

Modern Water and Sediment Quality Criteria: Toxicological and Chemical Interactions

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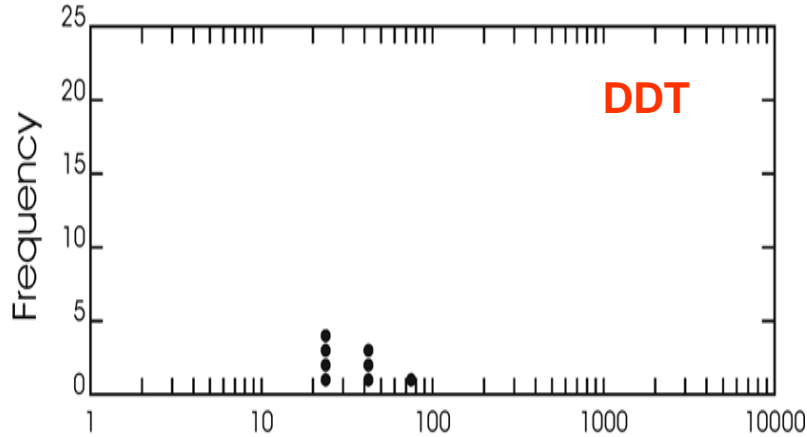
NYU Department of Environmental Medicine

Superfund Basic Research Program
National Institute of Environmental Health Science
Bioavailability Workshop
Newark NJ
November 9-10

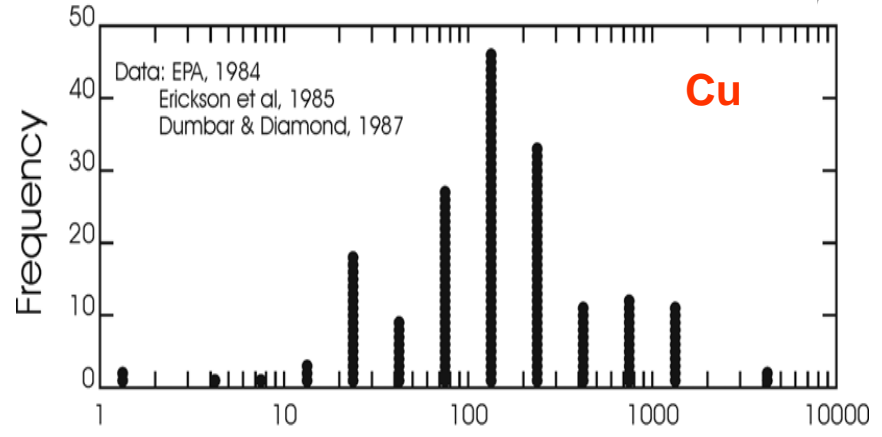


Variation in LC50 Same Organism and Chemical

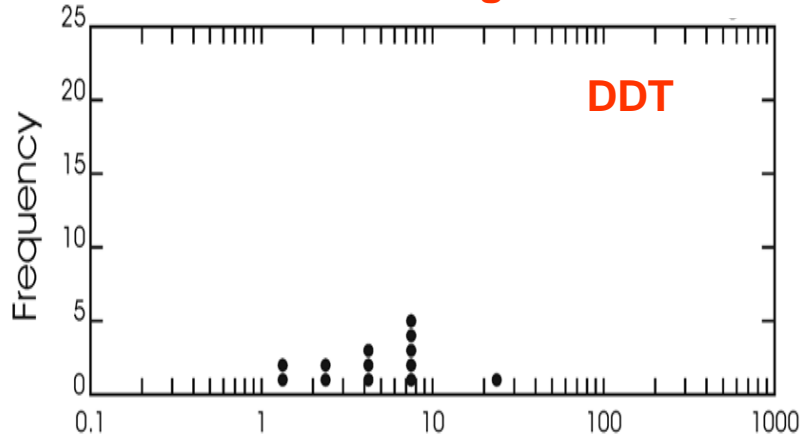
Fathead Minnow



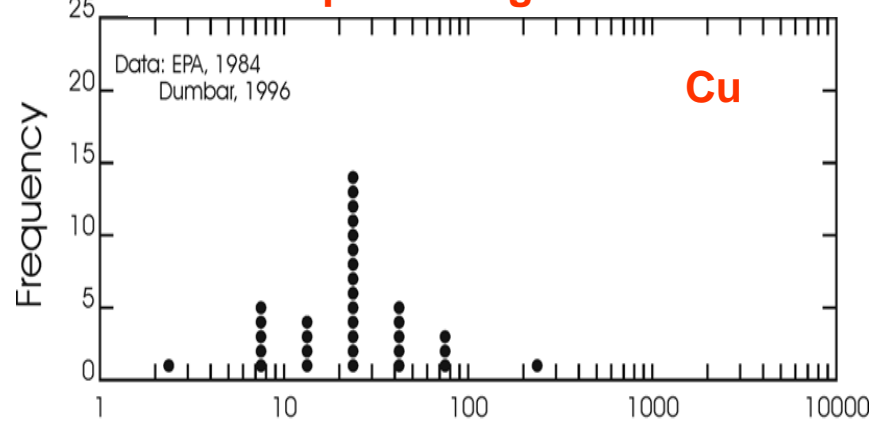
Fathead Minnow



Bluegill



Daphnia Magna/Pulex

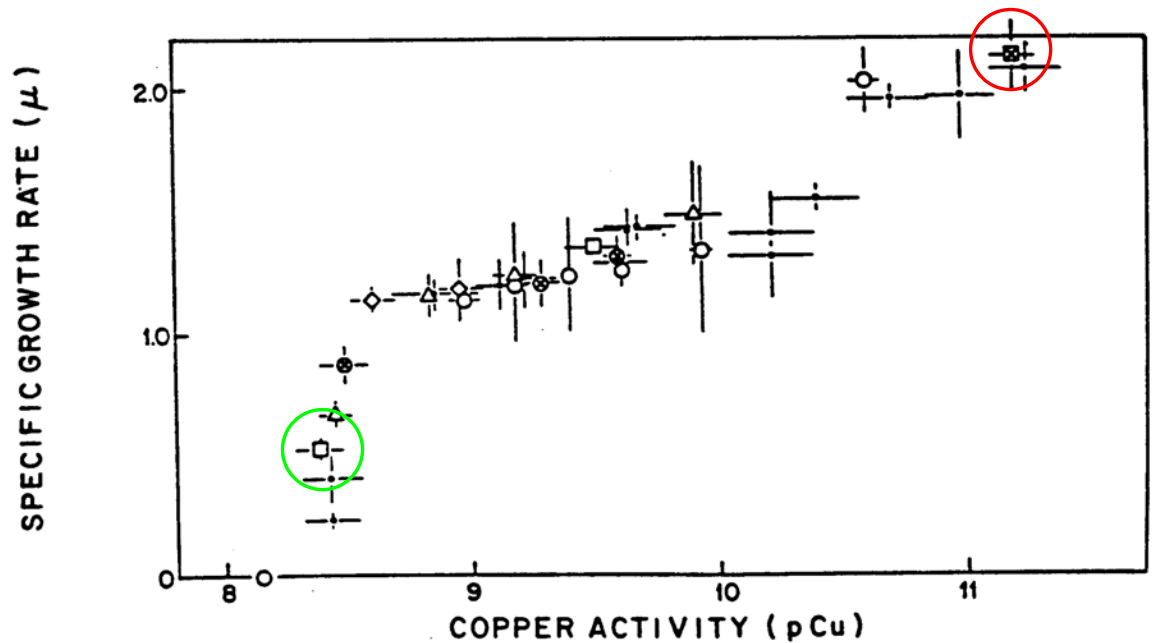
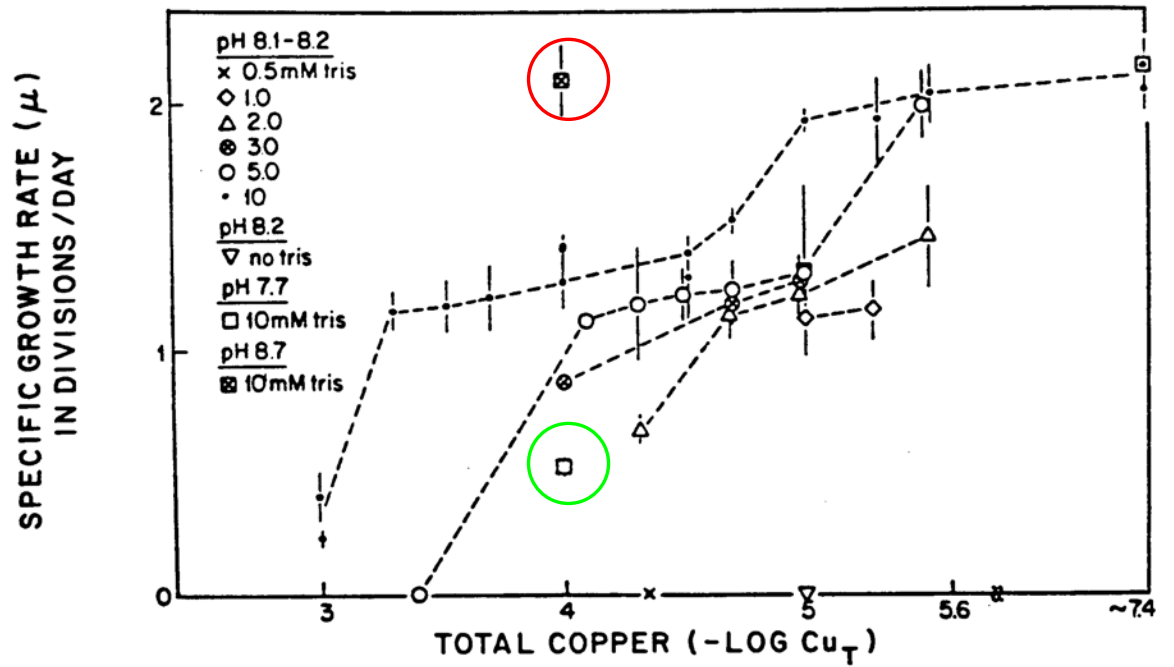


