

# State of the Science Ecological Effects

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# Outline

- Questions
- Risk-based approach
- SAB recommendations
  - Examples
- Conclusions

# Questions

- Identify which CECs are of sufficient concern to be incorporated into routine aquatic monitoring programs.
- Standardize the measurement processes and techniques that will be used for monitoring priority CECs.
- Determine thresholds of ecological and human health concern for interpreting CEC monitoring data.

# Exposure + Effect = Risk

- Exposure
  - Relatively low concentrations (ng/L)
  - Bioavailability
  - Persistence Bioaccumulative (food-chain transfer)
- Effects
  - What compounds have “adverse effects” at ng/L
    - Population (growth, reproduction, survival)
  - Mode of Action (conserved?)
  - Distribution of response (e.g. propranolol)
- Uncertainty
  - Indirect effects
  - Mixtures? (not just chemical; climate change)
  - Unknowns (metabolites/degradates)

# Collapse of a fish population after exposure to a synthetic estrogen

Karen A. Kidd<sup>\*†</sup>, Paul J. Blanchfield<sup>\*</sup>, Kenneth H. Mills<sup>\*</sup>, Vince P. Palace<sup>\*</sup>, Robert E. Evans<sup>\*</sup>, James M. Lazorchak<sup>‡</sup>, and Robert W. Flick<sup>‡</sup>

