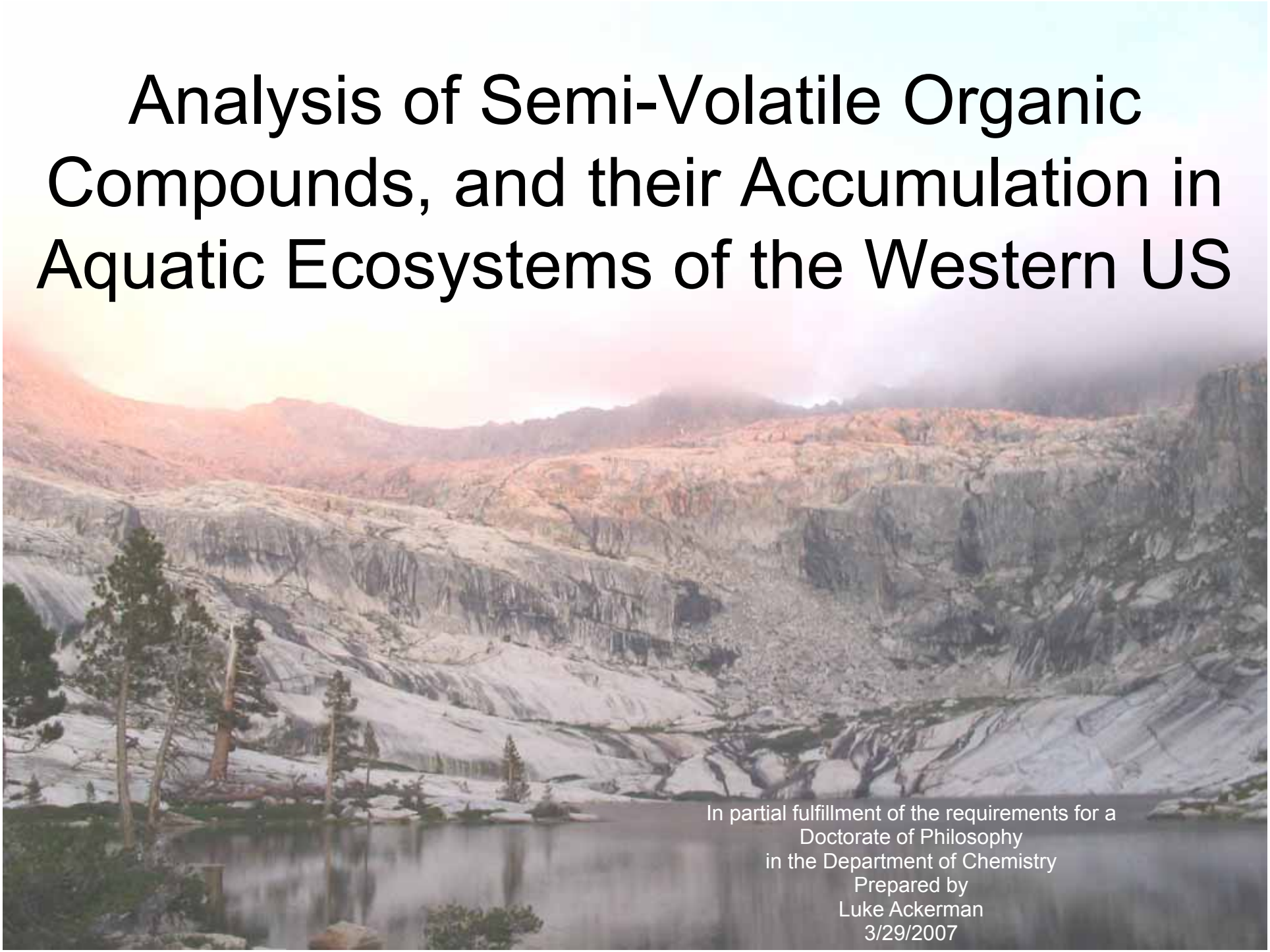
Analysis of Semi-Volatile Organic Compounds, and their Accumulation in Aquatic Ecosystems of the Western US



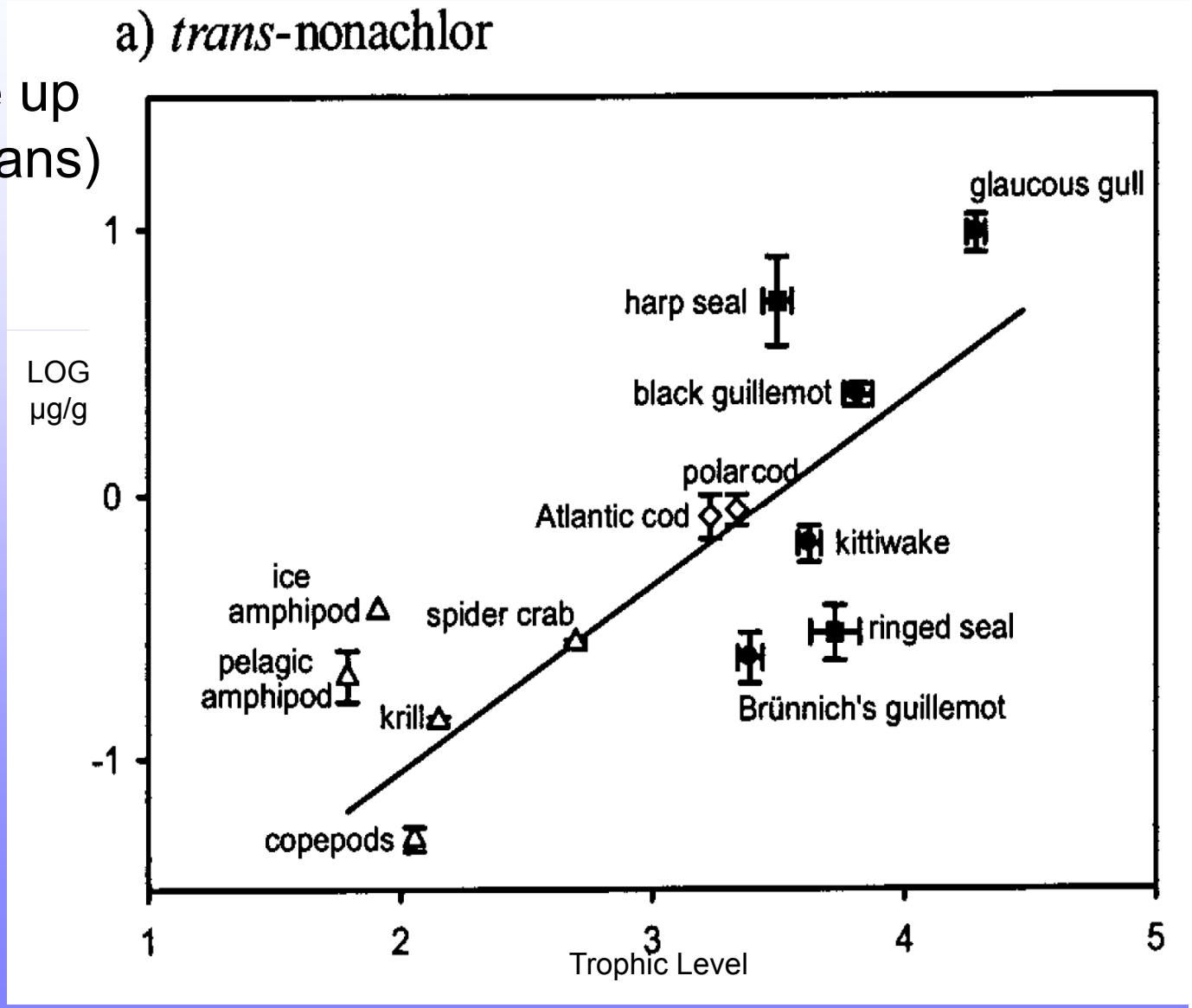
In partial fulfillment of the requirements for a
Doctorate of Philosophy
in the Department of Chemistry

Prepared by
Luke Ackerman

3/29/2007

Why study SOCs in fish?