DDT LC50 (µg/L)

Copper LC50 (µg/L)

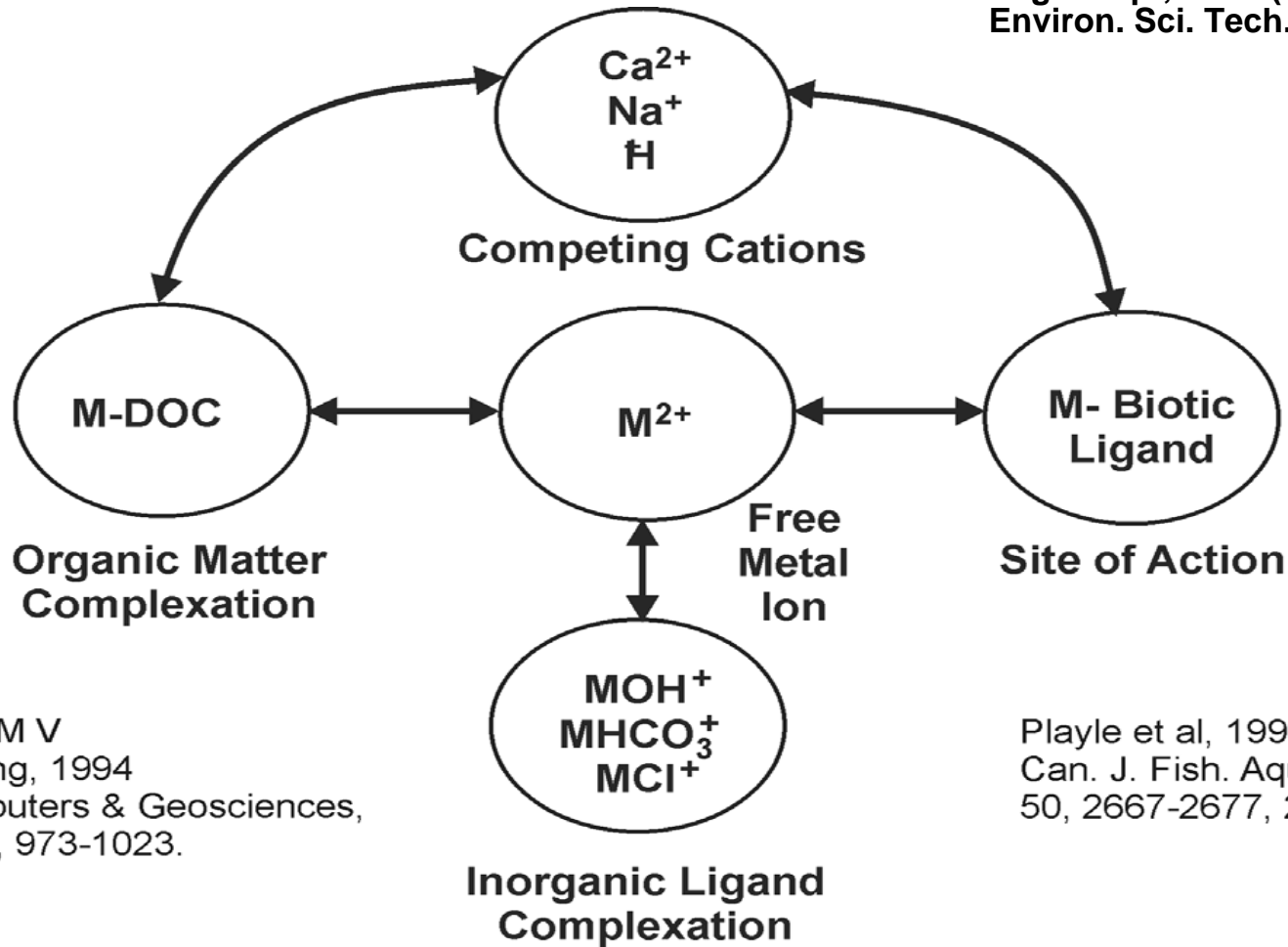
Free Ion
 Activity
 Model
 FIAM

Sunda, W., & Guillard, R. R. L.
 (1976). J. Mar. Res., 34, 511-529.