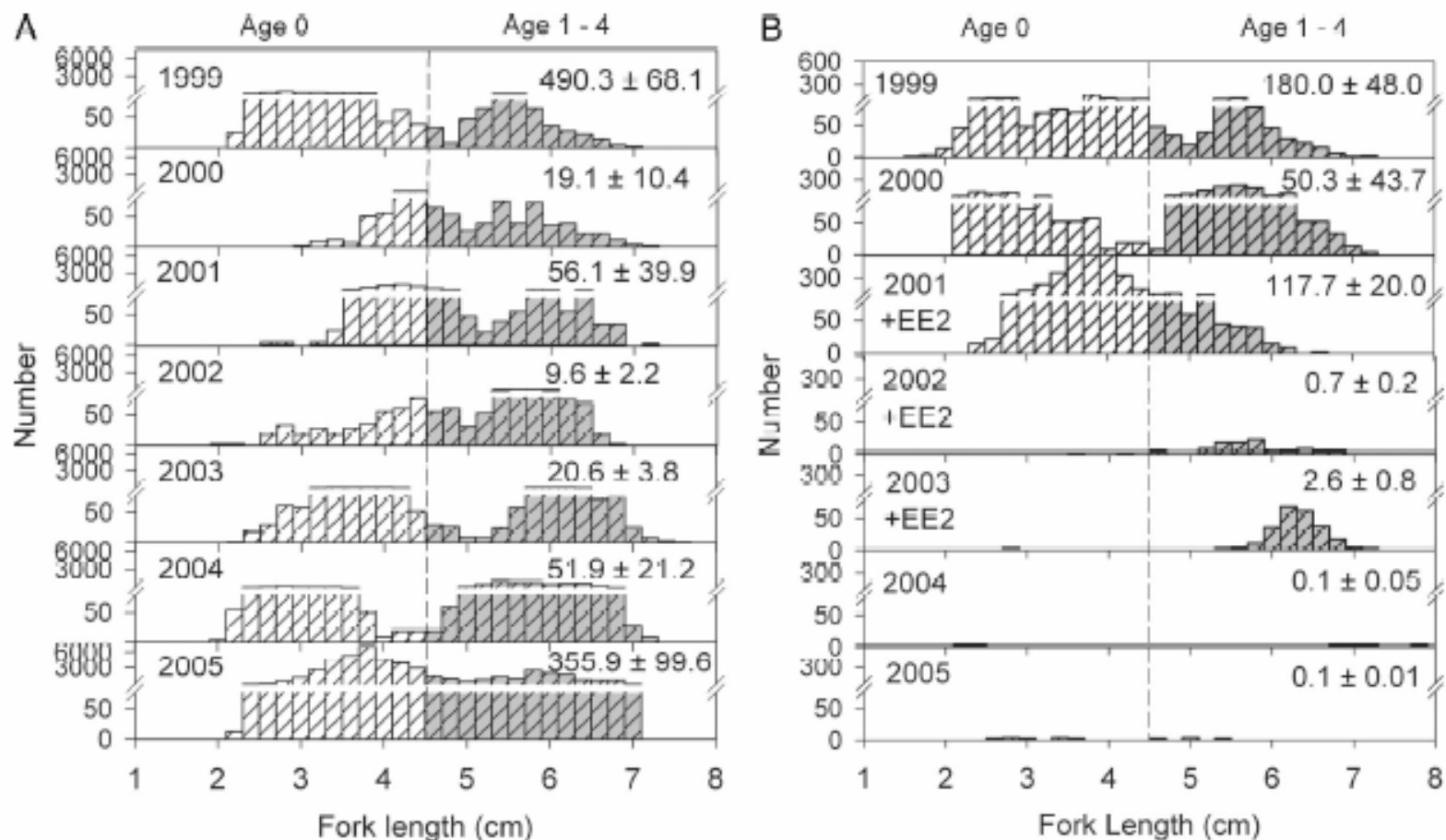


Fig. 3. Length frequency distributions of fathead minnow captured in trap nets in reference Lake 442 (A) and Lake 260 (B) (amended with 5–6 ng·L<sup>-1</sup> of EE2 in 2001–2003) during the fall of 1999–2005. Distributions for each fall have been standardized to 100 trap-net days. Mean  $\pm$  SE daily trap-net CPUE data for adults and juveniles for the fall catches are shown in the panels.

# USEPA--SAB Advisory on Aquatic Life Water Quality Criteria for Contaminants of Emerging Concern June 30, 2008

- Problem: EE2 would not likely have been a compound of concern using current EPA Aquatic Life Criteria Guidelines (1985)