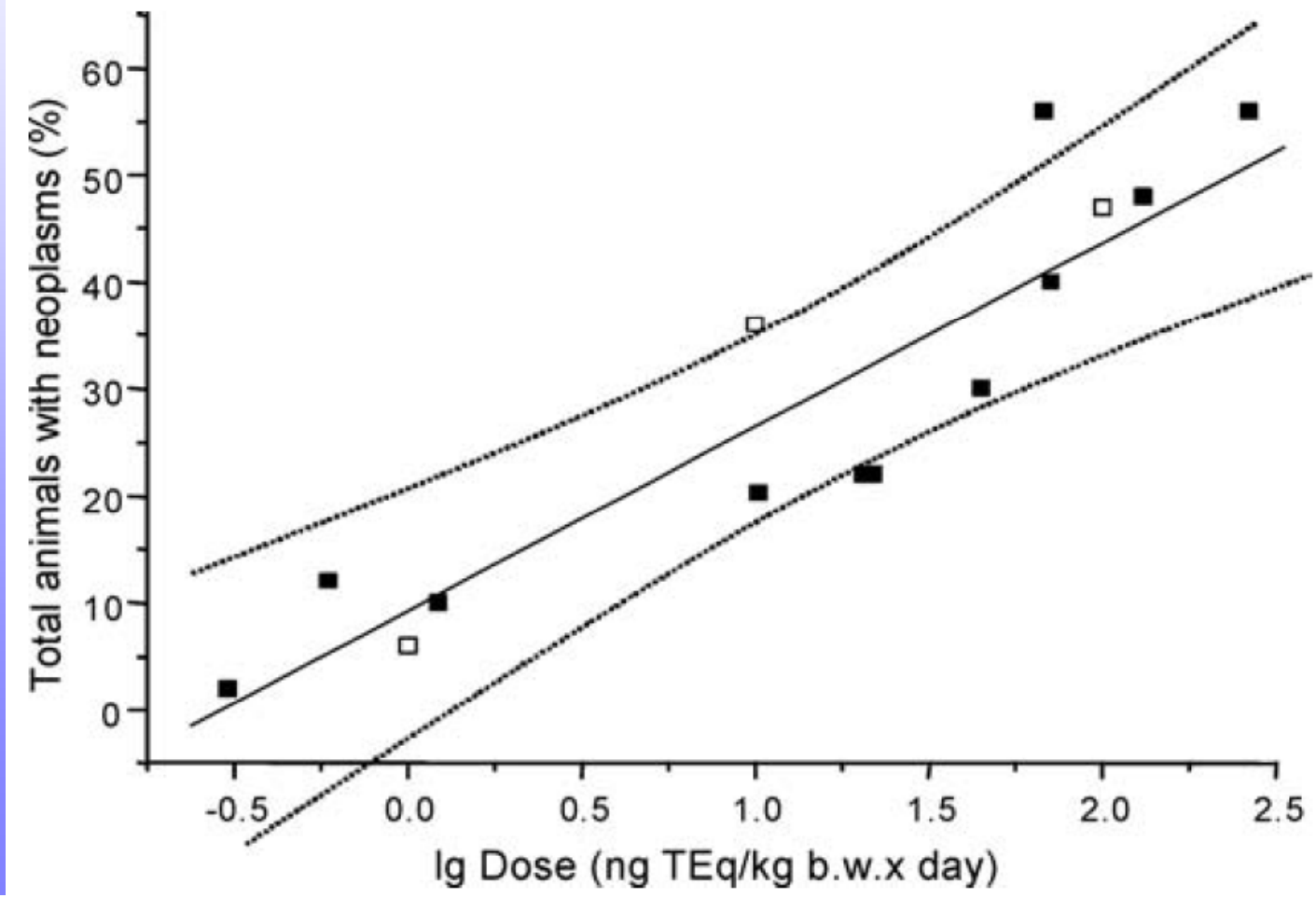
- Bioaccumulation
  - •conc. increase up food web (humans)



Hop et al, ES&T, '02

Why study SOCs in fish?

- Bioaccumulation
  - •conc. increase up food web
- Toxicity
  - acute
  - chronic
  - cancer
  - develop.
  - reproductive
  - ecosystemic



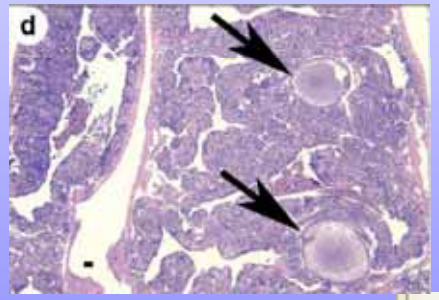
Knerr et al, Env.Pharm.Tox., '89

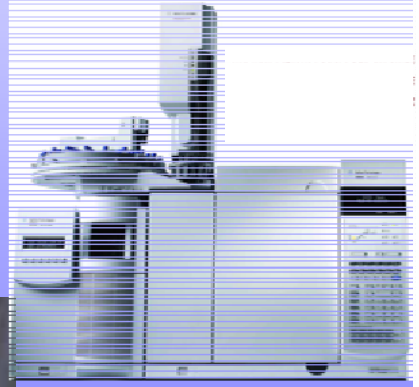
Research Questions

1. Are SOCs present in the fish of high elevation aquatic ecosystems of the Western US?
2. Are fish SOCs concentrations in western US aquatic ecosystems higher than elsewhere?
3. Do current use compounds accumulate in high elevation fish from the Western US?
4. Does fish SOC accumulation reach toxicologically relevant concentrations?
5. What ecosystem characteristics best explain the relative accumulation of SOCs?