Biotic Ligand Model

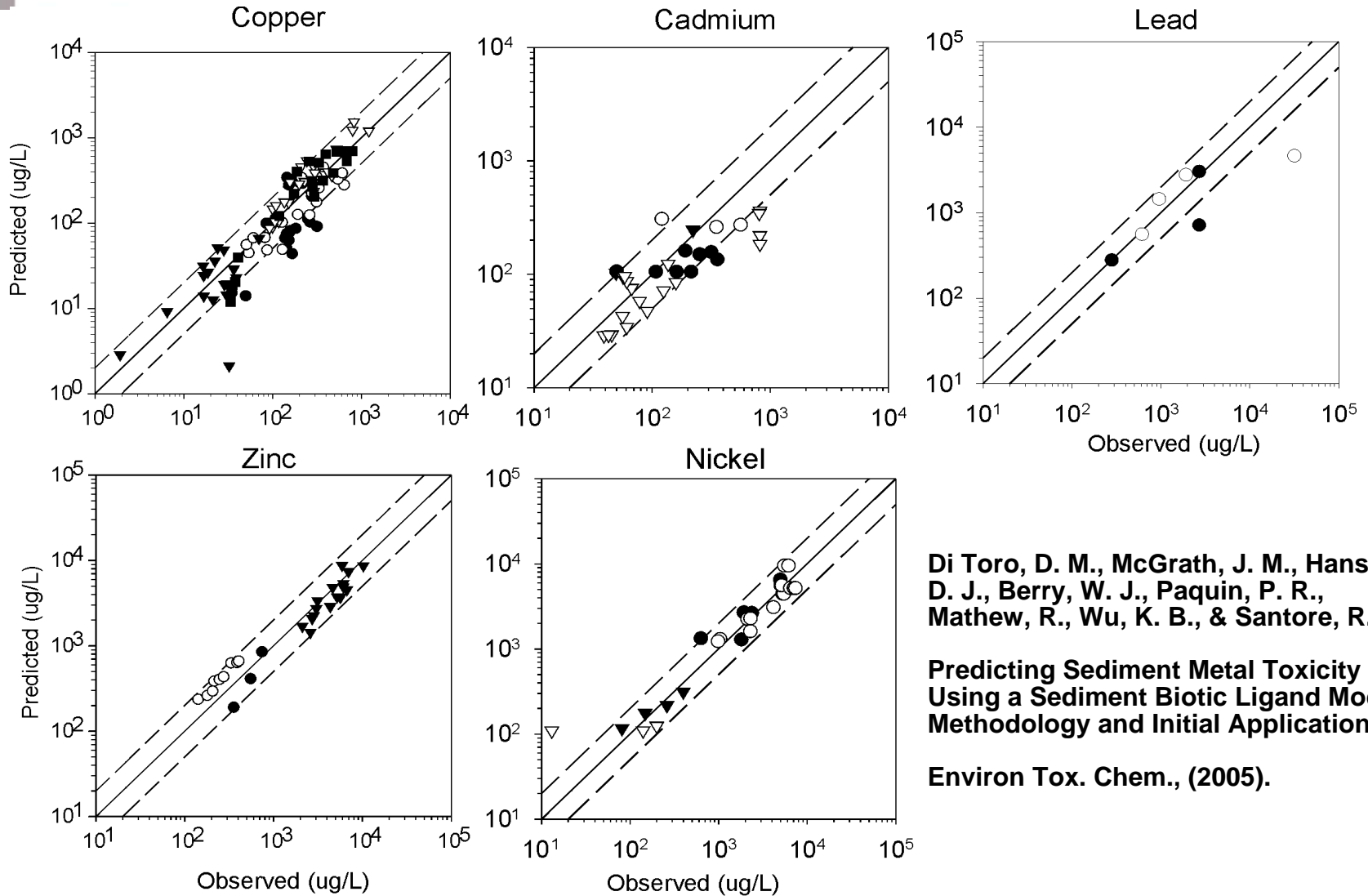
Pagenkopf, G. K. (1983).
 Environ. Sci. Tech., 17, 342



WHAM V
 Tipping, 1994
 Computers & Geosciences,
 20(6), 973-1023.

Playle et al, 1993
 Can. J. Fish. Aquat. Sci.,
 50, 2667-2677, 2678-2687.

Daphnia Magna BLM LC50 Concentrations

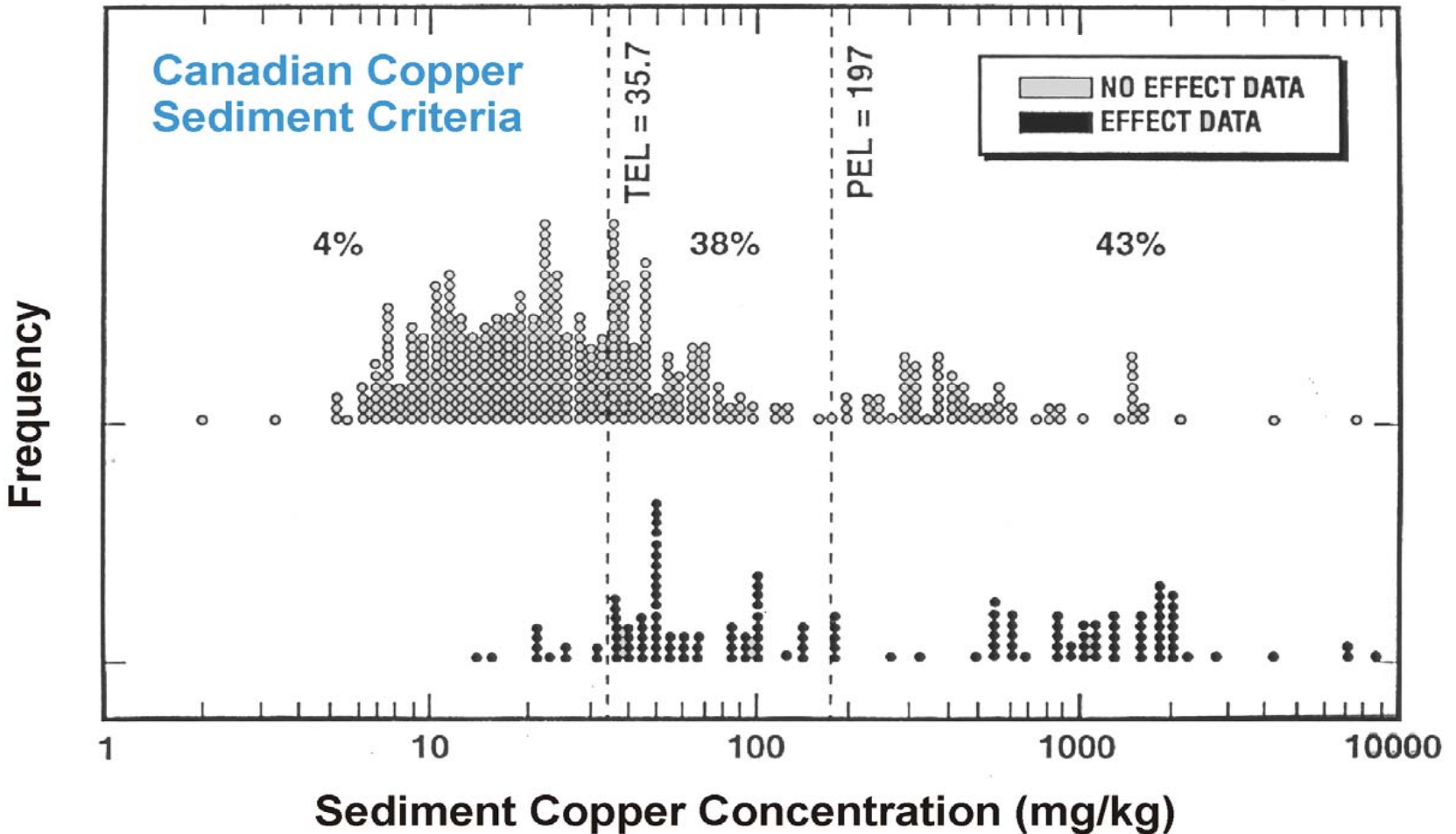


Di Toro, D. M., McGrath, J. M., Hansen, D. J., Berry, W. J., Paquin, P. R., Mathew, R., Wu, K. B., & Santore, R. C.

Predicting Sediment Metal Toxicity Using a Sediment Biotic Ligand Model: Methodology and Initial Application.

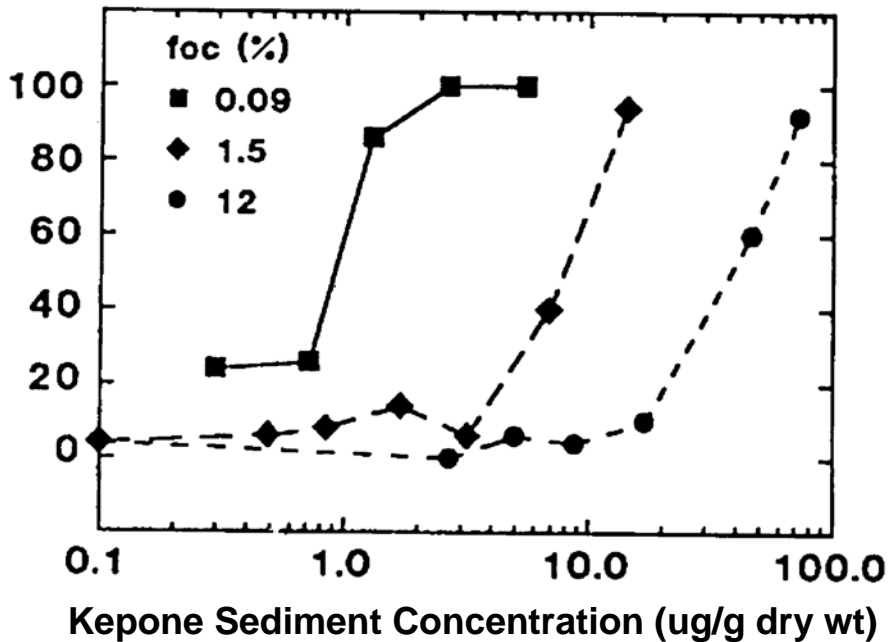
Environ Tox. Chem., (2005).

