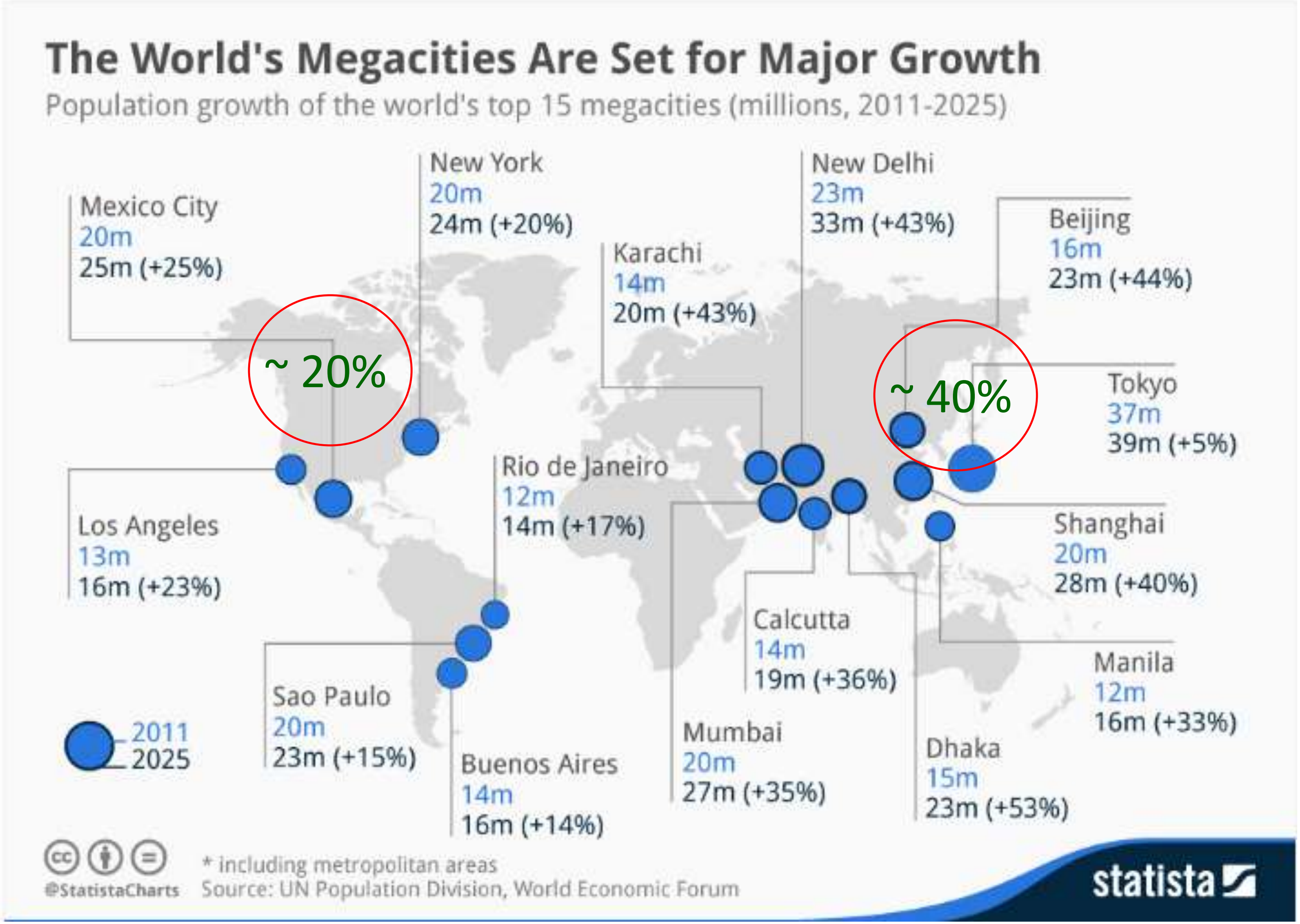
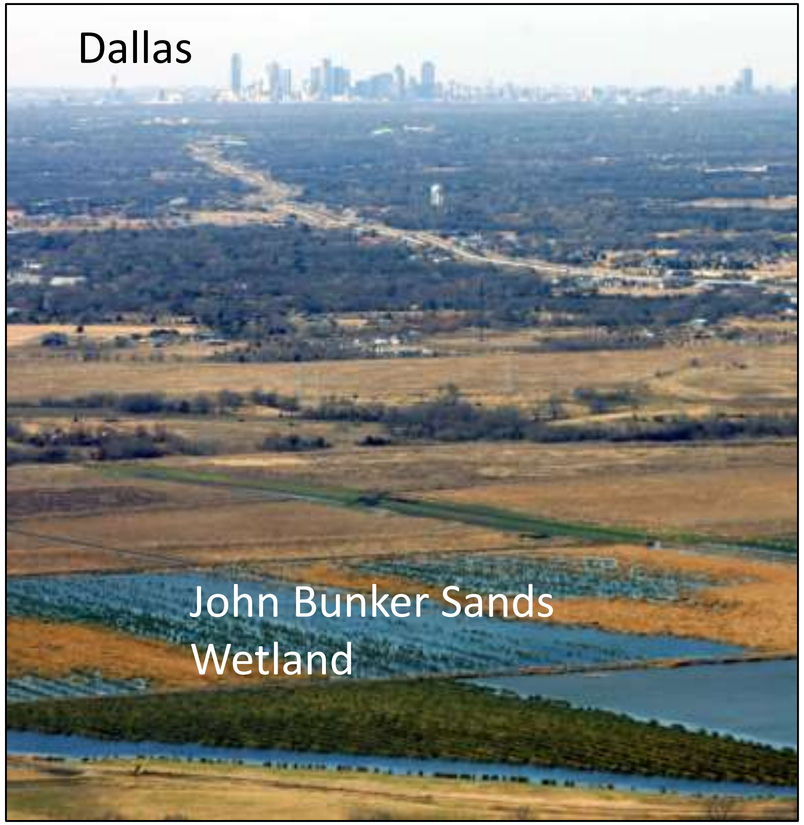
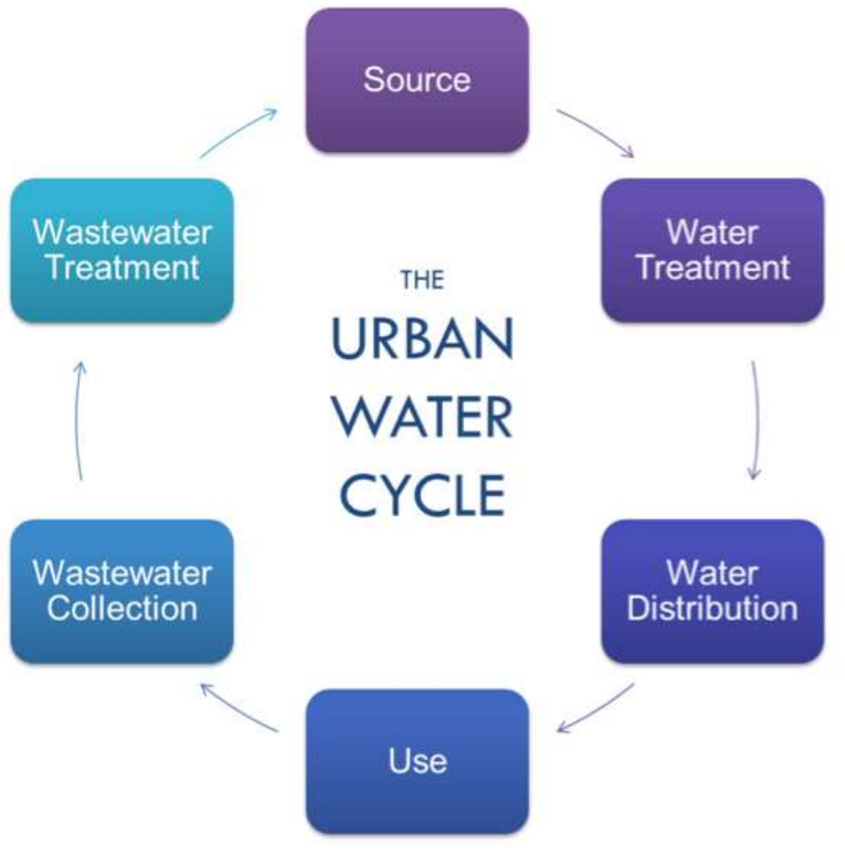


Photo Credit: https://www.statista.com

The Urban Water Cycle is the New Normal





INNOVATIONS IN THE FACE OF CLIMATE CHANGE

Wastewater-effluent-dominated streams as ecosystem-management tools in a drier climate

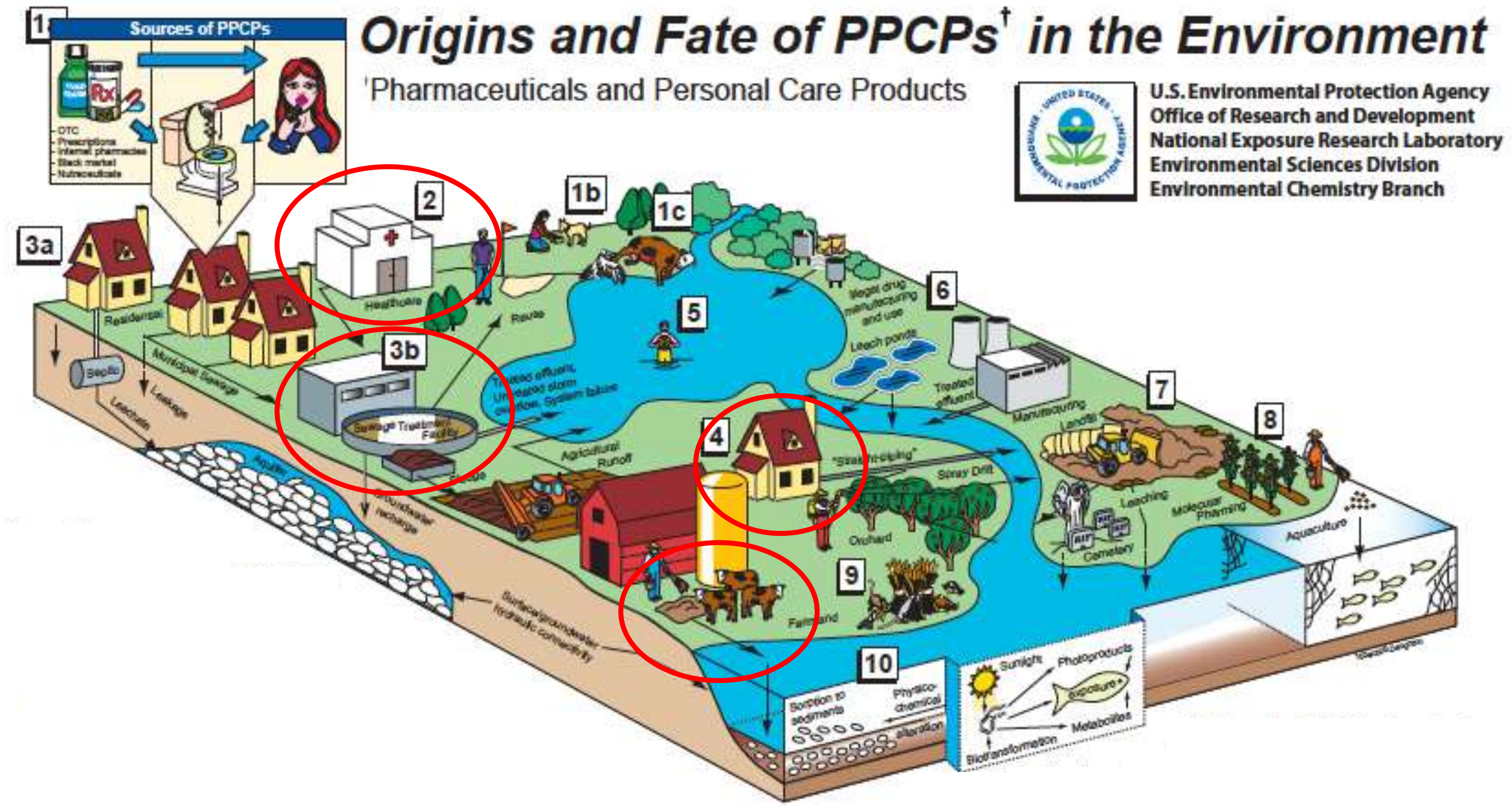
Richard G Luthy[1,2*], David L Sedlak[1,3], Megan H Plumlee[1,4], David Austin[1,5], and Vincent H Resh[1,6]