How we studied SOCs and Fish Health

- Fish Health & SOCs
  - Catch (20/lake), measure outward health, age, gender, size
  - Dissect, study major organs for stress (MA), malformations
  - Measure hormones (ELISA), look @ gender effects (Vitelogenin)
  - Select subset for SOC analysis (10/lake)
  - Homogenize, solvent extract, separate SOCs, measure (GC-MS)



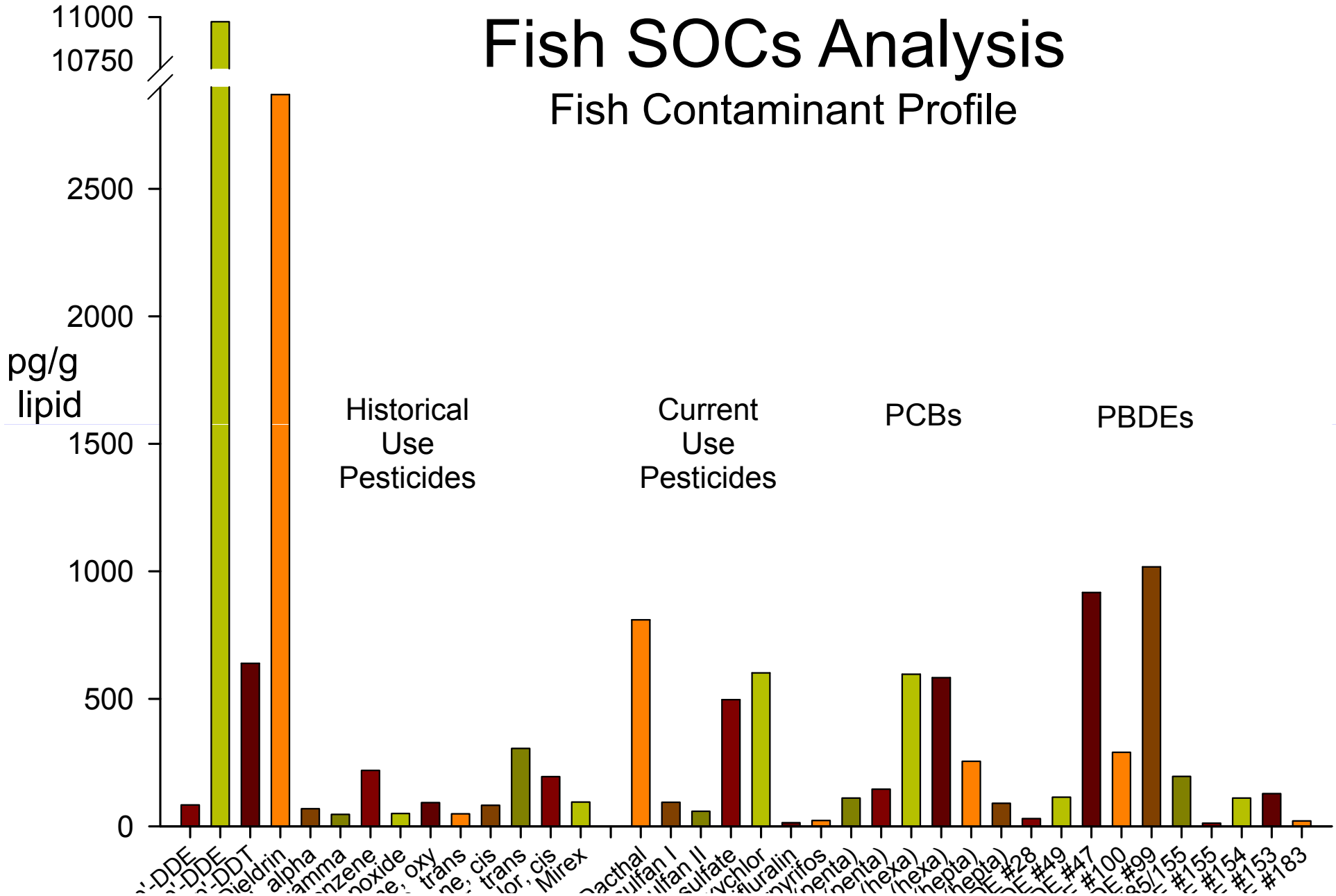


Fish SOCs Analysis

- 91 compounds measured, 136 samples = 12376 measurements
- interferants in 5%
- not detected in 0.03-100% samples by compound
- 14 compounds > 90% n.d. - PAHs, some current use pesticides (CUPs)
- 28 compounds < 33% n.d., further study