Bioavailability - Sediment

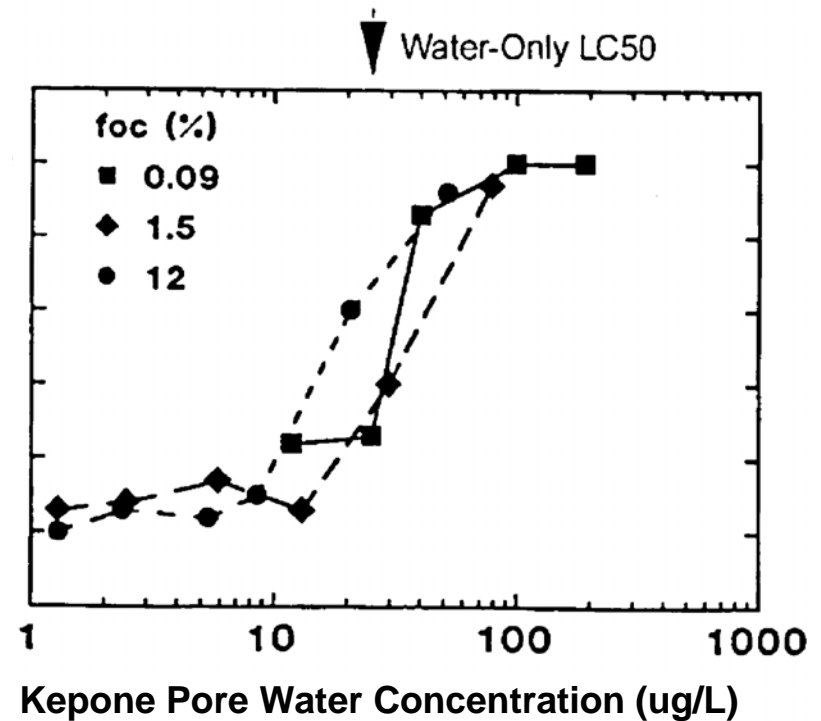


Pore water Concentration Predicts Sediment Toxicity

Dry Weight Normalization



Pore Water Normalization

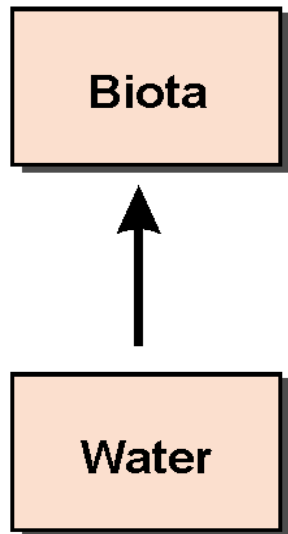


Adams, W. J., Kimerle, R. A., & Mosher, R. G. (1985). In R. D. Cardwell, R. Purdy, & R. C. Bahner (Eds.), *Aquatic Toxicology and Hazard Assessment: Seventh Symposium*. STP 854 (pp. 429-453). Am. Soc. for Testing and Materials.

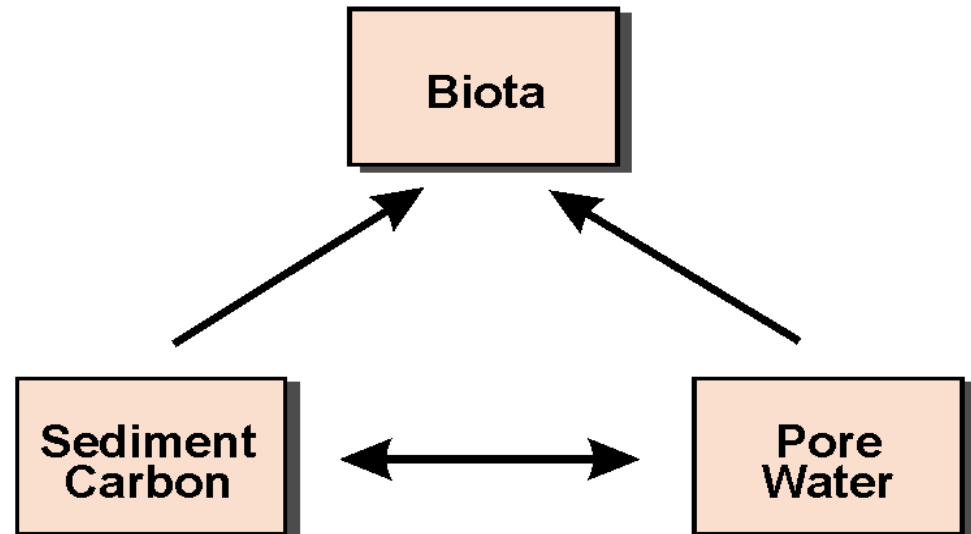
Di Toro, D. M., C. S. Zarba, D J. Hansen, W J Berry, R C. Swartz, C E. Cowan, S P. Pavlou H E. Allen, N A Thomas, P R Paquin. (1991). *Environ. Toxicol. Chem.* 11(12): 1541-1583.

Equilibrium Partitioning Model of Sediment Toxicity

Water Only Exposure



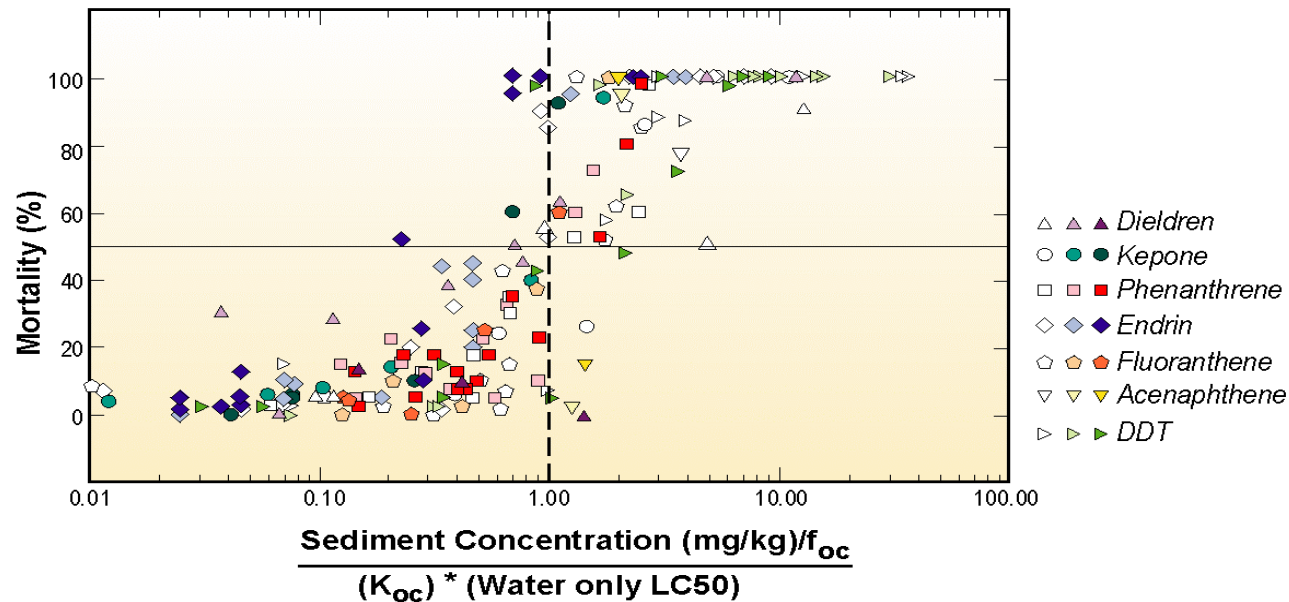
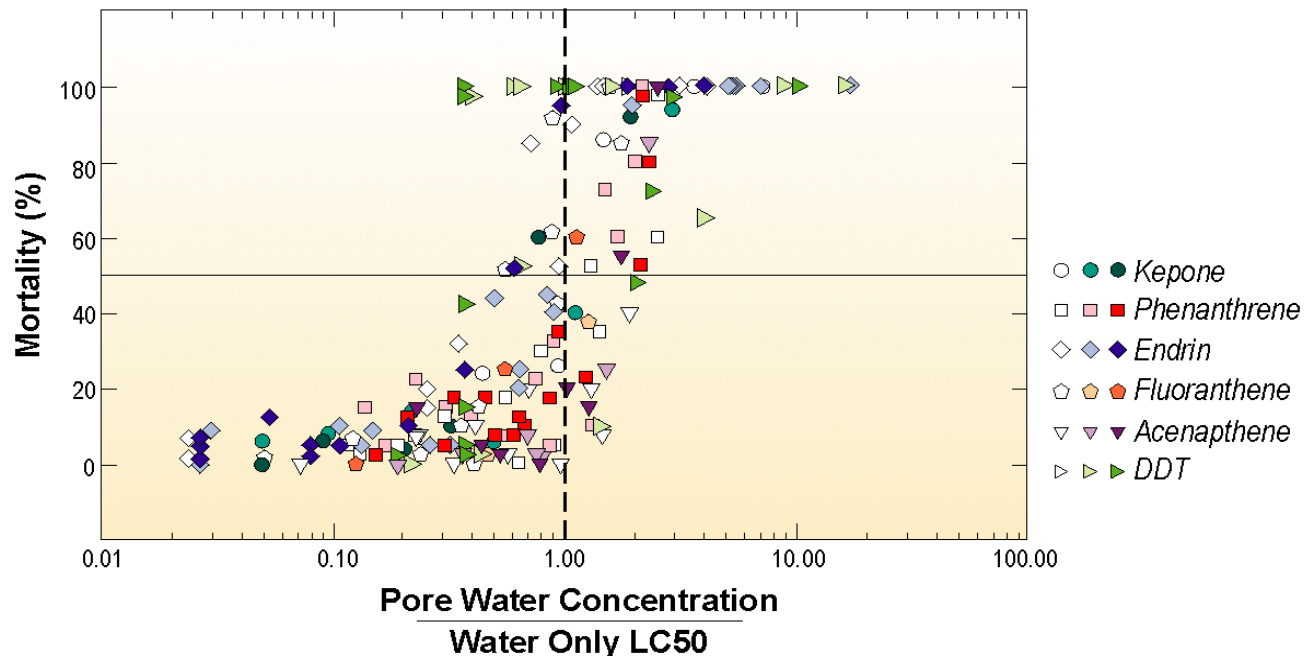
Sediment - Pore Water Exposure