The Urban Water Cycle is the New Normal

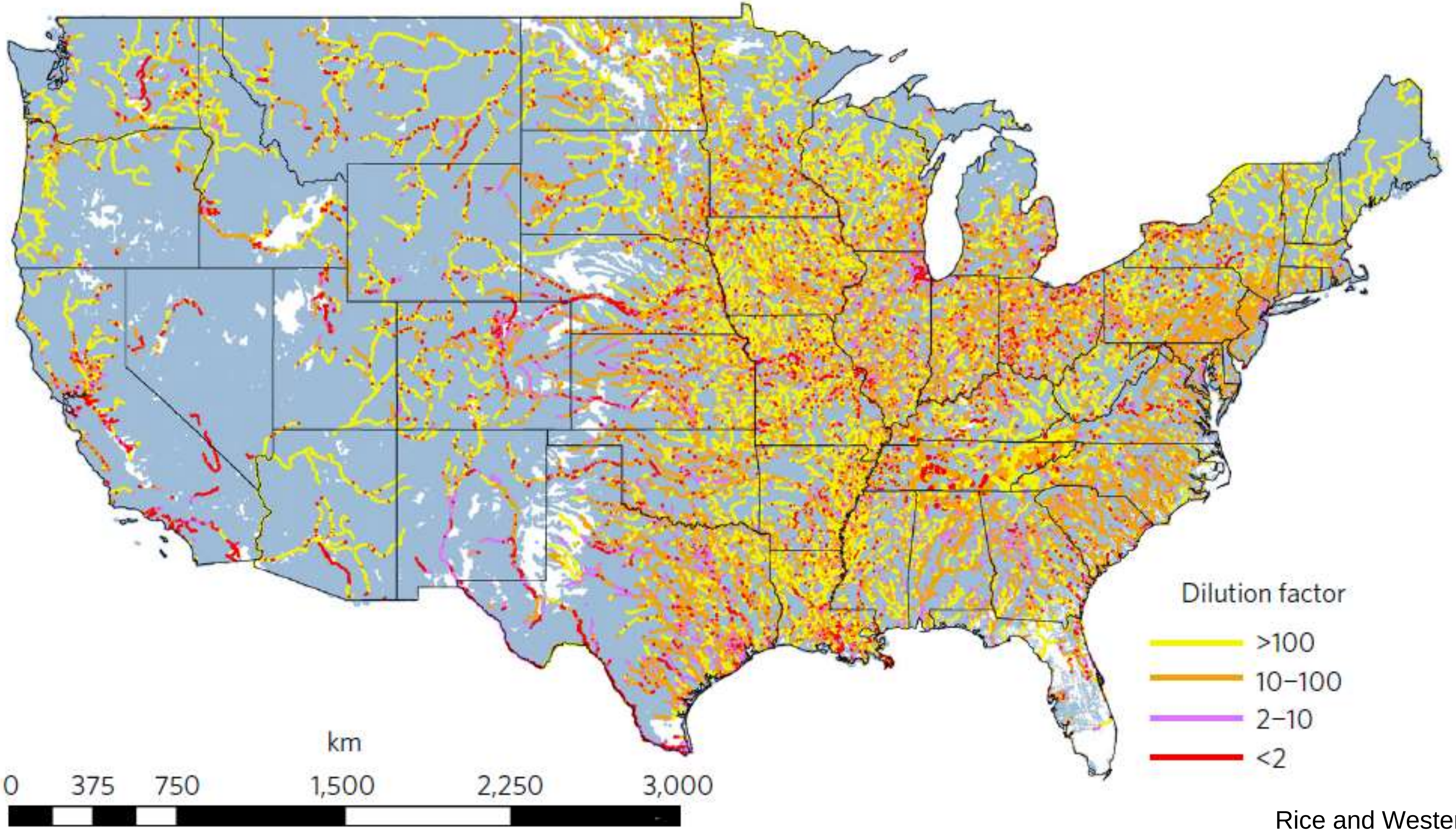
River base flows are increasingly dominated/dependent upon wastewater treatment plant discharges

The Urban Water Cycle is the New Normal

River base flows are increasingly dominated/dependent upon wastewater treatment plant discharges


Origins and Fate of PPCPs† in the Environment
†Pharmaceuticals and Personal Care Products
U.S. Environmental Protection Agency
Office of Research and Development
National Exposure Research Laboratory
Environmental Sciences Division
Environmental Chemistry Branch
1a
Sources of PPCPs
-OTC
-Prescriptions
-Internet pharmacies
-Black market
-Nutraceuticals
Rx
1b
1c
2
Healthcare
3a
Residential
Septic
Leakage
Leachate
Municipal Sewage
Aquifer
3b
Sewage Treatment Facility
Sludge
Groundwater recharge
Treated effluent, Untreated storm overflow, System failure
Reuse
Agricultural Runoff
Surface/groundwater hydraulic connectivity
4
"Straight-piping"
Spray Drift
Orchard
Farmland
5
6
Illegal drug manufacturing and use
Leach ponds
Treated effluent
Manufacturing
7
Landfill
Leaching
Cemetery
8
Molecular Pharming
Aquaculture
9
10
Sorption to sediments
Physico-chemical alteration
Sunlight
Photoproducts
Exposure
Metabolites
Biotransformation

High Levels of endocrine pollutants in US streams during low flow due to insufficient wastewater dilution



Rice and Westerhoff, 2017

Are they present in the environment?

Pharmaceuticals and Personal Care Products in the Environment

OCCURRENCE OF PHARMACEUTICALS AND PERSONAL CARE PRODUCTS IN FISH: RESULTS OF A NATIONAL PILOT STUDY IN THE UNITED STATES

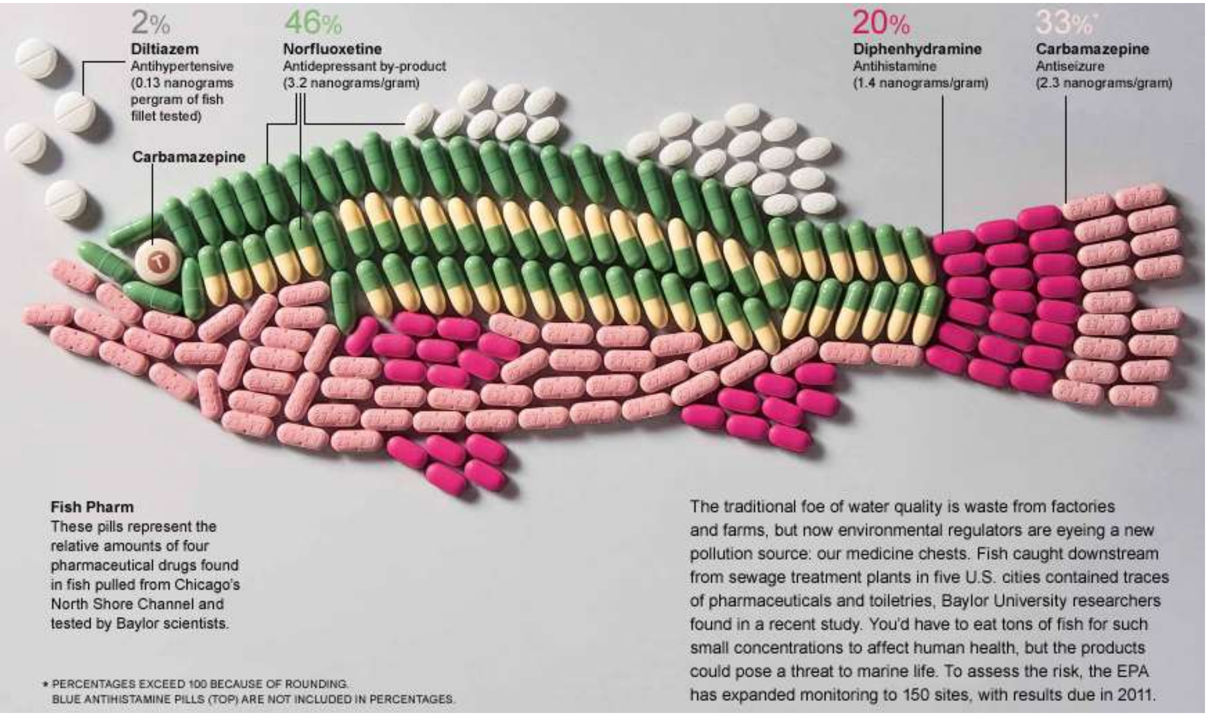
ALEJANDRO J. RAMIREZ,†§ RICHARD A. BRAIN,‡§ SASCHA USENKO,‡§ MOHAMMAD A. MOTTALEB,†§ JOHN G. O'DONNELL,‖ LEANNE L. STAHL,# JOHN B. WATHEN,# BLAINE D. SNYDER,‖ JENNIFER L. PITT,‖ PILAR PEREZ-HURTADO,† LAURA L. DOBBINS,‡§ BRYAN W. BROOKS,‡§ and C. KEVIN CHAMBLISS*†§
†Department of Chemistry and Biochemistry, ‡Department of Environmental Science, §Center for Reservoir and Aquatic Systems Research, Baylor University, One Bear Place 97348, Waco, Texas 76798, USA
‖Tetra Tech, Center for Ecological Sciences, 400 Red Brook Boulevard, Suite 200, Owings Mills, Maryland 21117, USA
#U.S. Environmental Protection Agency, Office of Water, Office of Science and Technology (4305T), 1200 Pennsylvania Avenue, Northwest, Washington, DC 20460

(*Received* 5 *November* 2008; *Accepted* 18 *February* 2009)

Integrated Environmental Assessment and Management — Volume 9999, Number 9999—pp. 1–12
© 2014 SETAC 1

Exposure and Food Web Transfer of Pharmaceuticals in Ospreys (*Pandion haliaetus*): Predictive Model and Empirical Data

Rebecca S Lazarus,†‡ Barnett A Rattner,† Bryan W Brooks,§ Bowen Du,§ Peter C McGowan,‖ Vicki S Blazer,# and Mary Ann Ottinger‡††*
†US Geological Survey, Patuxent Wildlife Research Center, Beltsville, Maryland
‡Marine-Estuarine Environmental Sciences Program and Department of Animal and Avian Sciences, University of Maryland, College Park, Maryland
§Department of Environmental Science, Center for Reservoir and Aquatic Systems Research, The Institute of Ecological, Earth and Environmental Sciences, Baylor University, Waco, Texas
‖US Fish and Wildlife Service, Chesapeake Bay Field Office, Annapolis, Maryland
#US Geological Survey, Leetown Science Center, Kearneysville, West Virginia
††Department of Biology and Biochemistry, University of Houston, Houston, Texas



Physiochemical characteristics- pharmaceuticals

K_{ow} - Octanol-water partition coefficient

Water solubility

$t_{½}$ - Clearance and elimination

pKa – dissociation constant, 50:50% neutral and ionized)

Bioconcentration Factor (BCF) = [tissue] / [water]

- Exposure via water across gills

Bioaccumulation Factor (BAF) = [tissue] / [diet]