Fish SOCs Analysis

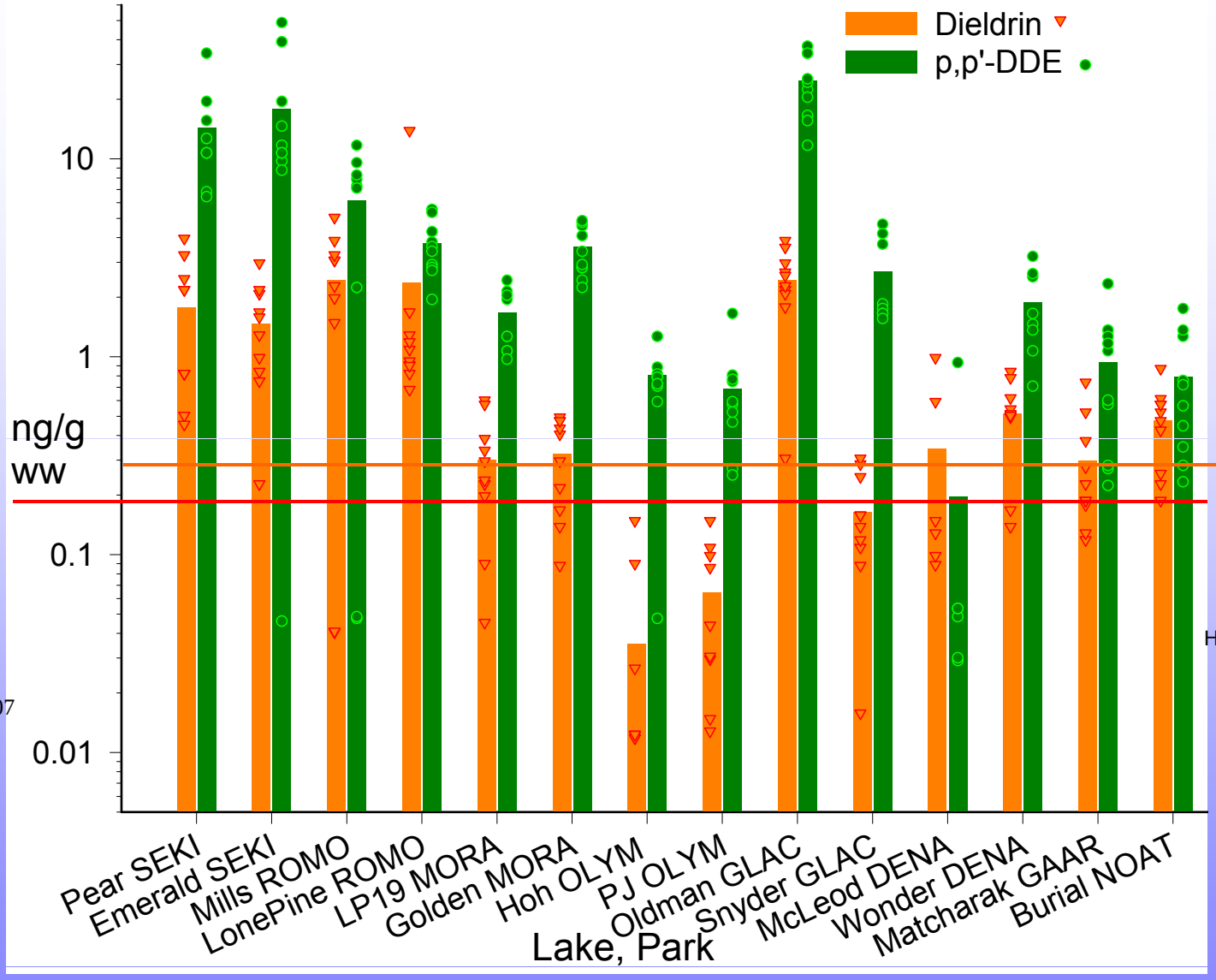
Fish Contaminant Profile



SOC concentrations in NP Fish

dieldrin, Canadian Mountain Trout

Demers et al, ES&T '07



Pacific Salmon dieldrin

Hites et al, Science '04

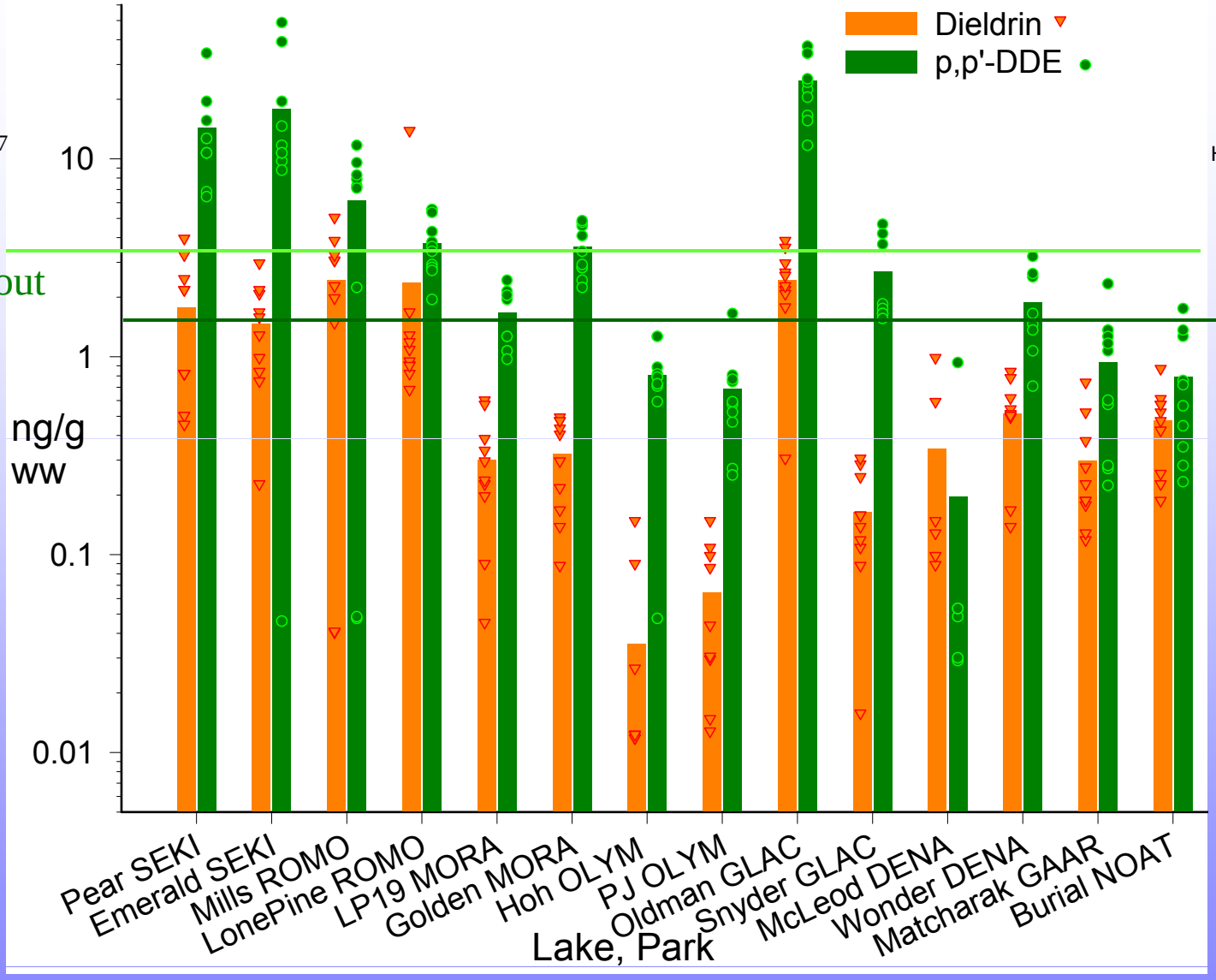
SOC concentrations in NP Fish

Demers et al, ES&T '07

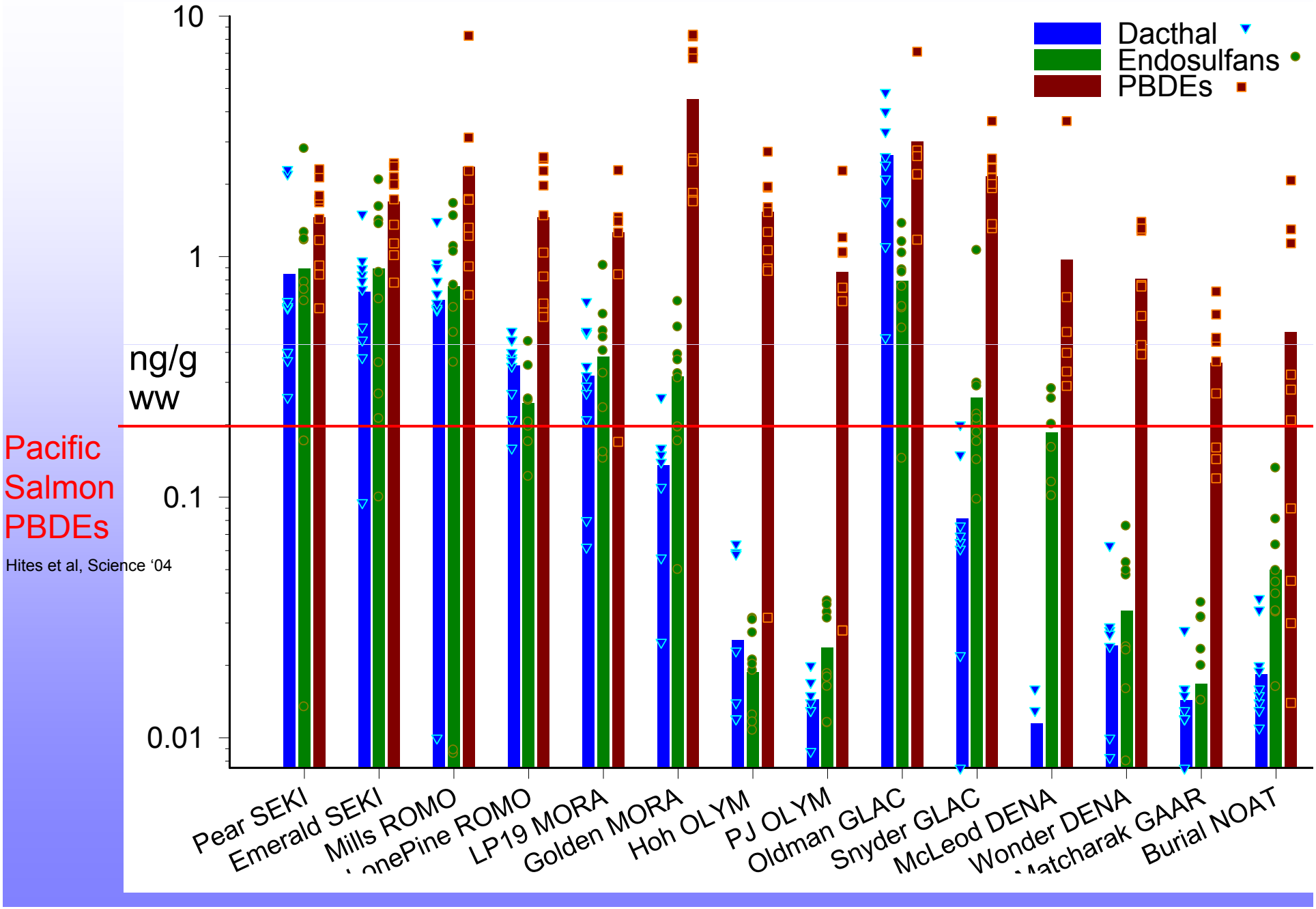
p,p'DDE, Canadian Mountain Trout

Hites et al, Science '04

Pacific Salmon p,p'DDE



Current-use SOC concentrations in Western Lakes



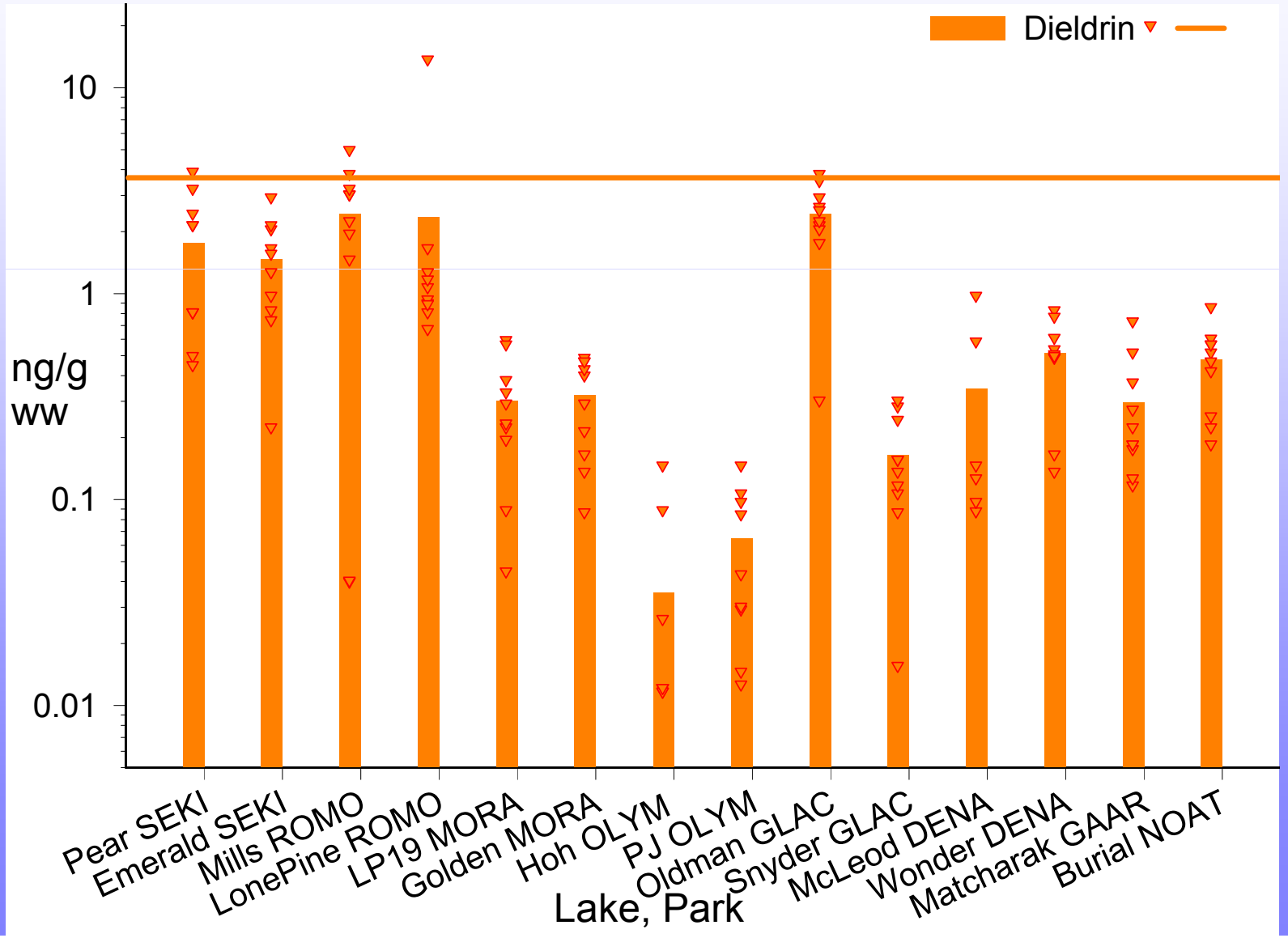
Assessing human health relevance.

Methods/Assumptions

- Used EPA Fish Contaminant Advisory Guidance
- No single target population – not specific advise
- Non-Cancer risk, 1 compound @ a time,
- Cancer risk – additive, no consump. w/o risk, ‘acceptable risk’
- Lifetime consumption, acceptable risk of 1:100,000
- calculated chemical specific screening concentration
  - Recreational fishers – 2.3 8oz meals/mo…muscle
  - Subsistence fishers – 19 8oz meals/mo…whole fish
- Also maximum consumption rate to avoid increased health risk

Health relevance …Recreational Fishers

- Lifetime consumption, fillets
- other SOCs 1-2 orders below recreational fishing values