Equilibrium Partitioning

Sediment Toxicity Prediction

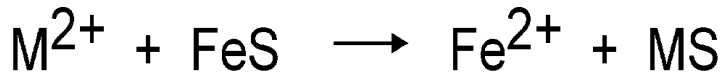
Pore Water Organic Carbon Normalized



USEPA (2000). Draft Technical Basis for the derivation of Equilibrium Partitioning sediment guidelines (ESG) for the protect of benthic organisms: Nonionic organics No. EPA-822-R-00-001

SEM – AVS Model of Metal Bioavailability

Metals are precipitated by reacting with iron monosulfide (AVS)

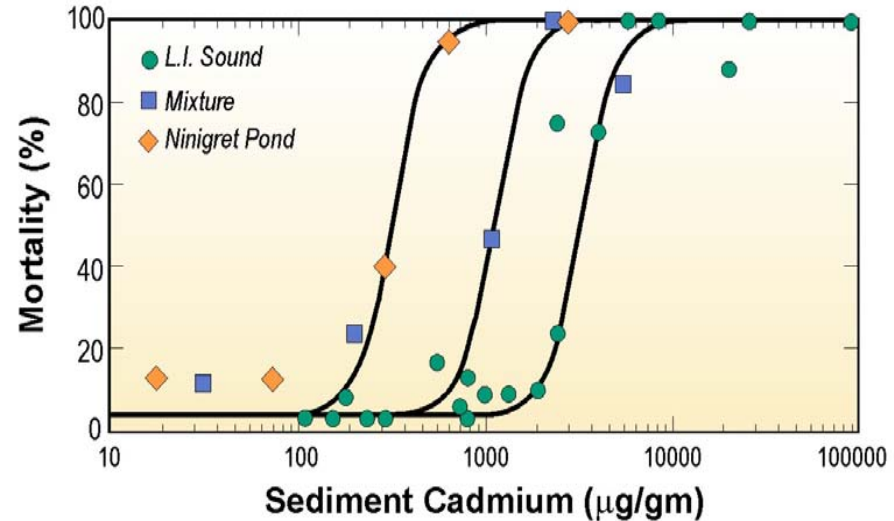


Sediment metal (SEM) is quantified using same extraction as for AVS (1N HCl)