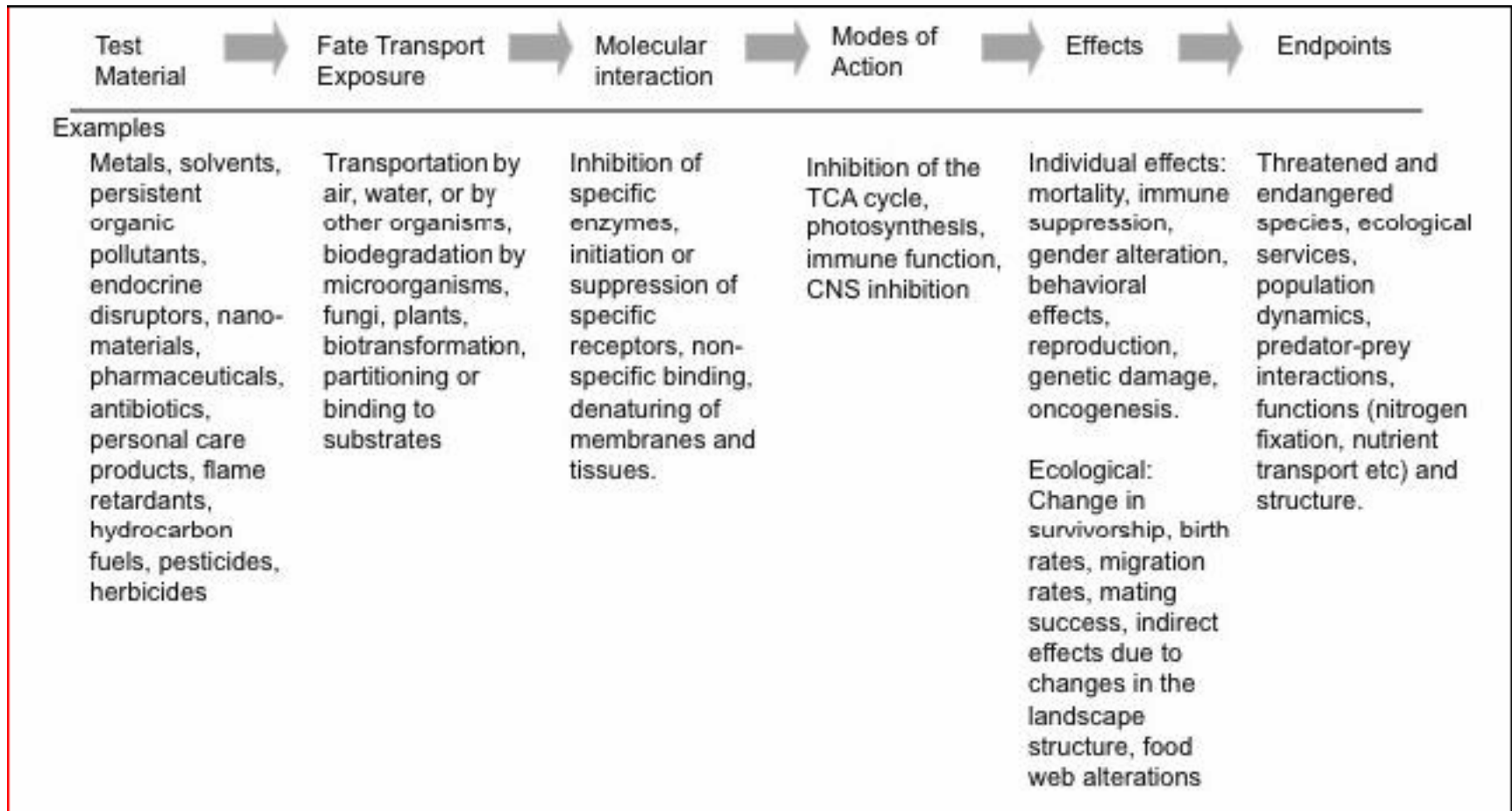
# SAB Recommendations

- “Hence, the SAB recommends that, to the extent practicable, the derivation of aquatic life criteria be **risk-based** using the principles defined in EPA’s 1998 *Guidelines for Ecological Risk Assessment* and the more recent *Advice to EPA on Advancing the Science and Application of Ecological Risk Assessment: A Report of the U.S. EPA Science Advisory Board* (U.S. EPA Science Advisory Board, 2007).”
- “Customize and update the 1985 Guidelines to address these issues.”

“...we urge EPA to include consideration of probable direct and/or indirect impacts on food webs, ecological processes and services, and endangered or unique species of special value or concern.”