- Exposure via water and diet or all routes

Nichols et al. 2015

Physiochemical characteristics- pharmaceuticals

K_{ow} - Octanol-water partition coefficient

Water solubility

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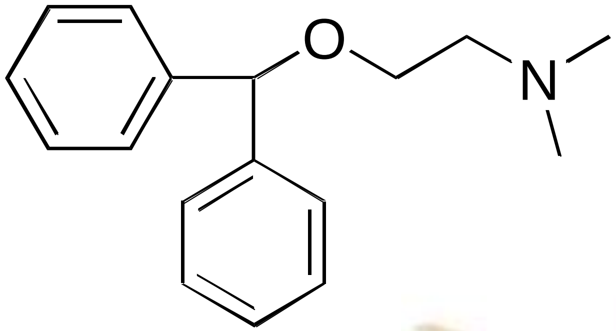
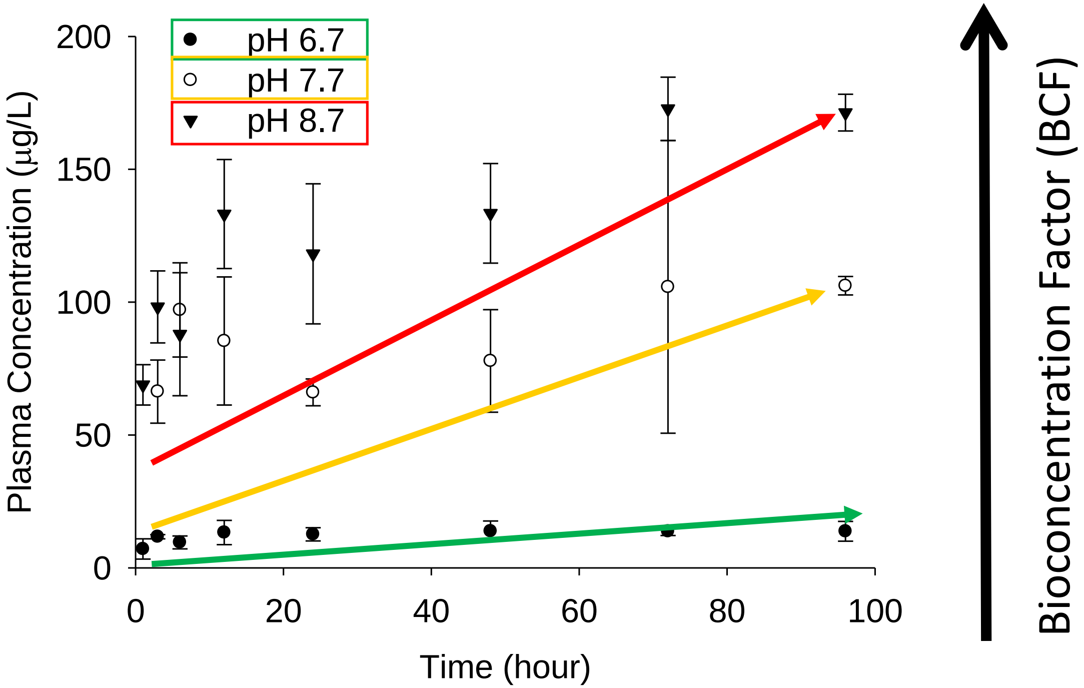
pKa – dissociation constant, 50:50% neutral and ionized)



Diphenhydramine

Bioconcentration Factor (BCF) = [tissue] / [water]
- Exposure via water across gills

Bioaccumulation Factor (BAF) = [tissue] / [diet]
- Exposure via water and diet or all routes



Nichols et al. 2015

Effects in organisms?

Enantiospecific sublethal effects of the antidepressant fluoxetine to a model aquatic vertebrate and invertebrate

Jacob K. Stanley [a,b,*], Alejandro J. Ramirez [a,c], C. Kevin Chambliss [a,c], Bryan W. Brooks [a,d]

[a] *Center for Reservoir and Aquatic Systems Research, Baylor University, One Bear Place # 97266, Waco, TX 76798-7266, United States*
[b] *Department of Biology, Baylor University, One Bear Place # 97266, Waco, TX 76798-7266, United States*
[c] *Department of Chemistry and Biochemistry, Baylor University, One Bear Place # 97266, Waco, TX 76798-7266, United States*
[d] *Department of Environmental Studies, Baylor University, One Bear Place # 97266, Waco, TX 76798-7266, United States*

Received 13 November 2006; received in revised form 19 April 2007; accepted 29 April 2007
Available online 19 June 2007

EFFECTS OF THE ANTIHISTAMINE DIPHENHYDRAMINE ON SELECTED AQUATIC ORGANISMS

JASON P. BERNINGER,*† BOWEN DU,‡ KRISTIN A. CONNORS,† STEPHANIE A. EYTCHESON,§ MARK A. KOLKMEIER,§ KRISTA N. PROSSER,§ THEODORE W. VALENTI JR.,‡ C. KEVIN CHAMBLISS,‡§|| and BRYAN W. BROOKS†‡§

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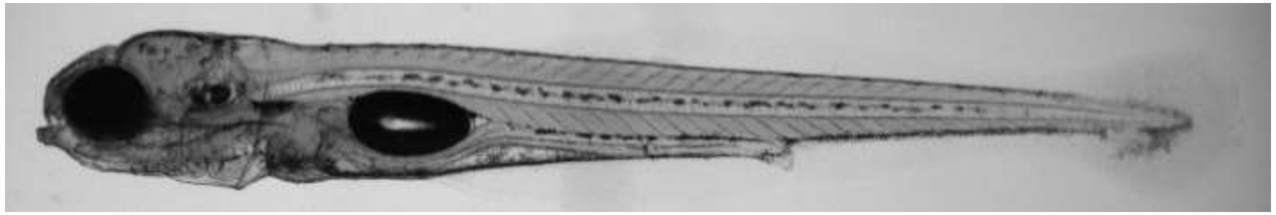
‡Institute of Ecological, Earth, and Environmental Sciences, Baylor University, Waco, Texas, USA
§Department of Environmental Science, Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, Texas, USA
||Department of Chemistry and Biochemistry, Baylor University, Waco, Texas, USA

(*Submitted* 2 *February* 2011; *Returned for Revision* 6 *April* 2011; *Accepted* 11 *May* 2011)



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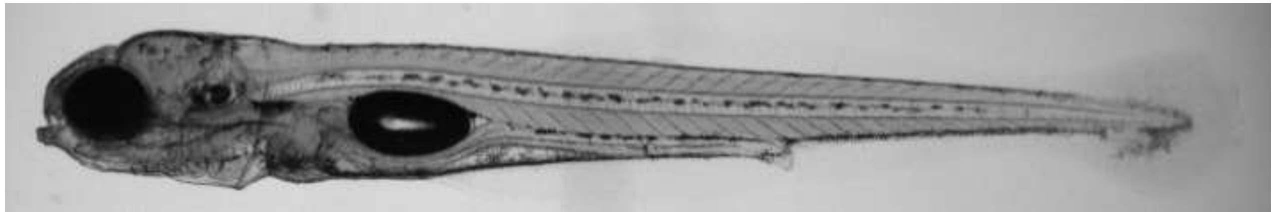
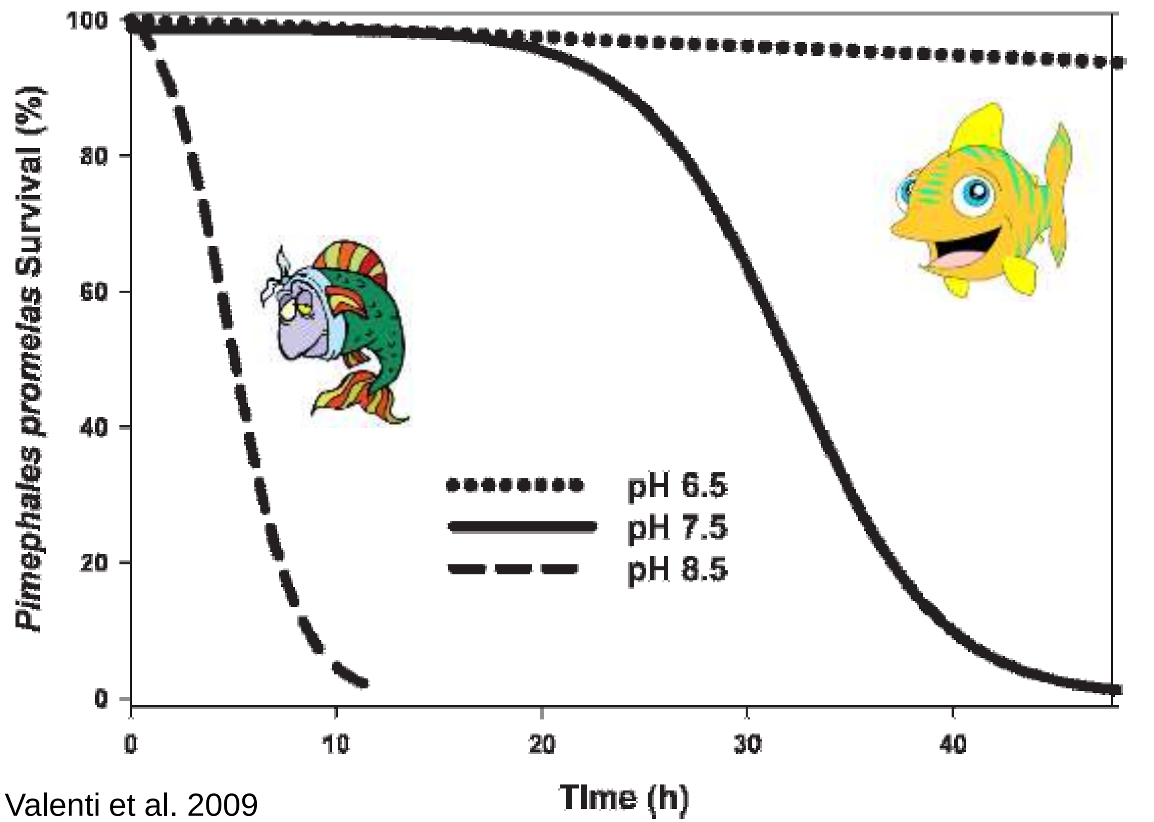




Valenti et al. 2009

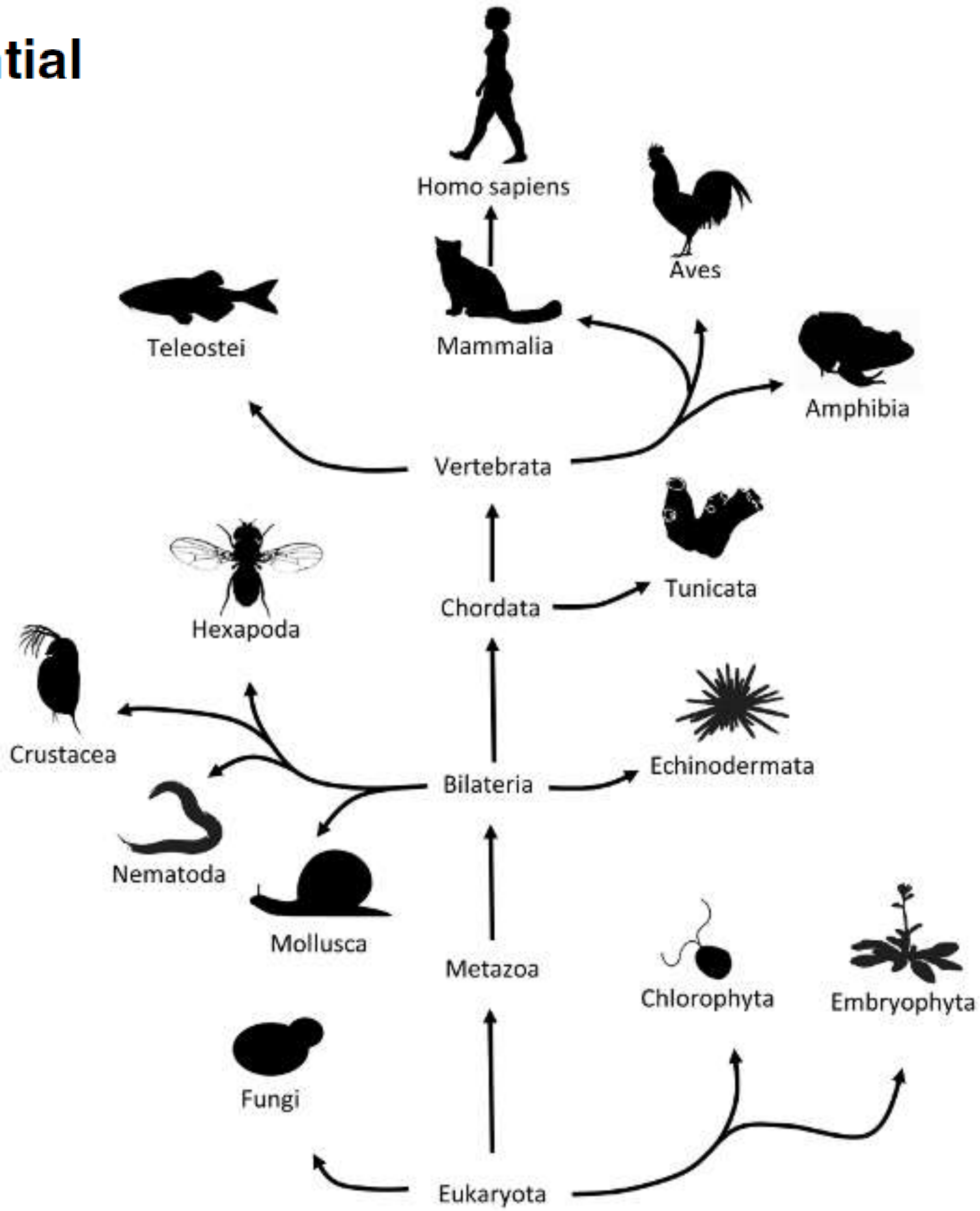
A Theoretical Model for Utilizing Mammalian Pharmacology and Safety Data to Prioritize Potential Impacts of Human Pharmaceuticals to Fish