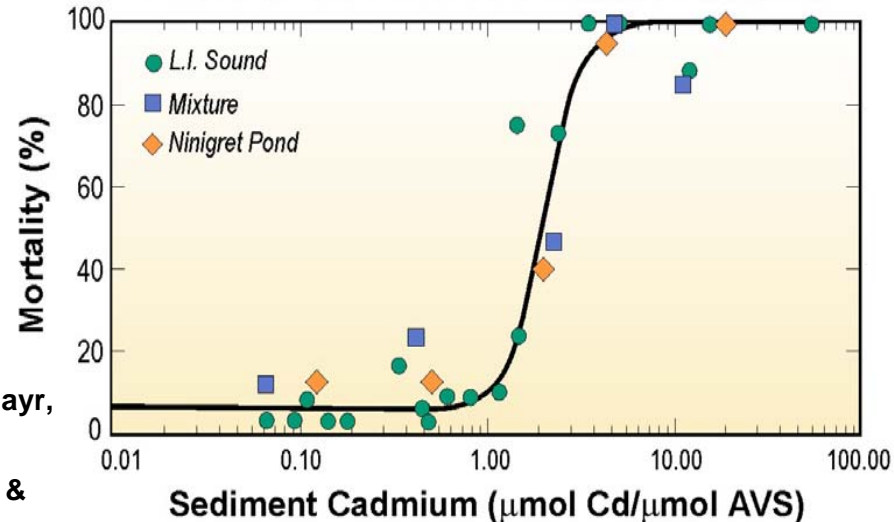
AVS > SEM No toxicity possible

AVS < SEM Toxicity possible

DRY WEIGHT NORMALIZATION



ACID VOLATILE SULFIDE NORMALIZATION

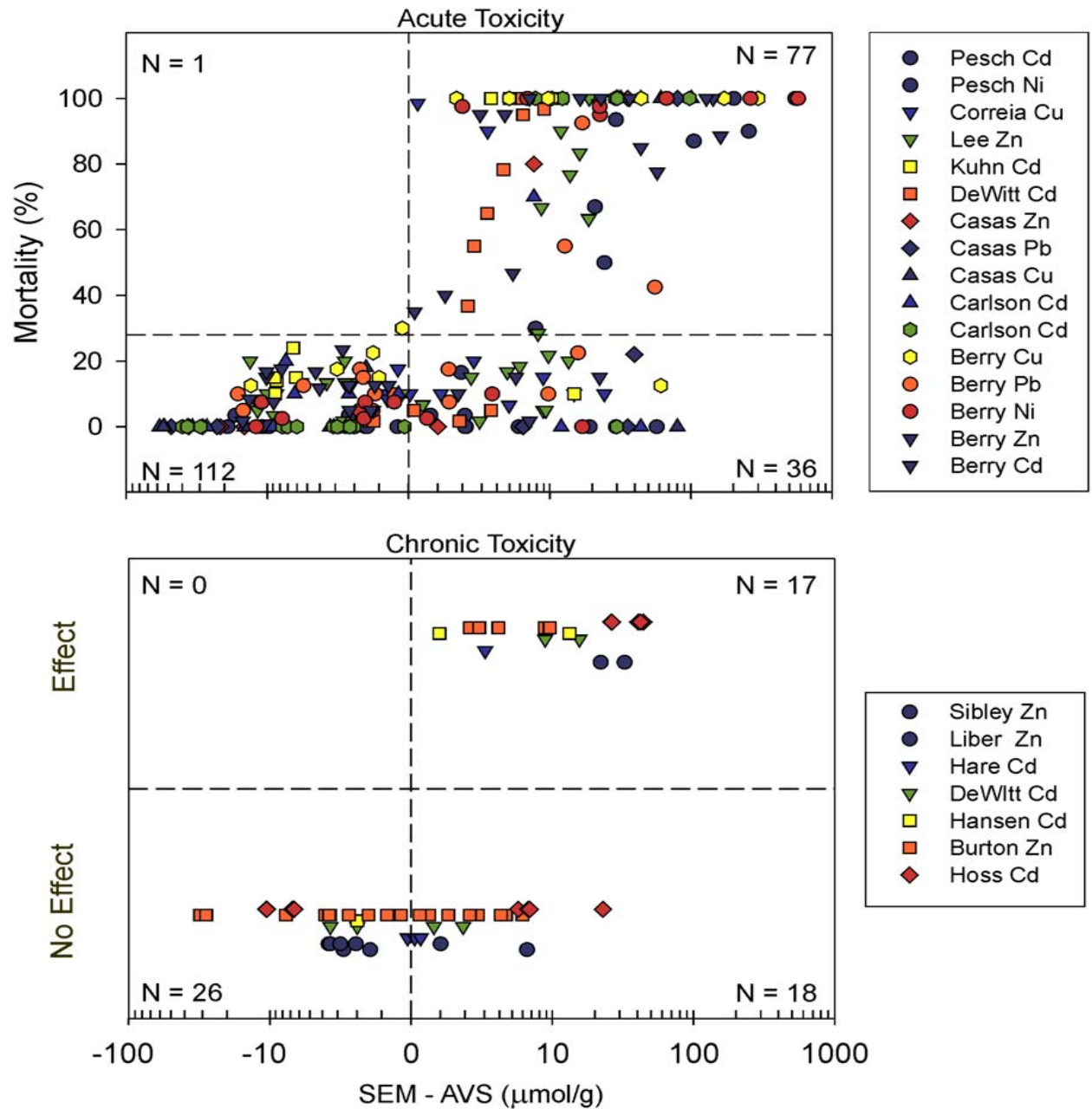


Di Toro, D. M., Mahony, J. D., Hansen, D. J., Scott, K. J., Hicks, M. B., Mayr, S. M., & Redmond, M. S. (1990). *Environ. Toxicol. Chem.*, 9, 1487-1502.

Di Toro, D. M., Mahony, J. D., Hansen, D. J., Scott, K. J., Carlson, A. R., & Ankley, G. T. (1992). *Environ. Sci. Tech.*, 26(1), 96-101.

SEM – AVS

Model Validation





Organic Carbon Normalized
Excess SEM

$$SEM_{x,OC} = (SEM - AVS)/f_{OC}$$

Observed Toxicity Boundary

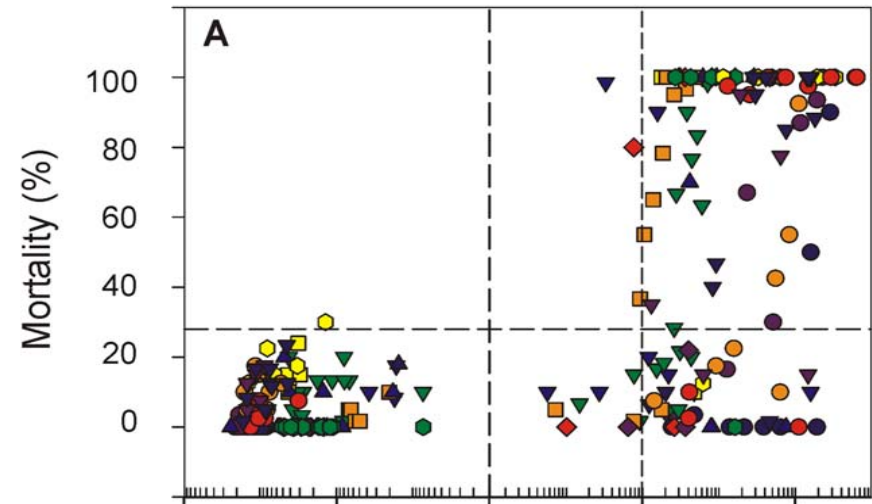
$$SEM_{x,OC} = 100 \mu\text{mol/gOC}$$

Acute

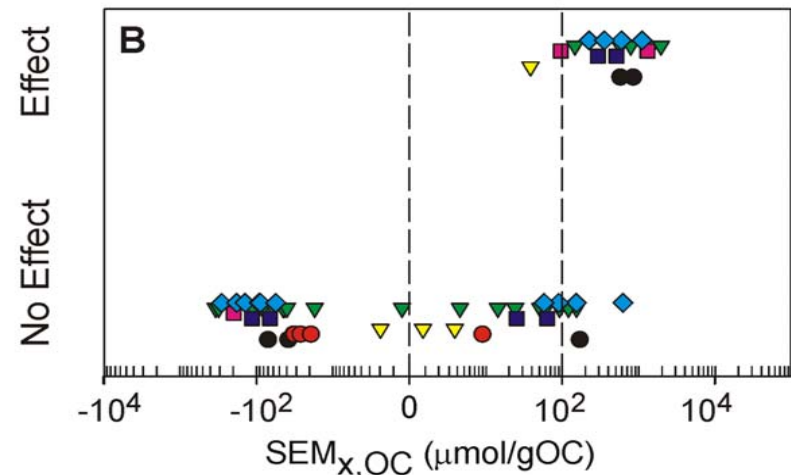
Chronic

● Pesch Cd [68]	▲ Casas Cu [67]	● Sibley Zn [72]
● Pesch Ni [68]	▲ Carlson Cd L. [69]	● Liber Zn [75]
▼ Correia Cu [64]	● Carlson Cd H. [69]	▼ Burton Zn [76]
▼ Lee Zn [66]	● Berry Cu [4]	▼ Hare Cd [73]
■ Kuhn Cd [65]	● Berry Pb [4]	■ DeWitt Cd [71]
■ DeWitt Cd [63]	● Berry Ni [4]	■ Hansen Cd [74]
◆ Casas Zn [67]	▼ Berry Zn [4]	◆ Hoss Cd [70]
◆ Casas Pb [67]	▼ Berry Cd [4]	