Health relevance …Subsistence Fishers

- Lifetime consumption
- Whole fish

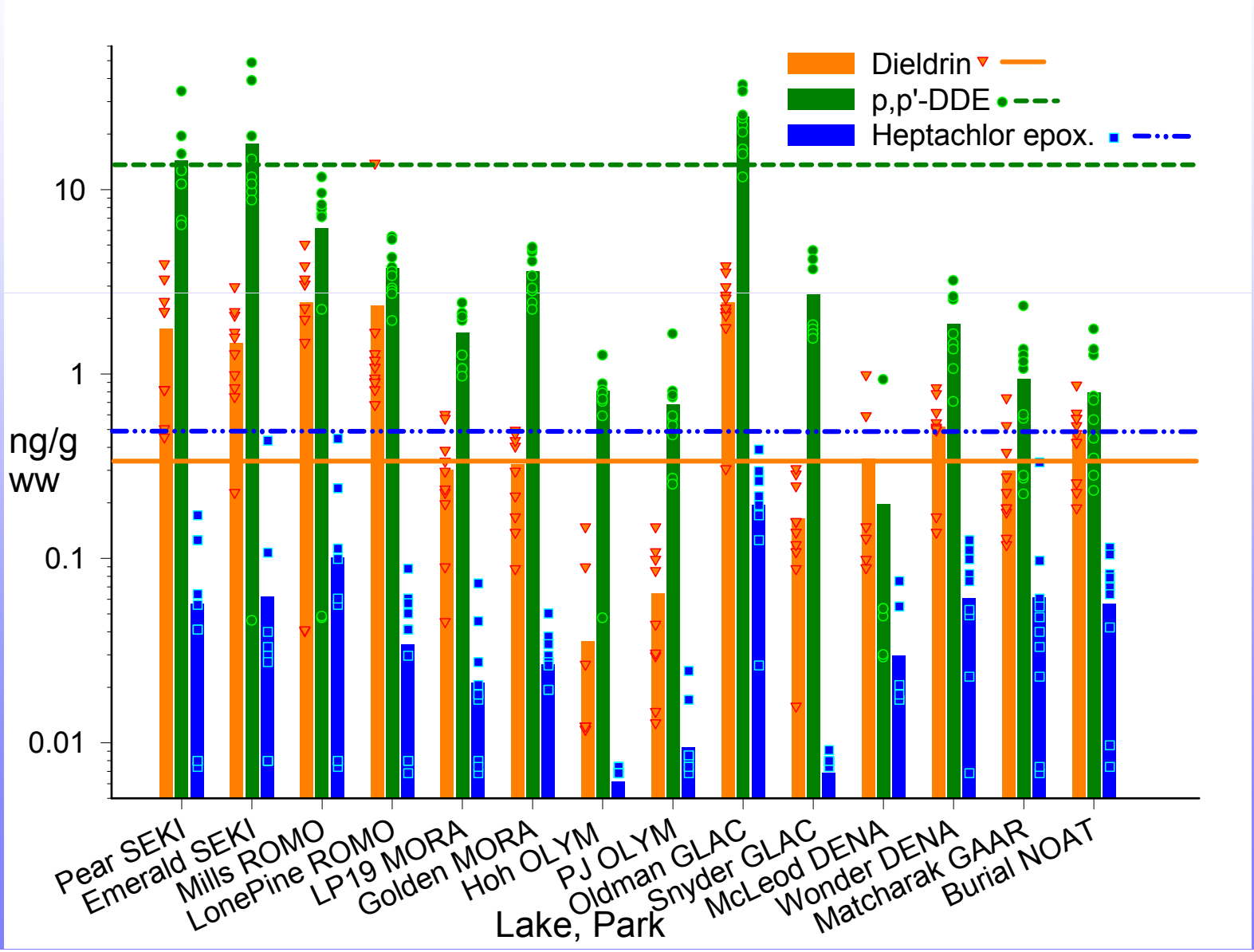


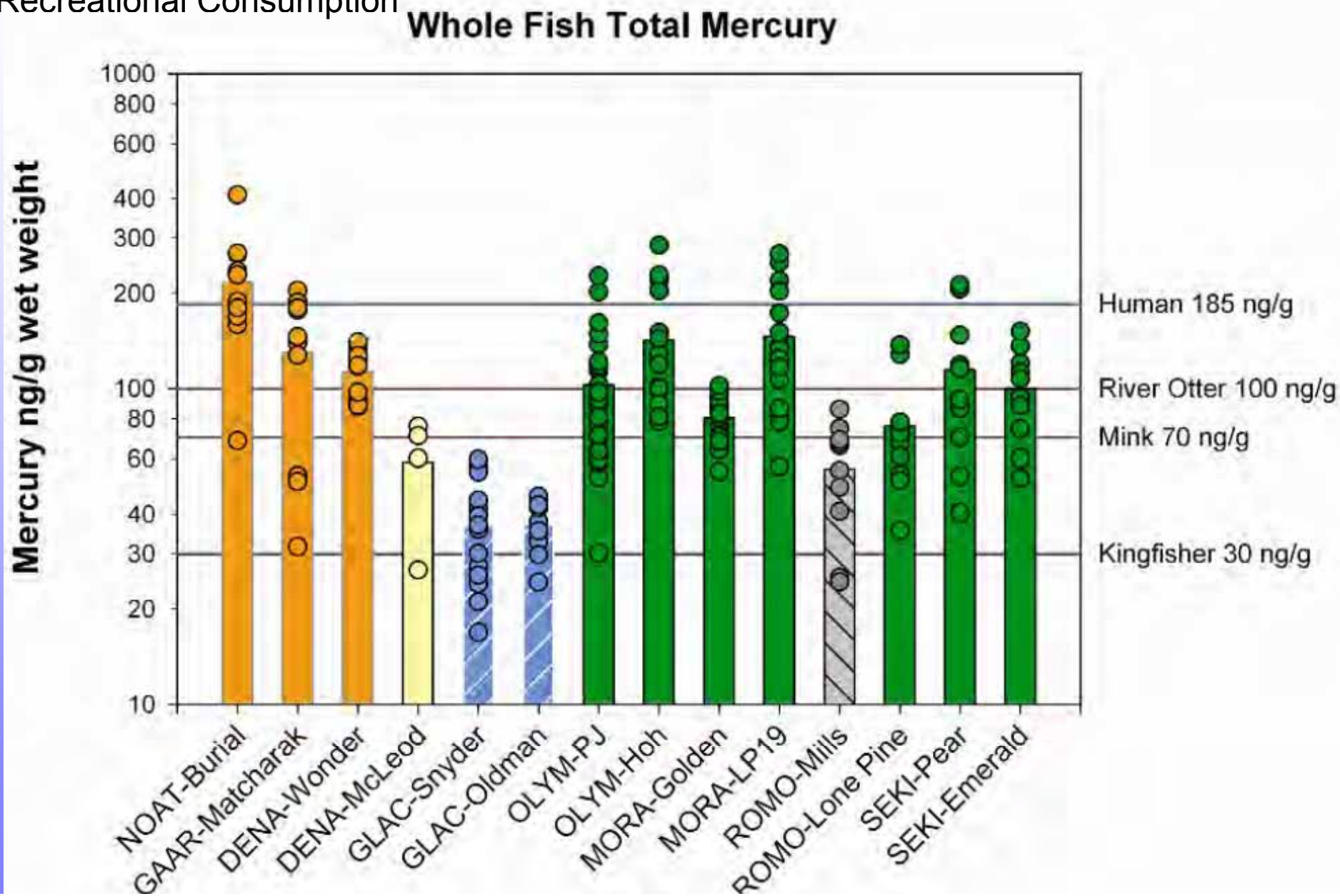
Table S4. Estimated Fish Consumption Guidelines:

Monthly, For Additive Cancer Risk, Lifetime Consumption

Lake, National Park/Preserve	# meals/mo 8 oz meals, Whole Fish	# meals/mo 8 oz meals, Fileted, Cooked
Emerald Lake, Sequoia NP	3.0*	4.0
Pear Lake, Sequoia NP	2.7*	3.5
Mills Lake, RockyMtn NP	2.2*	2.9
LonePine Lake, RockyMtn NP	2.3*	3.1
LP19 Lake, MtRanier NP	15*	19
Golden Lake, MtRanier NP	12*	16
Hoh Lake, Olympic NP	77	102
PJ Lake, Olympic NP	43	57
Oldman Lake, Glacier NP	1.7*	2.3
Snyder Lake, Glacier NP	23	30
McLeod Lake, Denali NP	12*	16
Wonder Lake, Denali NP	7.7*	10
Matcharak Lake, Gates of the Arctic NP	12*	16
Burial Lake, Noatak Nat.l Preserve	9.1*	12