2003

D. B. Huggett, J. C. Cook, J. F. Ericson, and R. T. Williams
Pfizer Global Research and Development, Groton, Connecticut, USA

ECOdrug

1				**Target_name**	**Sodium-dependent serotonin trar**
2				**interaction**	**inhibitor**
3				**UniProt_ID**	P31645
4	teleostei	Astyanax mexicanus	blind cave fish	7994	TRUE (70.1 %)
5	teleostei	Danio rerio	leopard danio	7955	TRUE (68.3 %)
6	teleostei	Gadus morhua		8049	TRUE (68.6 %)
7	teleostei	Gasterosteus aculeatus	three spined stickleback	69293	TRUE (70.1 %)
8	teleostei	Oreochromis niloticus		8128	TRUE (65.8 %)
9	teleostei	Oryzias latipes	Japanese rice fish	8090	TRUE (70 %)
10	teleostei	Poecilia formosa		48698	TRUE (70.3 %)
11	teleostei	Scleropages formosus	Asian arowana	113540	TRUE (62 %)
12	teleostei	Takifugu rubripes	tiger puffer	31033	TRUE (66.6 %)
13	teleostei	Tetraodon nigroviridis		99883	TRUE (65.6 %)
14	teleostei	Xiphophorus maculatus		8083	TRUE (66 %)



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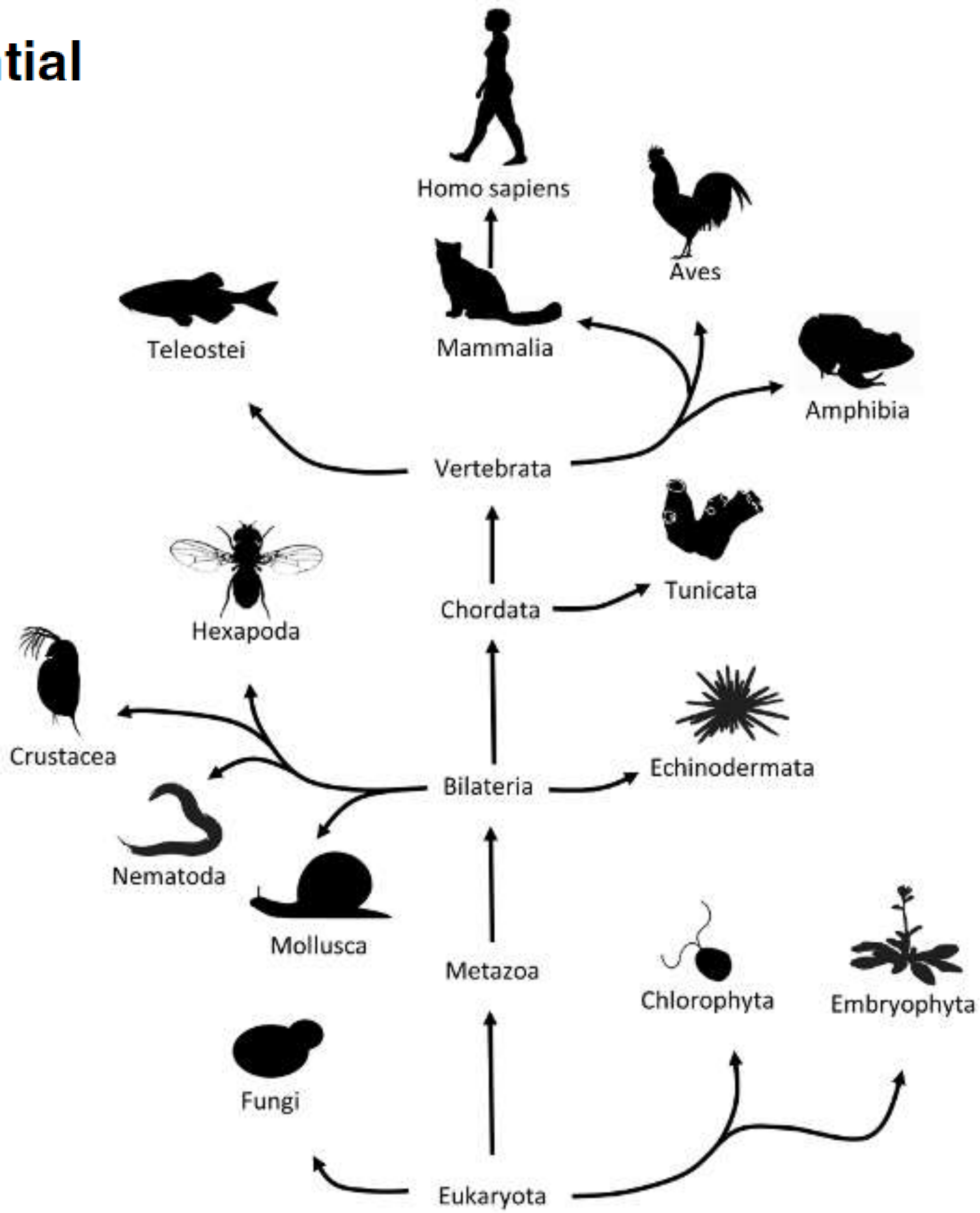
4	teleostei	Astyanax mexicanus	blind cave fish	7994	TRUE (70.1 %)
5	teleostei	Danio rerio	leopard danio	7955	TRUE (68.3 %)
6	teleostei	Gadus morhua		8049	TRUE (68.6 %)
7	teleostei	Gasterosteus aculeatus	three spined stickleback	69293	TRUE (70.1 %)
8	teleostei	Oreochromis niloticus		8128	TRUE (65.8 %)
9	teleostei	Oryzias latipes	Japanese rice fish	8090	TRUE (70 %)
10	teleostei	Poecilia formosa		48698	TRUE (70.3 %)
11	teleostei	Scleropages formosus	Asian arowana	113540	TRUE (62 %)
12	teleostei	Takifugu rubripes	tiger puffer	31033	TRUE (66.6 %)
13	teleostei	Tetraodon nigroviridis		99883	TRUE (65.6 %)
14	teleostei	Xiphophorus maculatus		8083	TRUE (66 %)



A Theoretical Model for Utilizing Mammalian Pharmacology and Safety Data to Prioritize Potential Impacts of Human Pharmaceuticals to Fish

2003

D. B. Huggett, J. C. Cook, J. F. Ericson, and R. T. Williams
Pfizer Global Research and Development, Groton, Connecticut, USA

ECOdrug

1				**Target_name**	**Sodium-dependent serotonin trar**
2				**interaction**	**inhibitor**
3				**UniProt_ID**	P31645
4	teleostei	Astyanax mexicanus	blind cave fish	7994	TRUE (70.1 %)
5	teleostei	Danio rerio	leopard danio	7955	TRUE (68.3 %)
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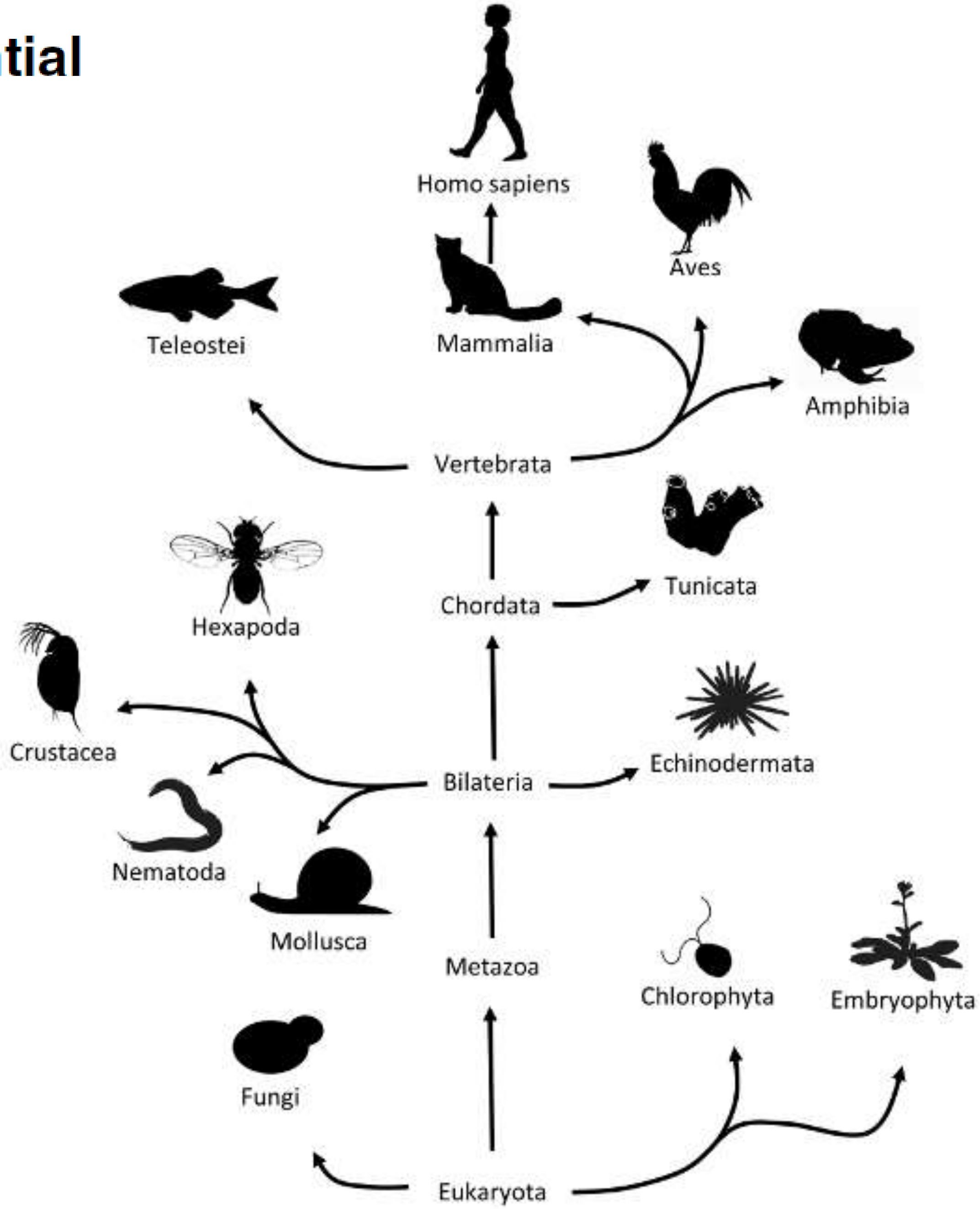


Fish plasma modeling

C_{min} –minimum human therapeutic plasma dose

P_{BW} = Blood:Water partition coefficient

THV = C_{max} / P_{BW}

Diltiazem THV = 150 ng/l (pH: 8.3)

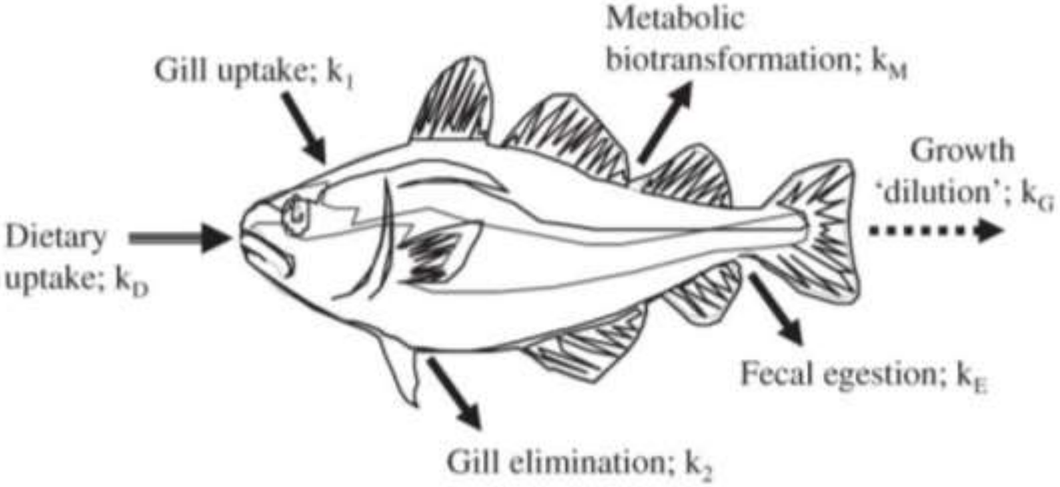
Based on adult rainbow trout experiments and uptake modeling.