Acute Toxicity

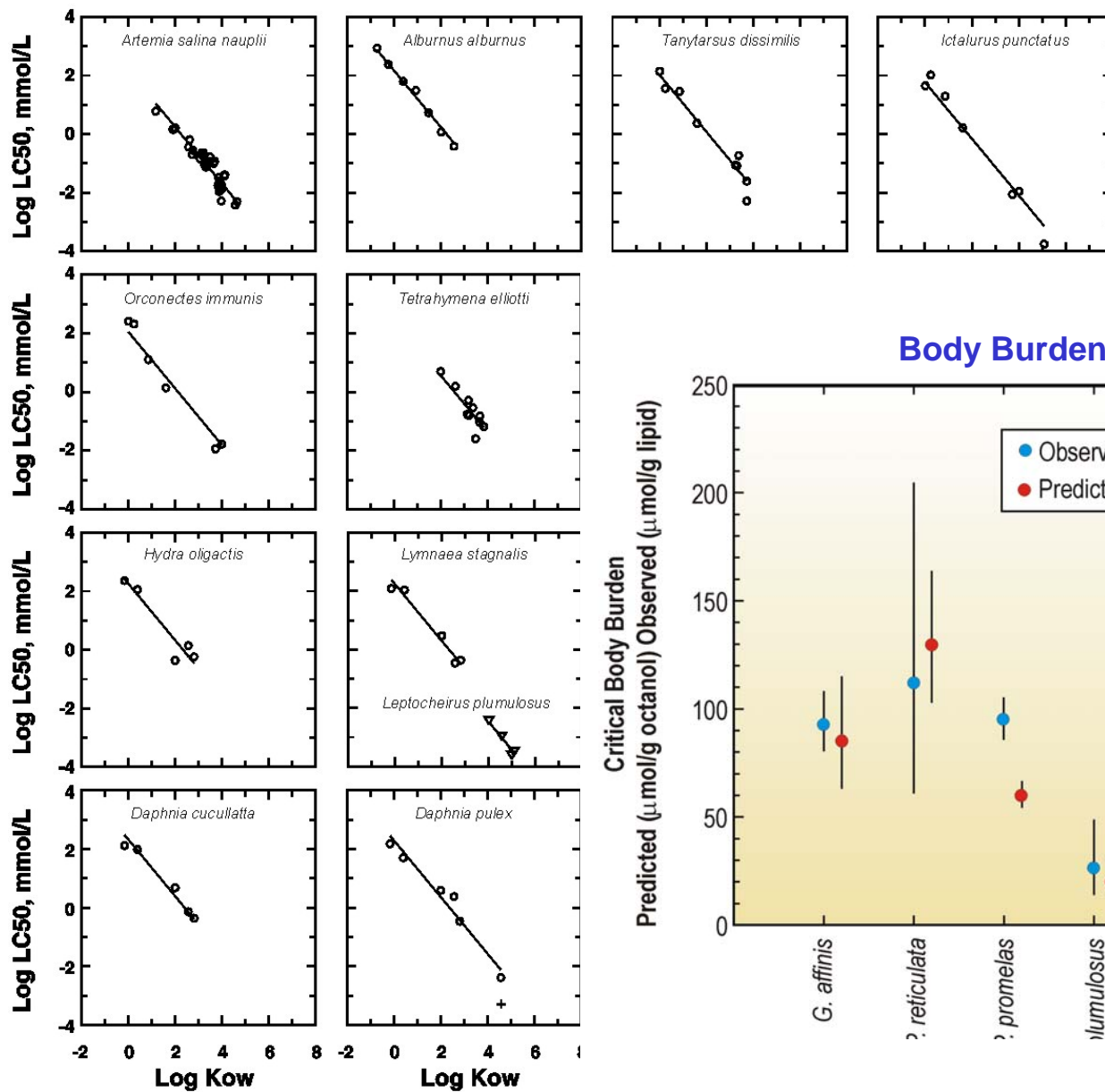


Chronic Toxicity



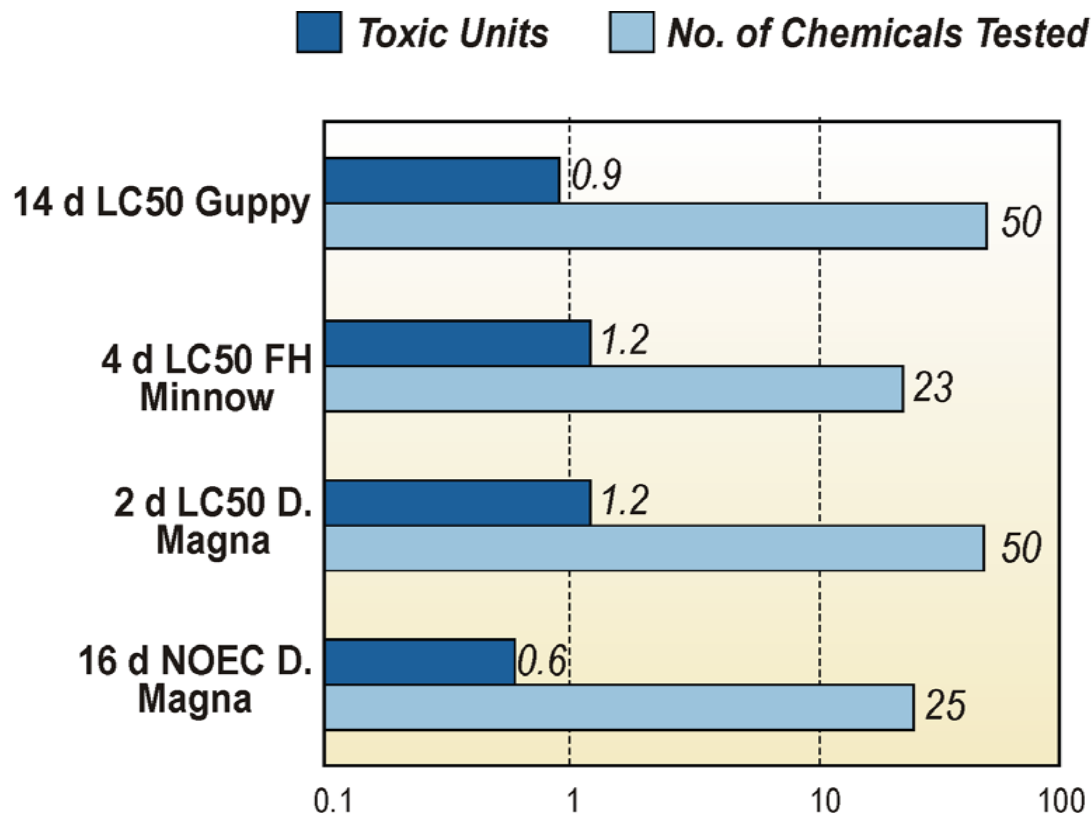
Narcosis Target Lipid Model

LC50s for Various Species



Di Toro, D. M., McGrath, J. A., & Hansen, D. J. (2000). Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. *Environ.Toxicol.Chem.*, 19, 1951-1970.