Health relevance …Mercury In Fish

- Lifetime consumption
- Recreational Consumption

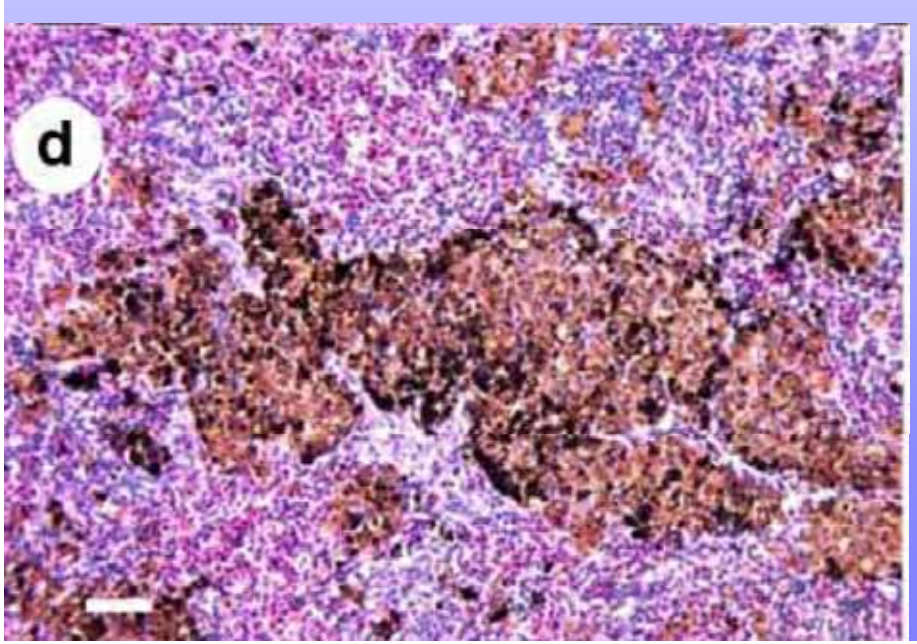


Assessing Ecosystem Health Risks

- Fish Health – Measured Some Aspects Directly
- Fish Eating Wildlife – Compared to thresholds
  - EPA Great Lakes Water Qual. Doc. -from sci. studies
  - Compound Specific, Species Specific,
  - lowest observ. negative health effect (reproductive)
- Ecosystem Health – Ecosys Function Model
  - Most complex, most accur. for simple, known sys.
  - general direction of total contam. effect on trophic guild (population, age structure)

Fish Health

- Most fish outwardly healthy
- SEKI Brook Trout skinny, ~stressed, younger, eat anything
- Macrophage Aggregates (MA) also slightly higher in SEKI
- MA's increased with age, and with Mercury load
- Female egg protein in several males from SEKI, but not clearly 'elevated', No gonad abnormalities



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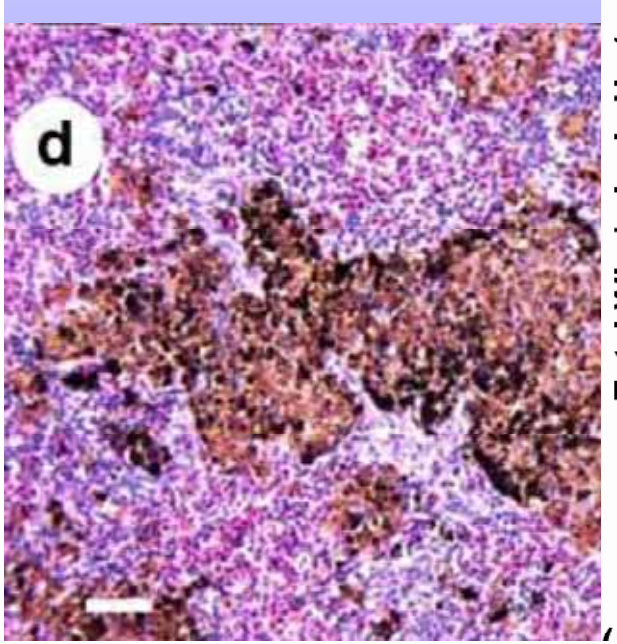