Therapeutic Hazard Value (THV)

- Predicted water concentration expected to cause a human therapeutic level of a pharmaceutical in fish plasma

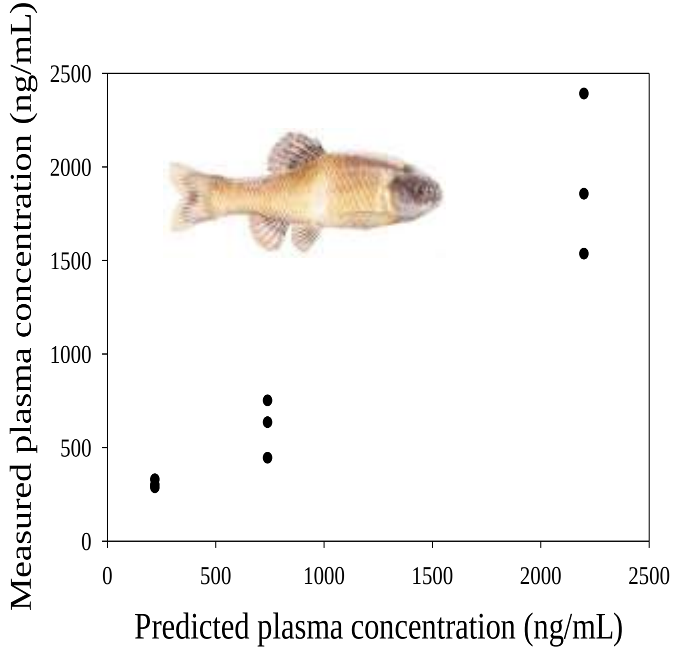
Physiochemical Properties:

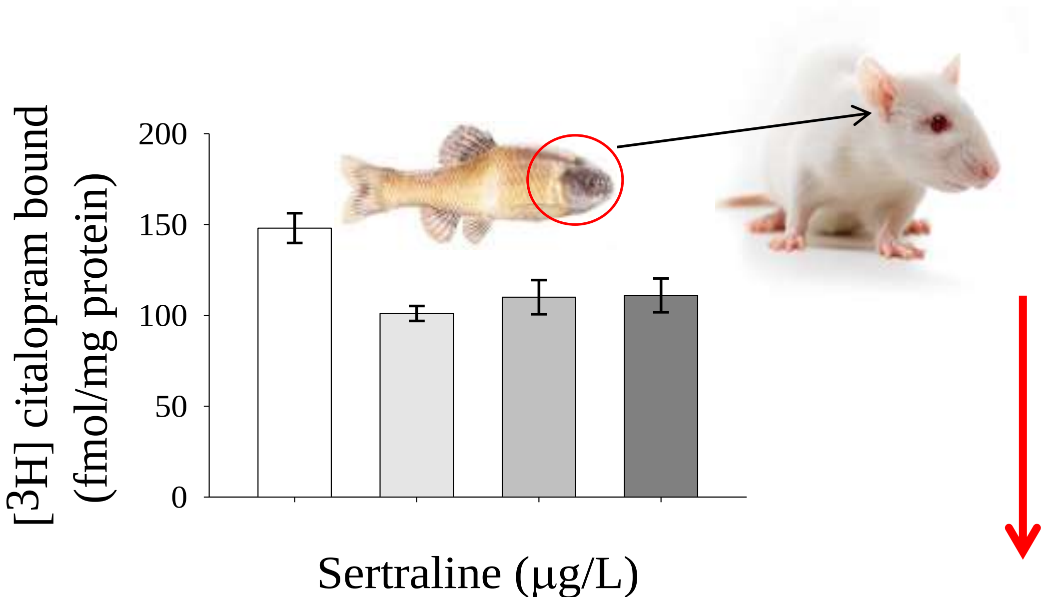
M.W. = 414.518
log K_{ow} = 2.73 - 4.73
pKa = 8.18-8.94
V_D = ~305 L (humans)
$T_{1/2}$ = 3.0-4.5 hrs (humans)
$C_{min\text{-}max}$ = 0.03 and 0.13 ng/ml

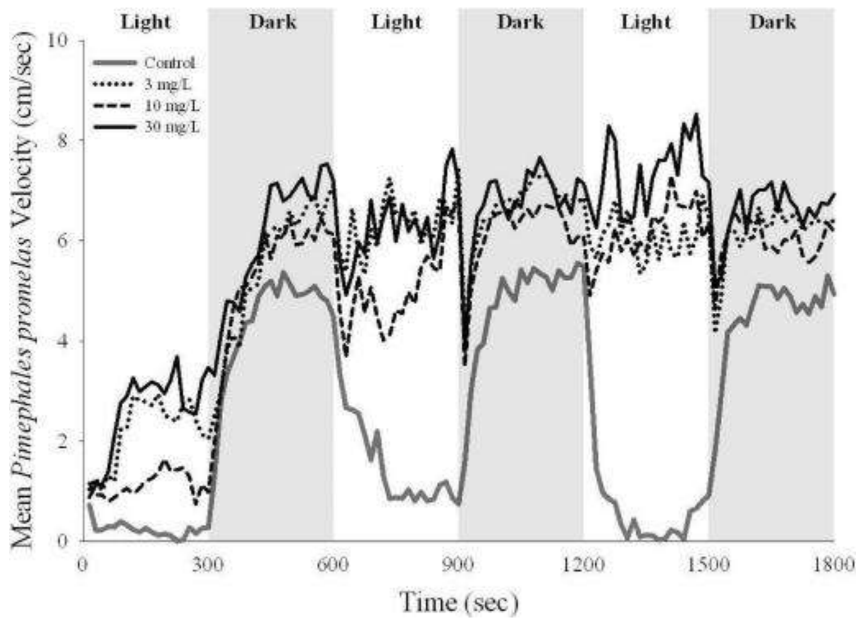


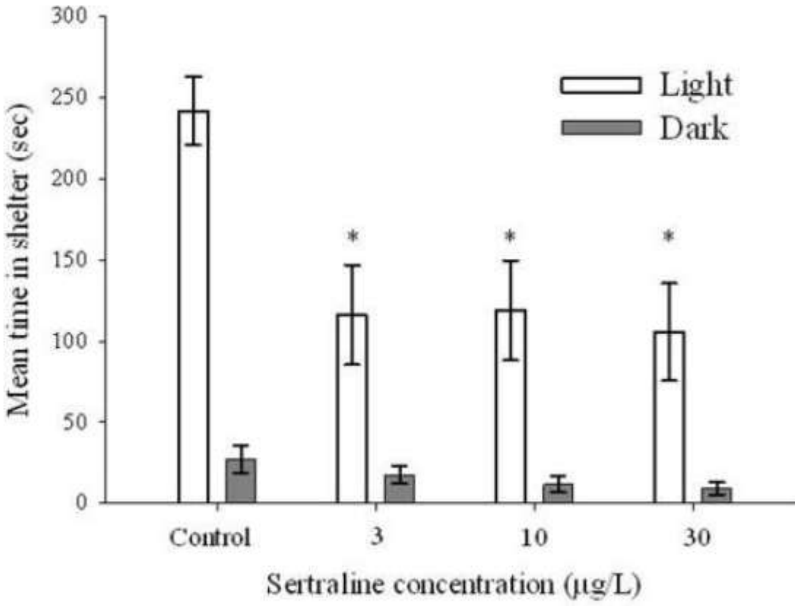
Fitszimmons et al, 2001; Huggett et al 2003; Fick et al, 2010; Berninger et al, 2011; Brooks 2014

Antidepressant uptake, CNS binding, anxiety behavior









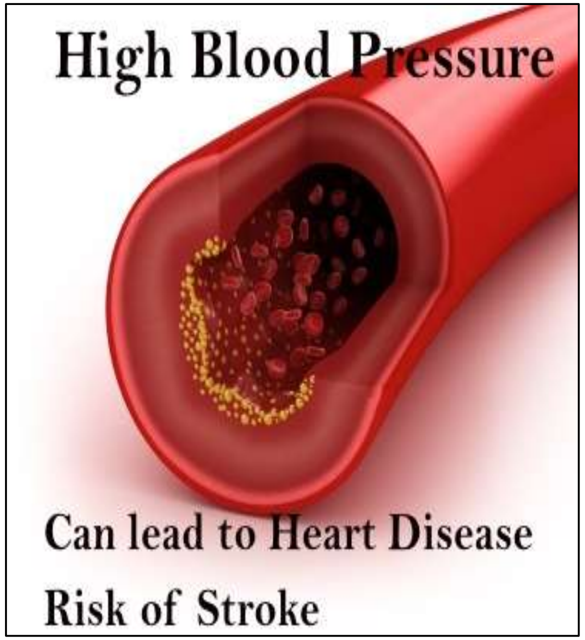
Valenti et al. 2012

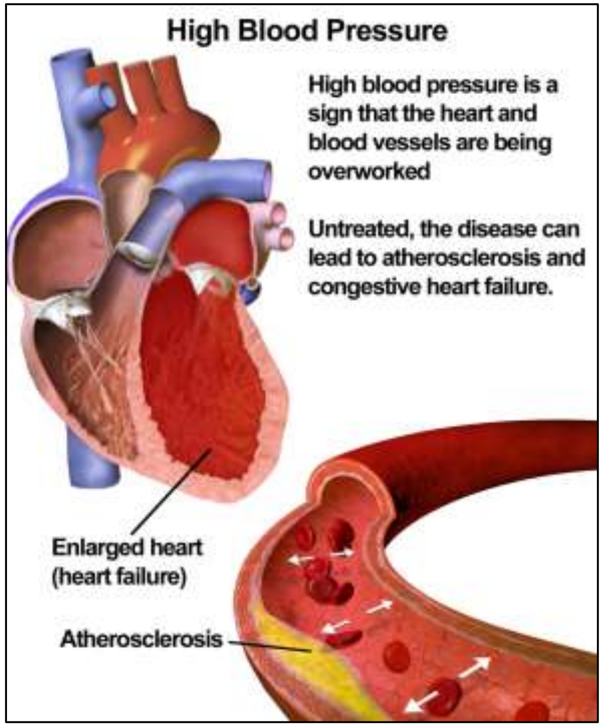
PREDICTED AND OBSERVED THERAPEUTIC DOSE EXCEEDANCES OF IONIZABLE PHARMACEUTICALS IN FISH PLASMA FROM URBAN COASTAL SYSTEMS