Toxicity of Narcotic Mixtures is Additive

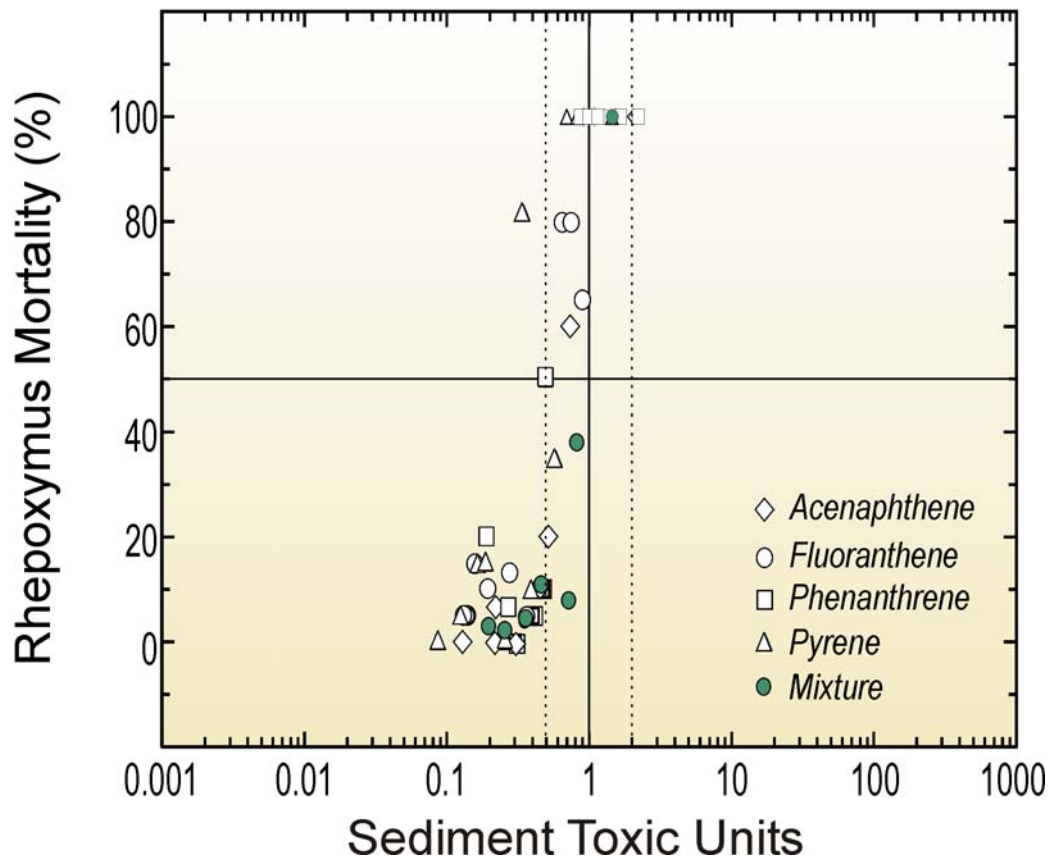


$$TU = \text{Measured Concentration} / \text{LC50 Concentration}$$

$$TU_{\text{mixture}} = \sum TU$$

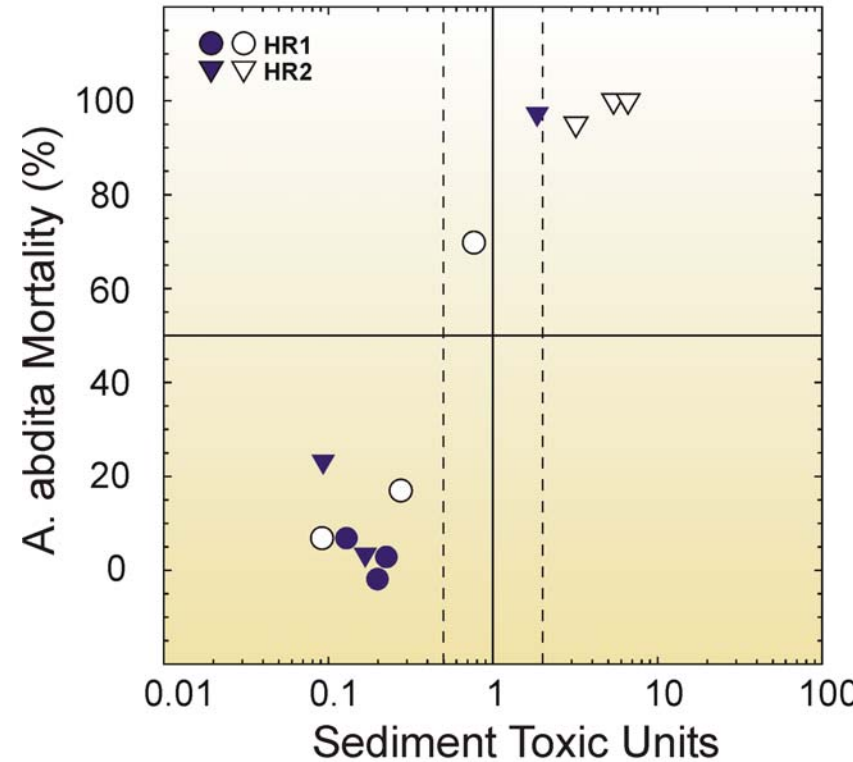
Predicted Sediment Toxicity for Single PAHs and PAH Mixtures Narcosis Target Lipid Model

Laboratory Spiked Data



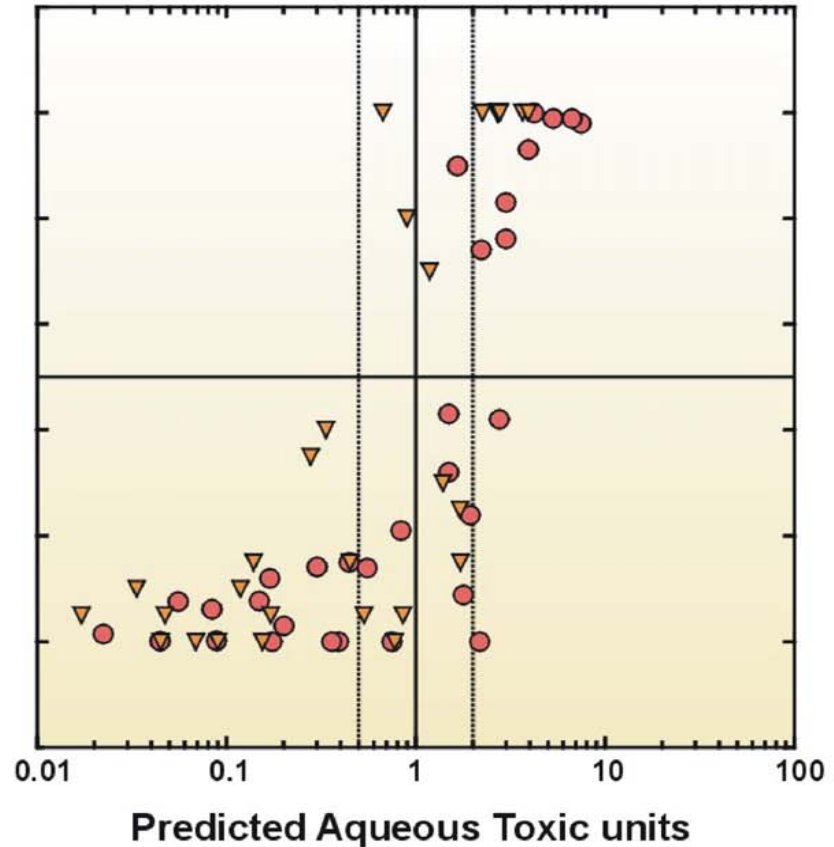
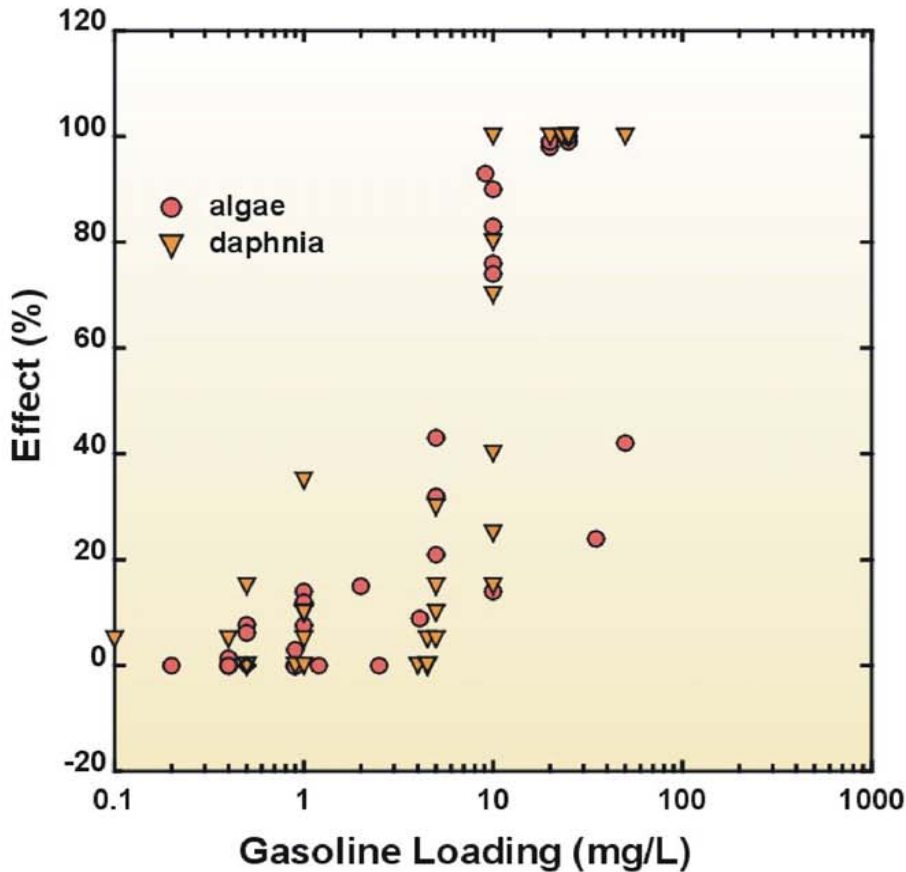
Oil Spill Data

Open symbols < 100 days post spill
Filled symbols > 100 days post spill



(Ho et al., Marine Pollution Bulletin 1999)

Toxicity of Gasoline Narcosis Target Lipid Model



McGrath, J., Parkerton, T., Hellweger, F., & Di Toro, D. (2005). Validation of the narcosis target lipid model for petroleum products: Gasoline as a case study. *Environ. Toxicol. Chem.*, 24(9), 2382-2394.