## Conceptual Model

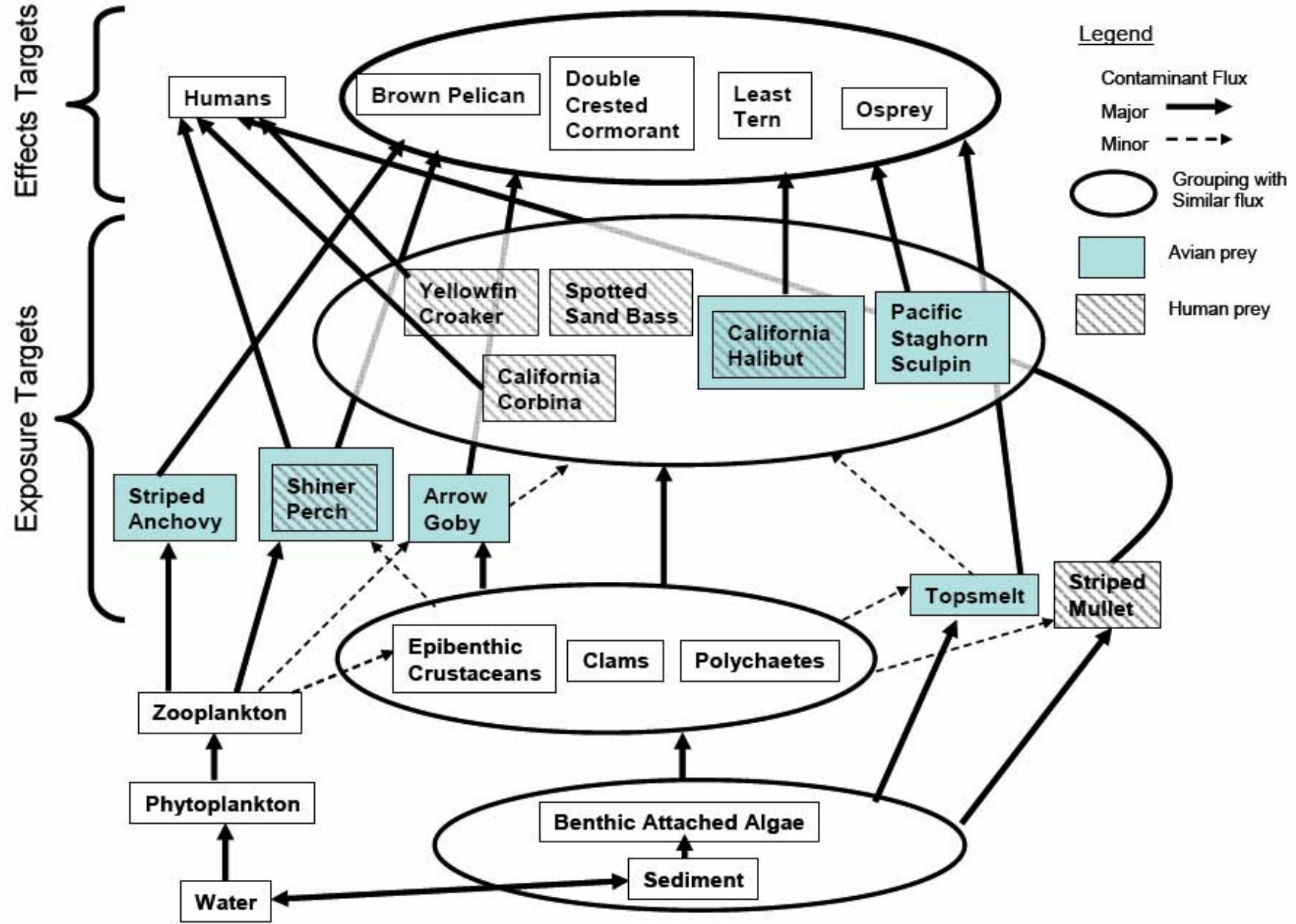
# Conceptual Model



# Models for Indirect Effects

- Gobas Arnot (Exposure)
- Comprehensive Aquatic Simulation Model (CASM)
  - indirect effects (FW)

**Figure 4.1.** Conceptual model of Newport Bay for indirect effects case study. Trophic position generally increases moving up the diagram. Arrows represent contaminant flux (dietary transfer for animals). Circled areas represent groupings to simplify understanding of contaminant flux. When an arrow points to a circle, all organisms within that circle receive that flux.



“...develop multiple lines of evidence, consider uncertainty, and bolster consideration of mode of action in the criteria development process.”

- When available; mammalian pharmacology data (FDA)
  - Pharmaceuticals
- Pursue “Omic-based” analyses
  - Genomics/proteomics/metabolomics
- Utilize Quantitative Structure Activity Relationships (QSAR)

---be used to screen CECs for modes of action and assess potential multiple modes of action for individual CECs.