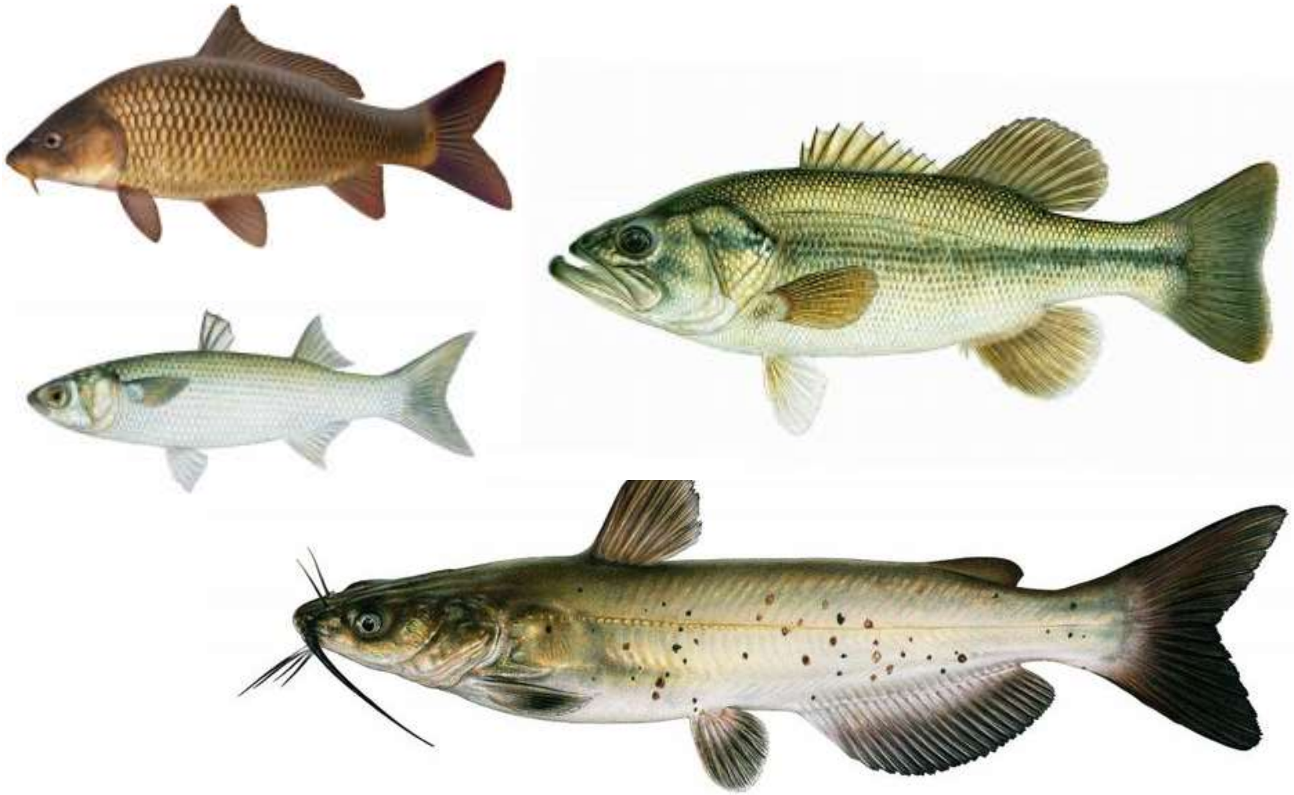
W. Casan Scott,† Bowen Du,† Samuel P. Haddad,† Christopher S. Breed,† Gavin N. Saari,† Martin Kelly,‡ Linda Broach,‡ C. Kevin Chambliss,†§ and Bryan W. Brooks*†

†Department of Environmental Science, Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, Texas, USA
‡Texas Commission on Environmental Quality, Houston, Texas, USA
§Department of Chemistry and Biochemistry, Baylor University, Waco, Texas, USA

(Submitted 26 June 2015; Returned for Revision 20 August 2015; Accepted 6 September 2015)







Heart medication global occurrence?

Chemosphere 189 (2017) 466–478

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Review

high blood pressure medication

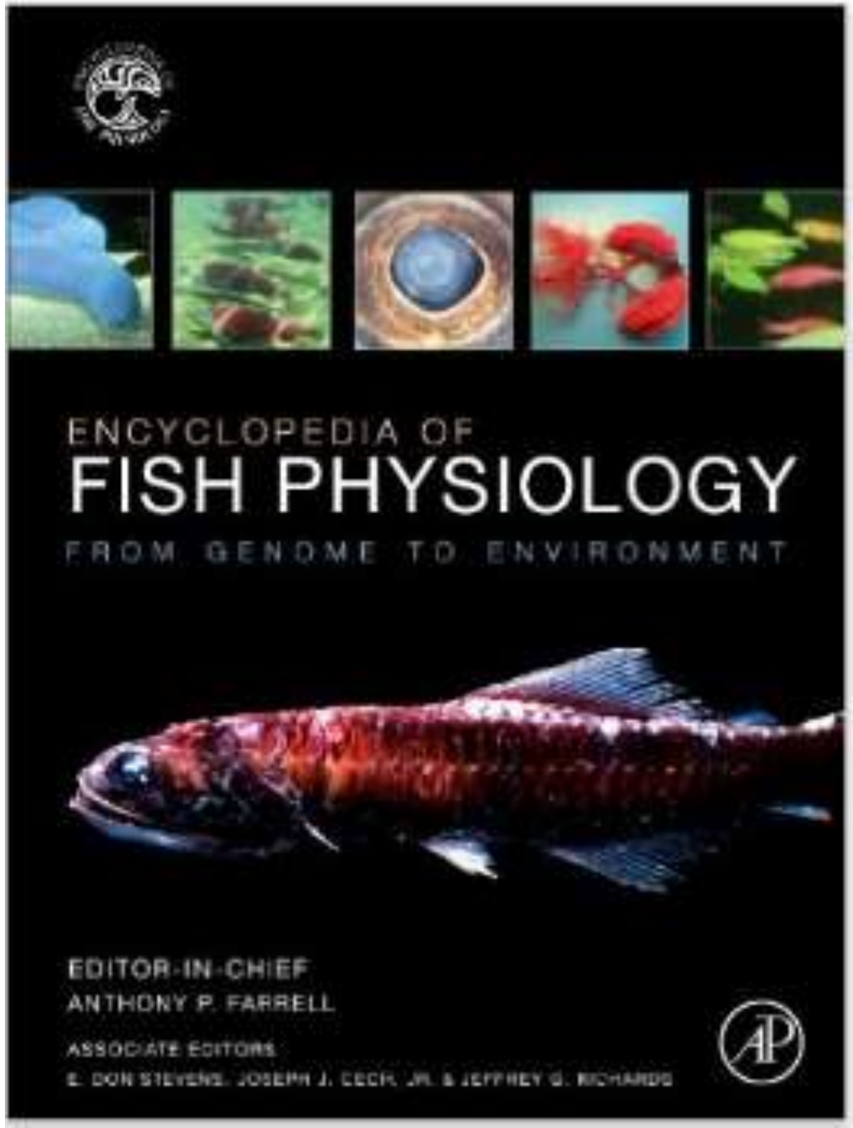
Global scanning assessment of ~~calcium channel blockers~~ in the environment: Review and analysis of occurrence, ecotoxicology and hazards in aquatic systems

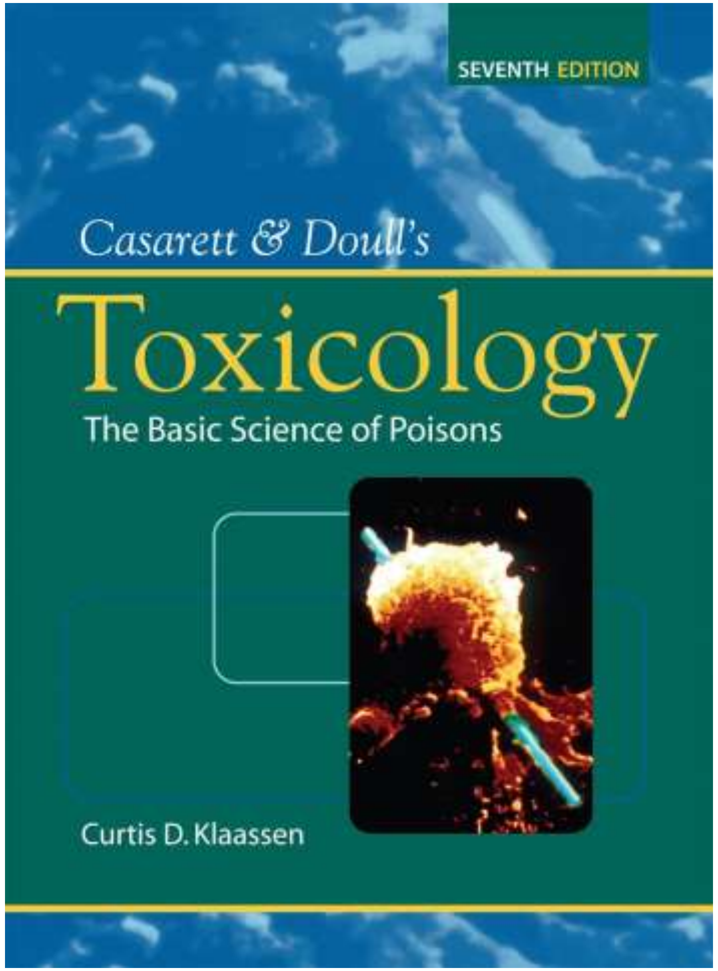
CrossMark

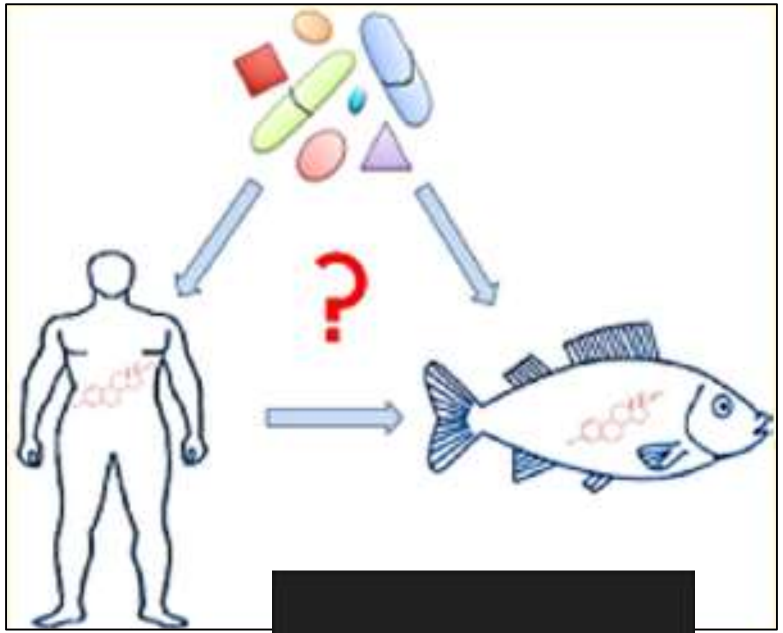
Gavin N. Saari, W. Casan Scott, Bryan W. Brooks*

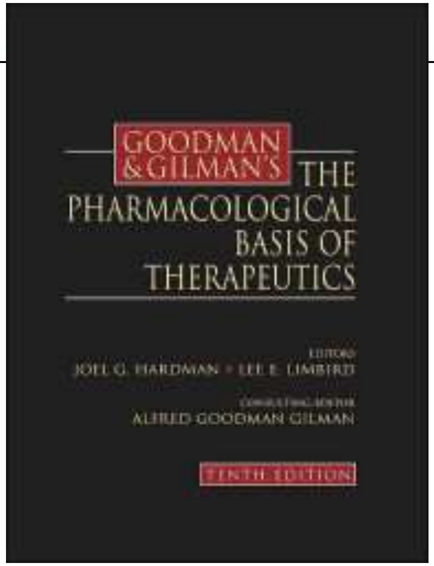
Department of Environmental Science, Center for Reservoir and Aquatic Systems Research, Baylor University, Waco, TX, USA

Read across- mammals to fish?