Human and Ecological Risk Assessment, 9: 1789–1799, 2003

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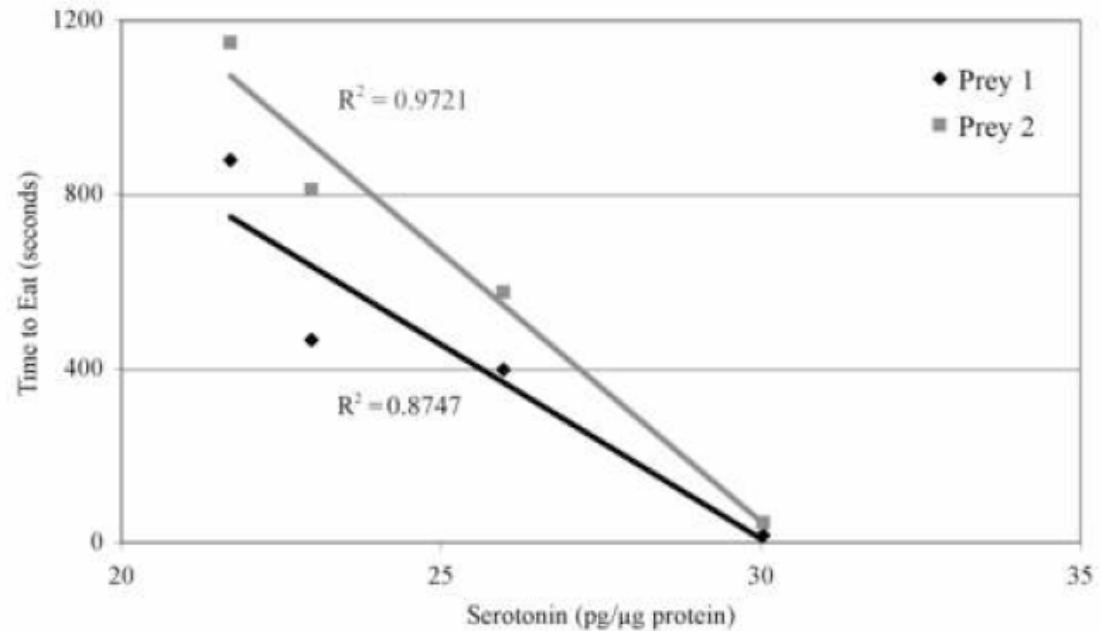
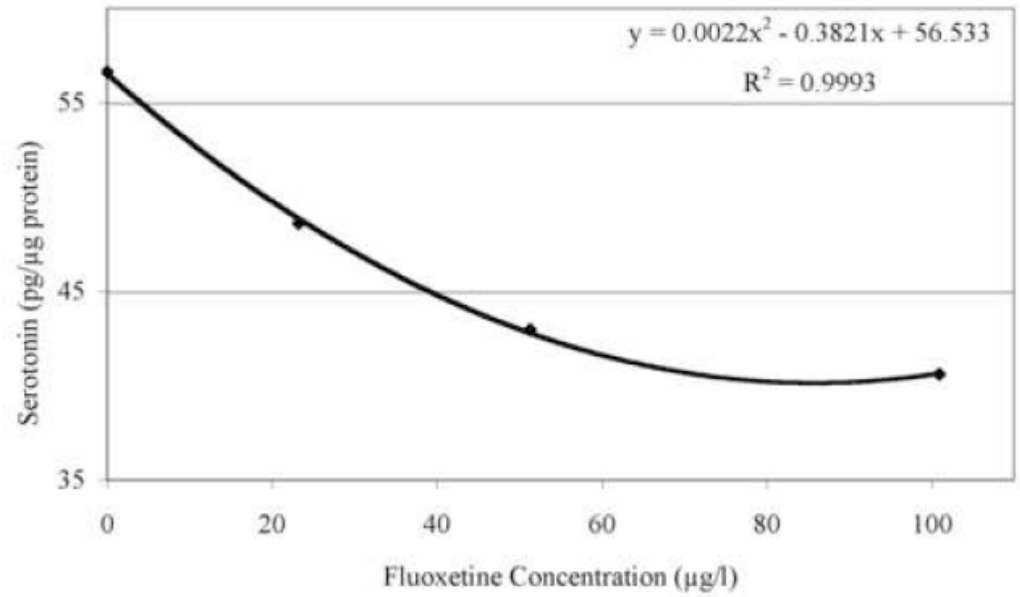
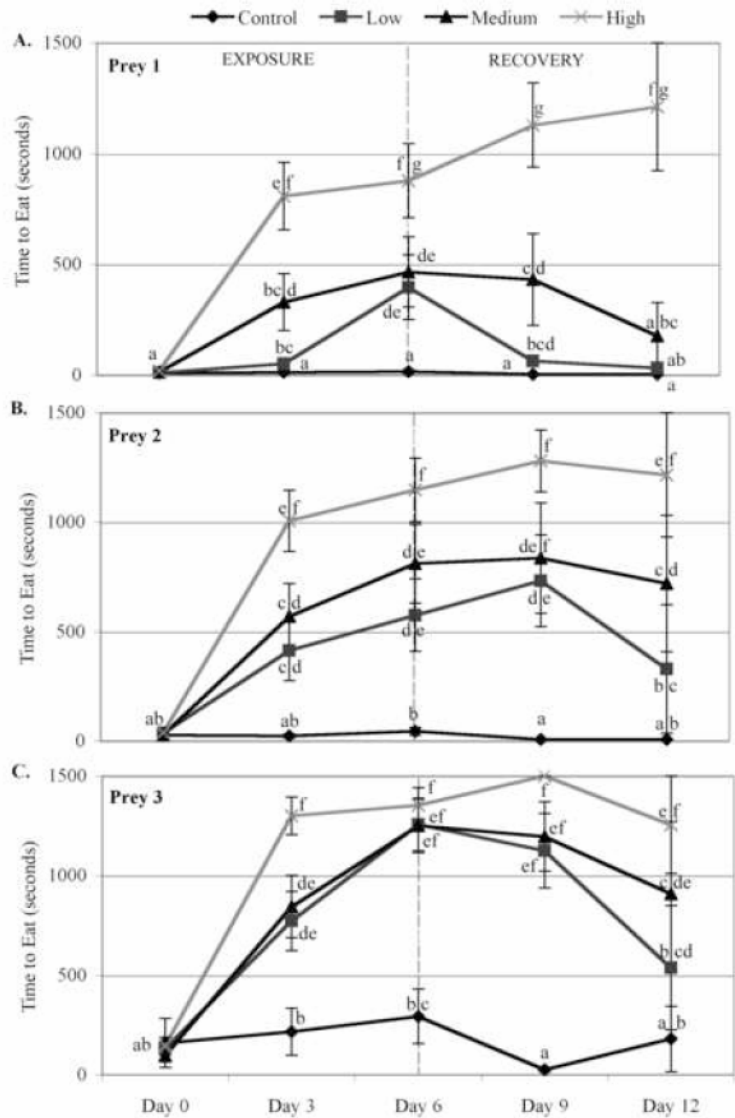
DOI: 10.1080/10807030390260498

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

**D. B. Huggett, J. C. Cook, J. F. Ericson, and R. T. Williams**

Pfizer Global Research and Development, Groton, Connecticut, USA

# Fluoxetine and Feeding



## **Are flame retardants the next DDT?**

KJ Fernie, JL. Shutt, RJ Letcher, IJ Ritchie and DM Bird. 2009.

**Environmentally relevant concentrations of DE-71 and HBCD alter eggshell thickness and reproductive success of American kestrels.**

[Environmental Science and Technology 43\(6\):2124–2130.](#)

**TABLE 3. Measurements of Eggs Laid by American Kestrels Exposed to Control Vehicle (Safflower Oil) or Environmentally Relevant Levels of DE-71**

egg variable	Control Eggs			Low-Exposure Eggs			High-Exposure Eggs			effect of DE-71 exposure (df = 49, 226) <sup>a</sup>	effect of delayed laying (df = 1, 226) <sup>b</sup>
	N	mean	SEM	N	mean	SEM	N	mean	SEM		
egg size when first laid <sup>c</sup>											
egg volume (mm <sup>3</sup> )	97	16419.2	86.69	95	15687.2	179.08	87	15209.74	195.6	<0.0001	<0.0001
egg length (mm)	97	35.37	0.10	95	34.70	0.12	87	34.39	0.14	<0.0001	<0.0001
egg width (mm)	97	28.83	0.07	95	28.51	0.08	87	27.53	0.10	<0.0001	0.0144
egg mass (g)	97	15.76	0.06	95	15.06	0.07	87	14.21	0.09	<0.0001	<0.0001
egg shell quality <sup>d</sup>											
shell weight (g)	17	1.082	0.036	18	0.989	0.031	16	1.031	0.035	0.0659	N.A.
shell thickness (mm)	14	0.173	0.006	14	0.171	0.003	15	0.163	0.002	0.0093	N.A.
egg size at midincubation											
absolute weight loss over 14 d (g) <sup>e</sup>	37	0.69	0.02	39	0.64	0.02	33	0.95	0.03	<0.0001	<0.0001
proportional weight loss over 14 d (%) <sup>e</sup>	37	4.23	0.16	39	4.32	0.13	33	6.02	0.19	<0.0001	<0.0001