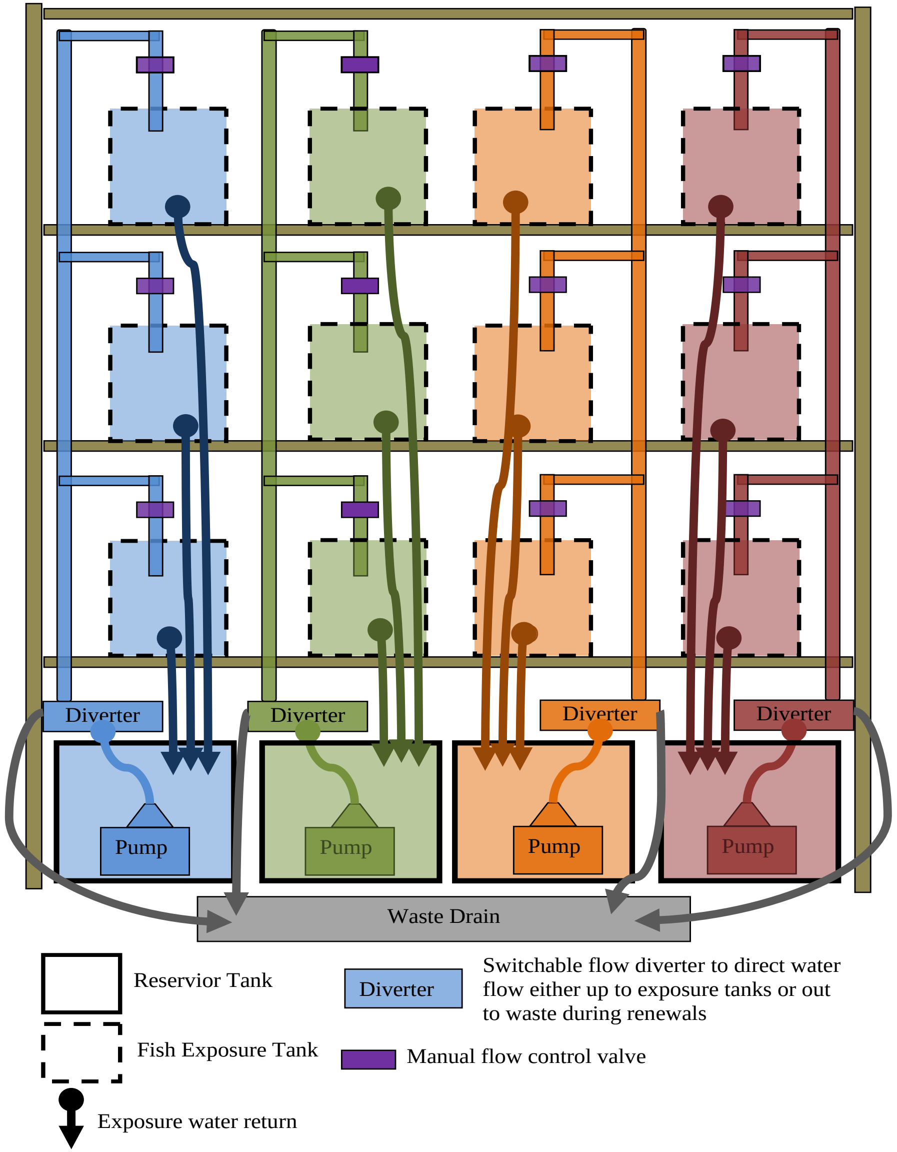


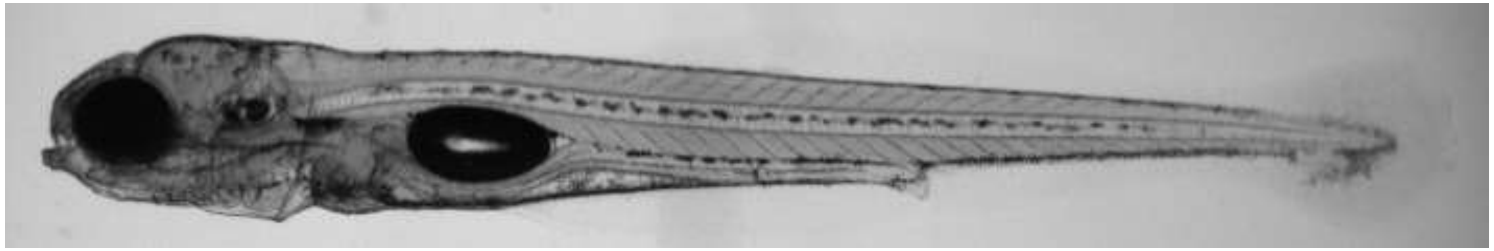






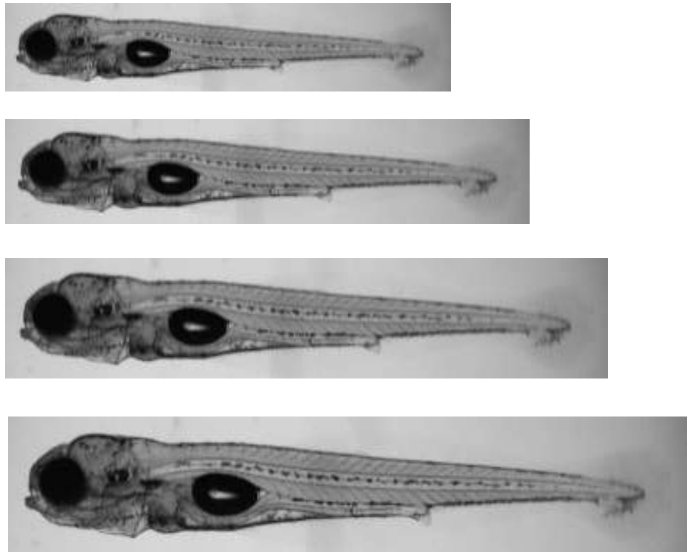
Exposure across multiple life stages

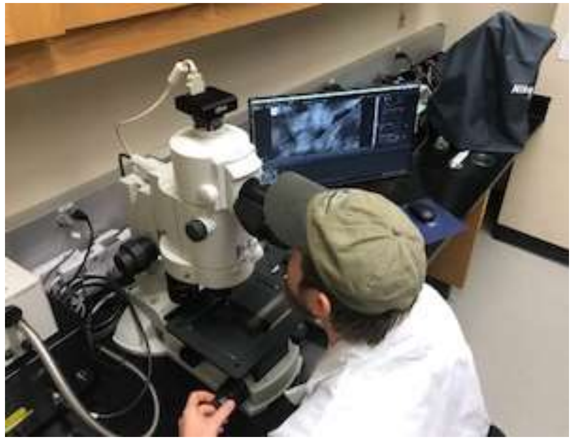


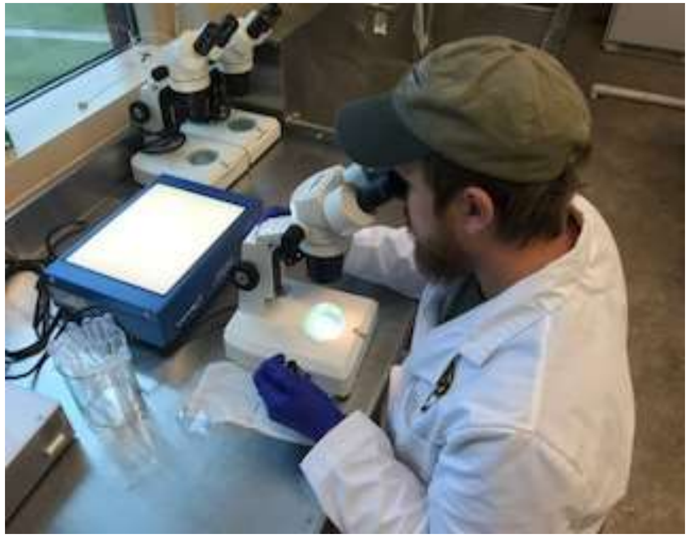


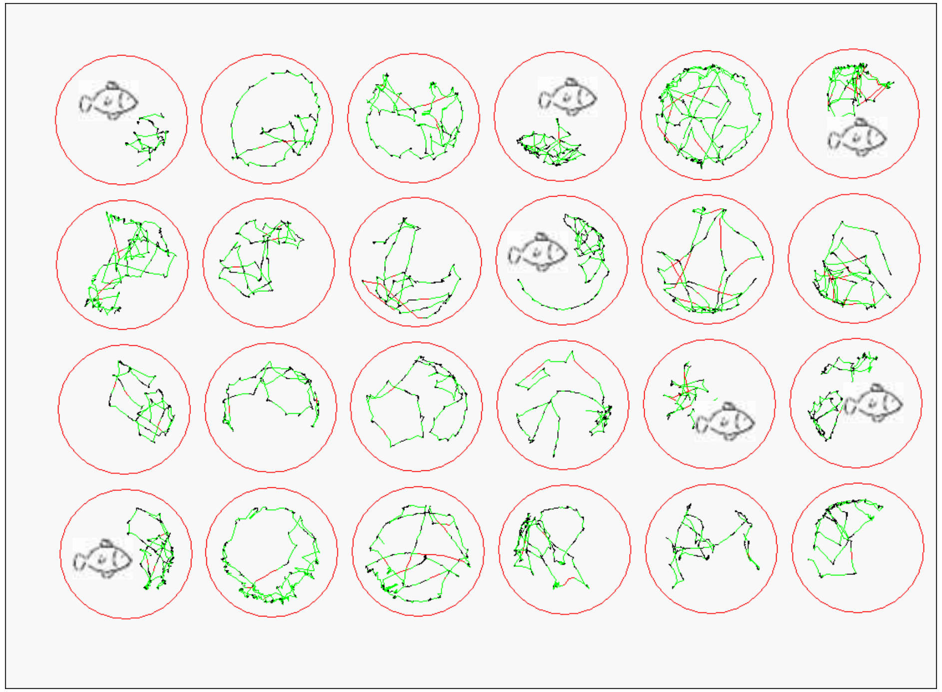
Nichols et al, 2015; Incardona et al, 2004; 2011