<sup>a</sup> Nested ANOVAs (pair within treatment). <sup>b</sup> ANCOVA (Julian laying date used as a covariate). <sup>c</sup> Variables statistically analyzed on a per-pair basis, least-squares means presented by individual eggs. <sup>d</sup> These measures completed only on the first egg laid and collected for contaminant analysis. <sup>e</sup> "Mid-incubation mass" and "weight loss over 14 d" measured in 2006 only.

## Non-EDCs?....

”many CECs will require special consideration because they do not fit the effect model discussed in the White Paper (i.e., disruption of endocrine function)...”

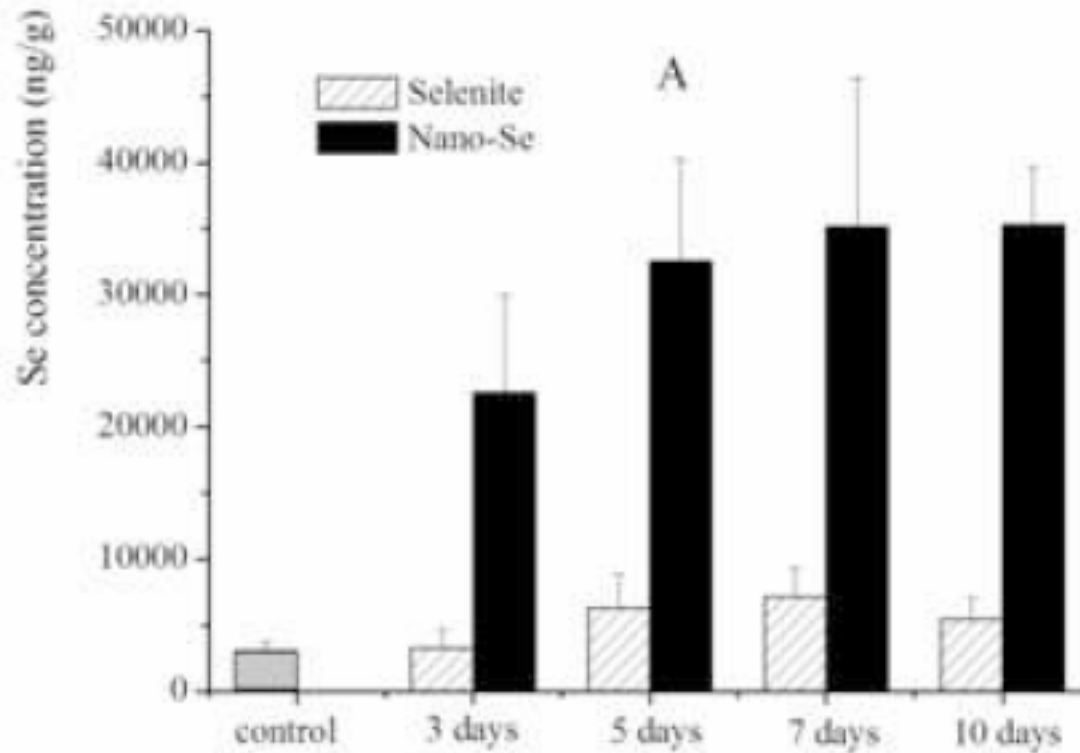
- **Nanomaterials**

- Bioavailable???

- UCToxics Review Panel 2005:

- “these compounds are not bioavailable and should not be an issue in the environment....”

## Temporal comparisons of Se uptake in liver of medaka



# Mixtures and environmental stressors (temperature/salinity)

- Climate change
- Metabolites/degradates
- Unknowns

# Effects of APE surfactants on estrogenic activity of 2,4 D in rainbow trout

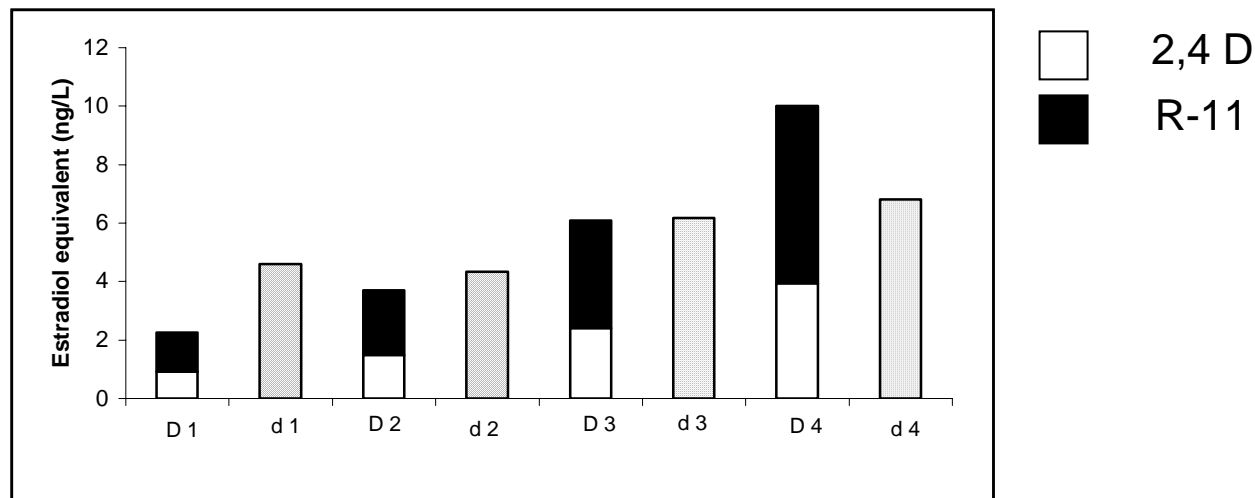


Figure 2. Estradiol equivalent concentrations (EEQs) of various concentrations of R-11 and 2,4-D. Solid bars are R-11, open bars are for 2,4-D, while dashed bars are for the mixture of R-11 and 2,4-D.

Dose	Conc.s of chemicals		dose	Conc.s of chemicals
Ž	R-11 (mg/L)	2,4-D (mg/L)	Ž	R-11 (mg/L)+2,4-D (mg/L)
D 1	0.00089	0.00164	d 1	0.00089 R-11 + 0.00164 2,4-D
D 2	0.0089	0.0164	d 2	0.0089 R-11 + 0.0164 2,4-D
D 3	0.089	0.164	d 3	0.089 R-11 + 0.164 2,4-D
D 4	0.89	1.64	d 4	0.89 R-11 + 1.64 2,4-D

# • Schlenk's Chemicals of Concern

- EE2---population impacts clearly shown at ng/L conc.
- Steroid hormones (progestins??)
- Diclofenac (clear population impacts in scavenging birds)
- SSRIs (neurobehavioral impacts at relevant conc.)
- Antilipidemic (inverts-conserved Mode of Action)
- APE/APs
- High LogP B-adrenergic antagonists (Beta blockers)
- Nanomaterials (QDs--high uncertainty---difficult to measure)
- New PBTs/POPs
  - » PBDEs (too similar in structure to OCs)

# Second Tier

- Carbamazepine
- X-Ray Developers
- Carbon-based Nanomaterials
- UV-suncreens
- Antibiotics---India
- Nitro-musks
- Current use pesticides
  - Pyrethroids/ Phenyl-pyrazoles (fipronil)

# Summary Conclusions

- Risk Based Approach
- Mode of Action
- Mixtures
- Metabolites/Degradates
- Unknowns