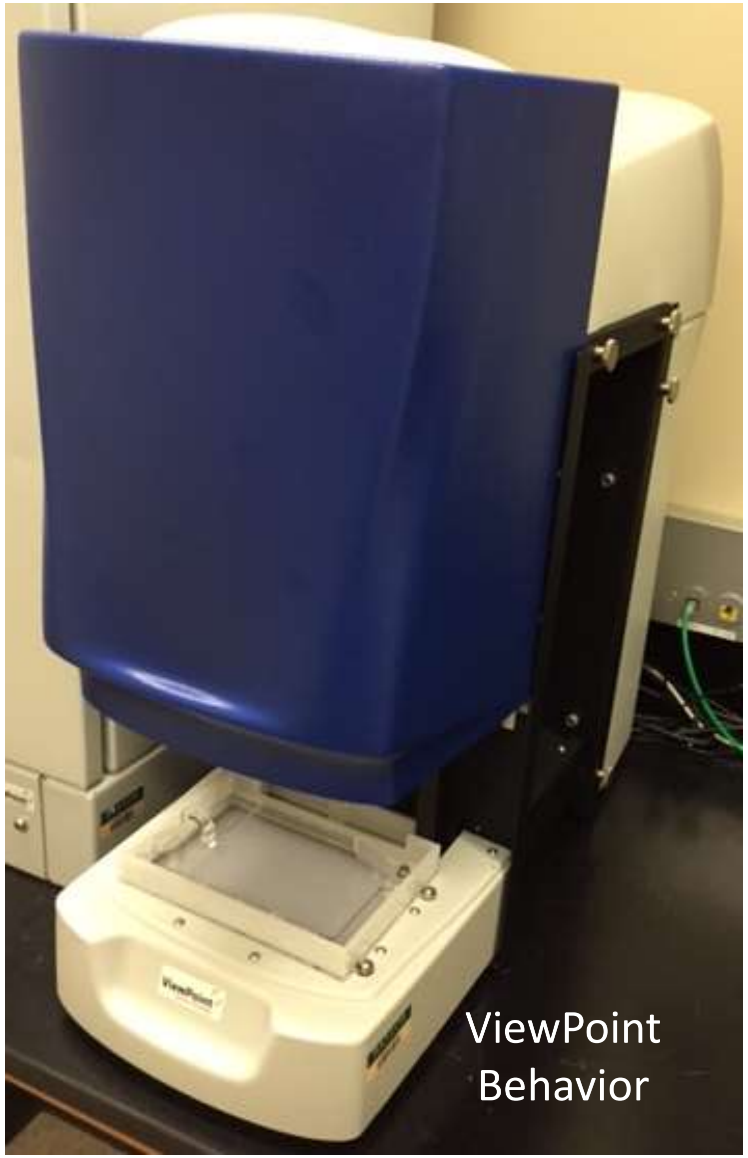
U.S. EPA standard toxicity studies

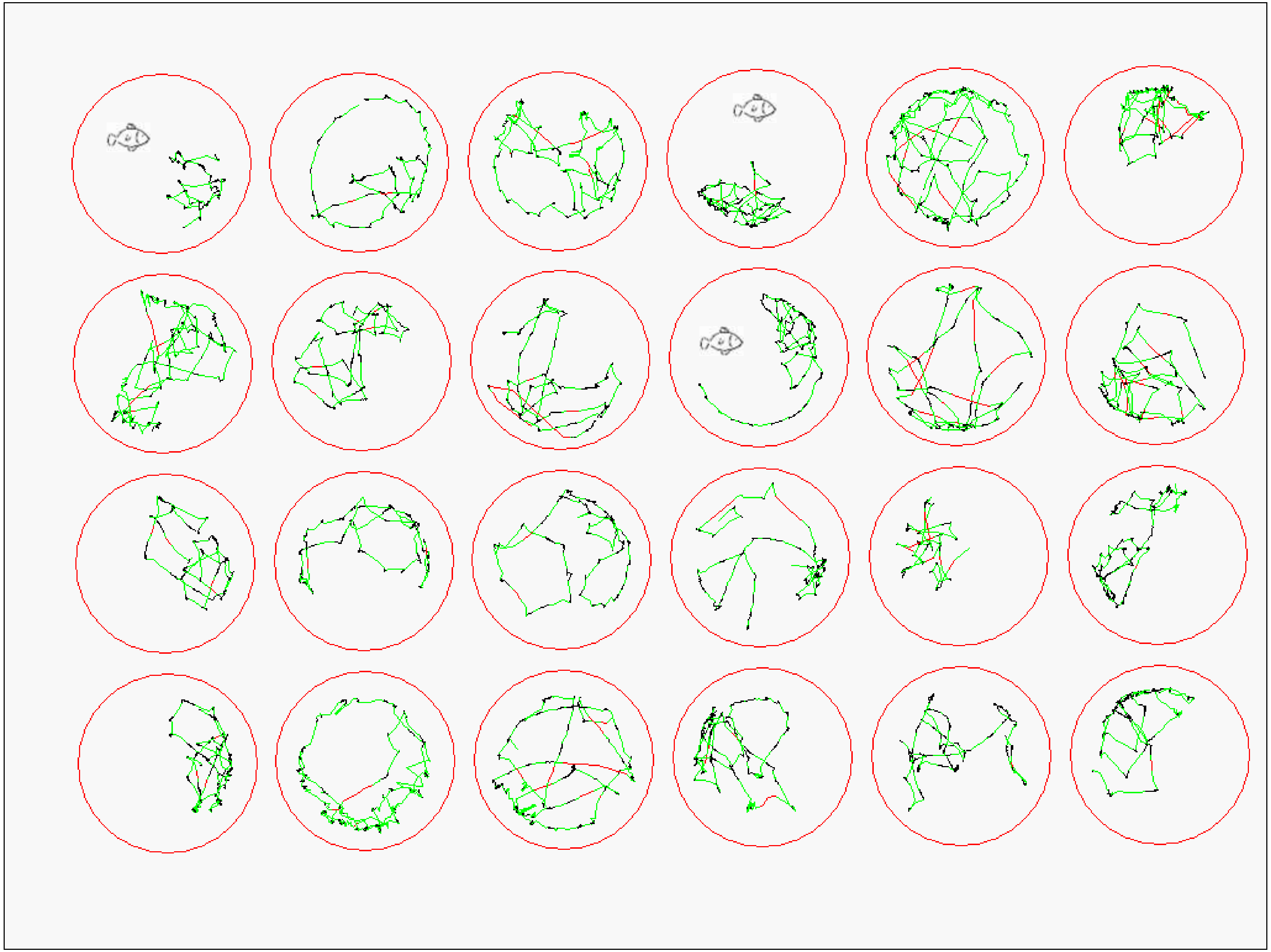




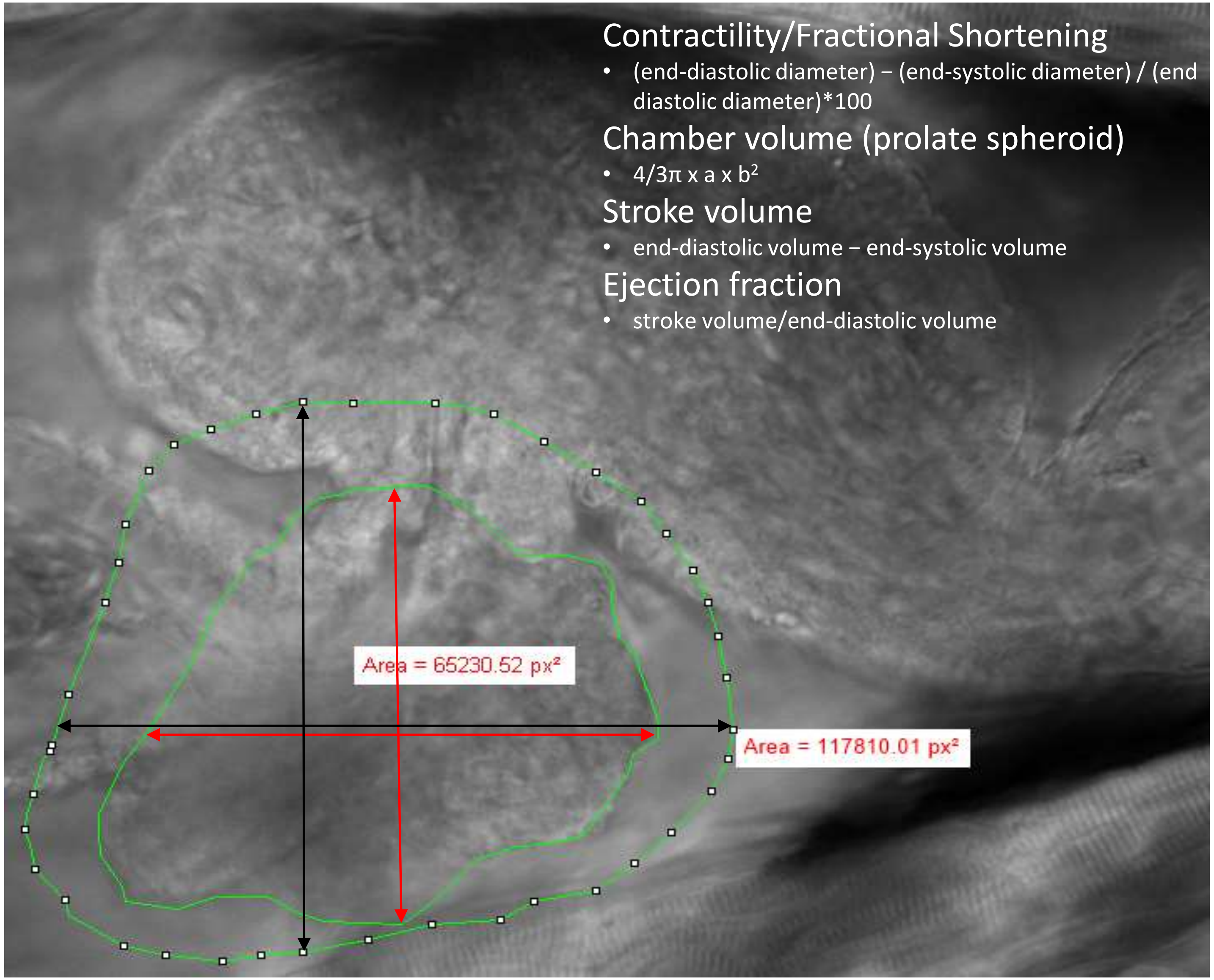








Videomicroscopy



Contractility/Fractional Shortening

- (end-diastolic diameter) – (end-systolic diameter) / (end diastolic diameter)*100

Chamber volume (prolate spheroid)

- $4/3\pi \times a \times b^2$

Stroke volume

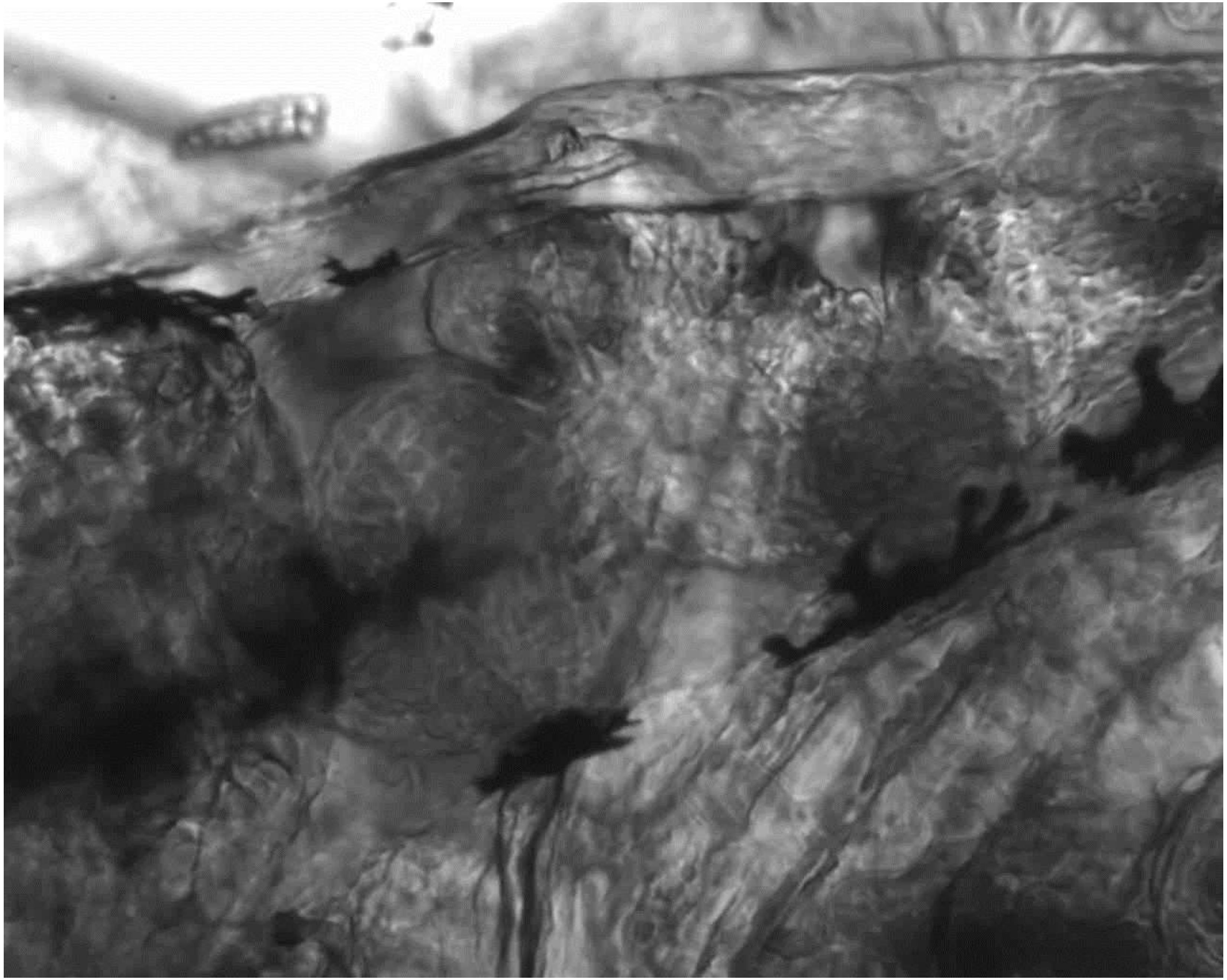
- end-diastolic volume – end-systolic volume

Ejection fraction

- stroke volume/end-diastolic volume

Incardona et al, 2004; 2011

Control



Effects on swimming performance at human therapeutic levels?

Many people to thank…Questions?

UNIVERSITY of WISCONSIN Superior

LSRI Lake Superior Research Institute Est. 1967

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Baylor University PhD

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