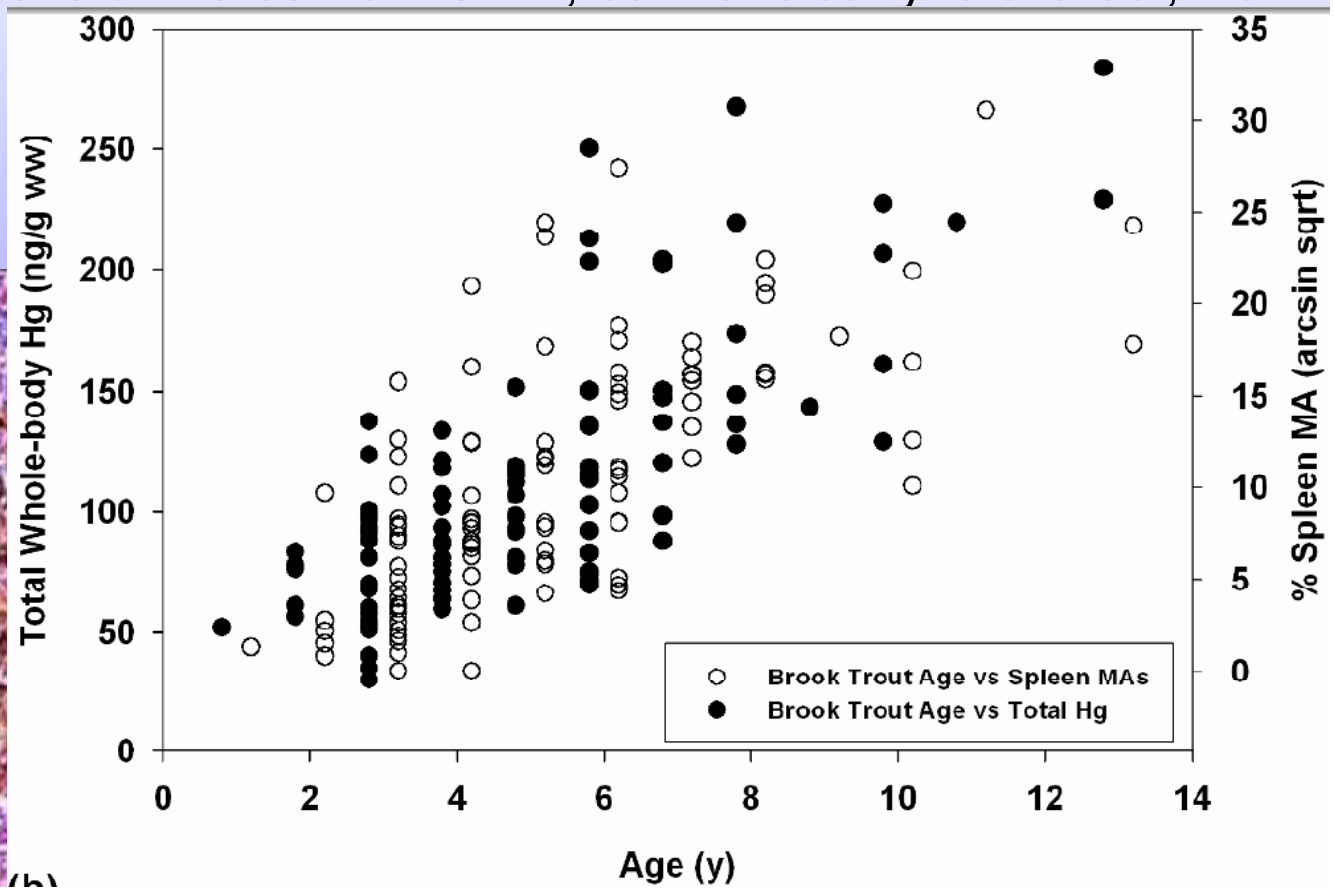

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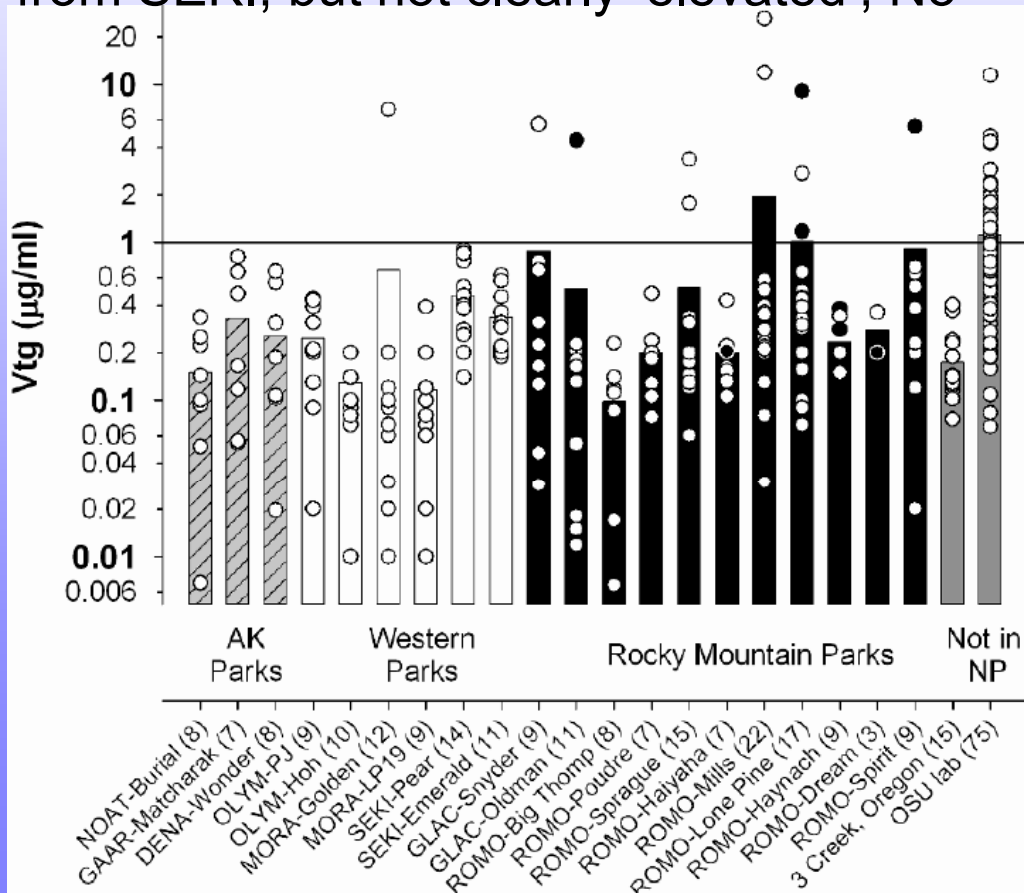
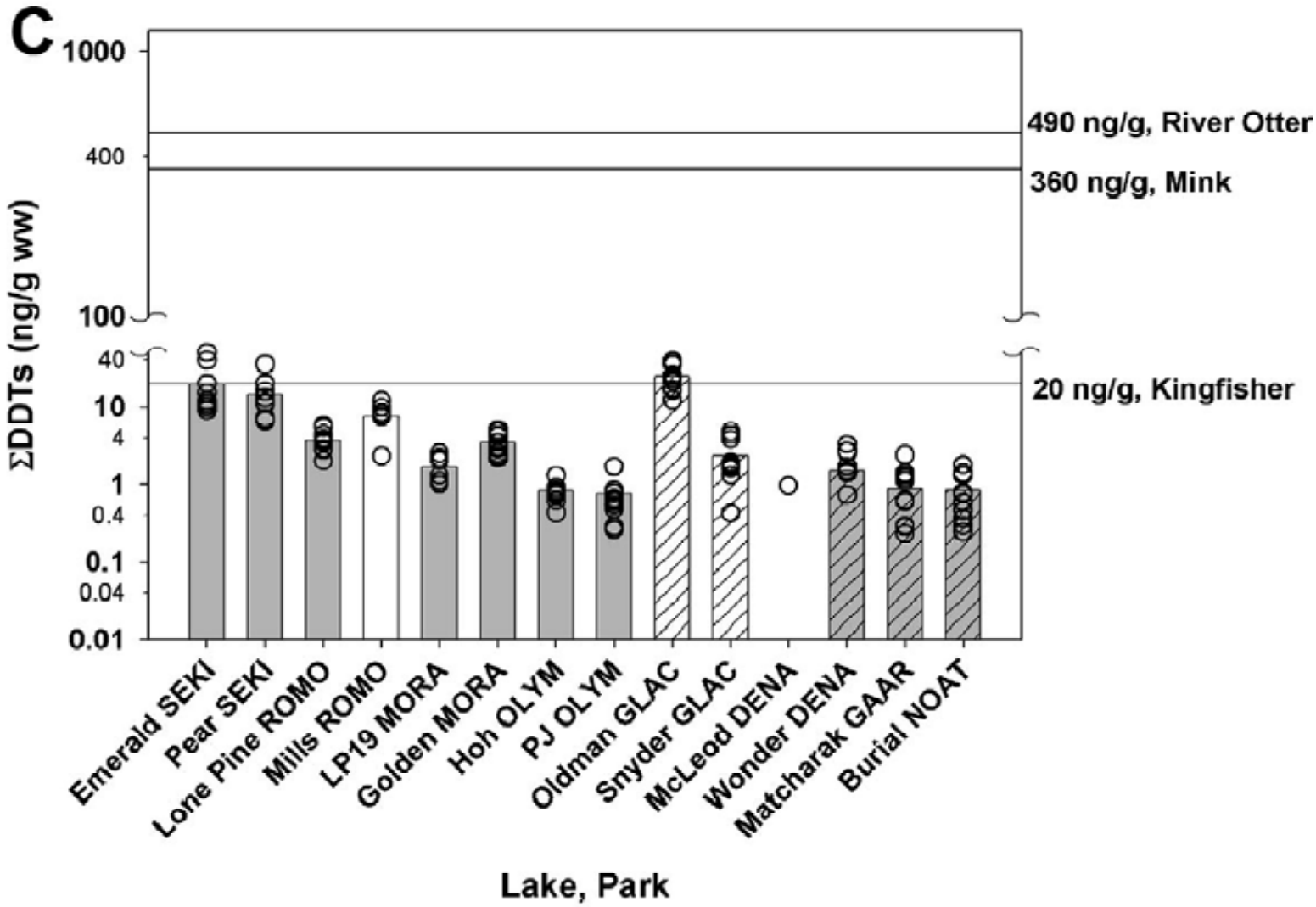


Wildlife Health

- No lakes exceeded wildlife health thresholds
- DDT's in ~5 SEKI fish exceeded Kingfisher reprod health threshold
- Hg exceeded Kingfisher, Mink, and River Otter thresholds



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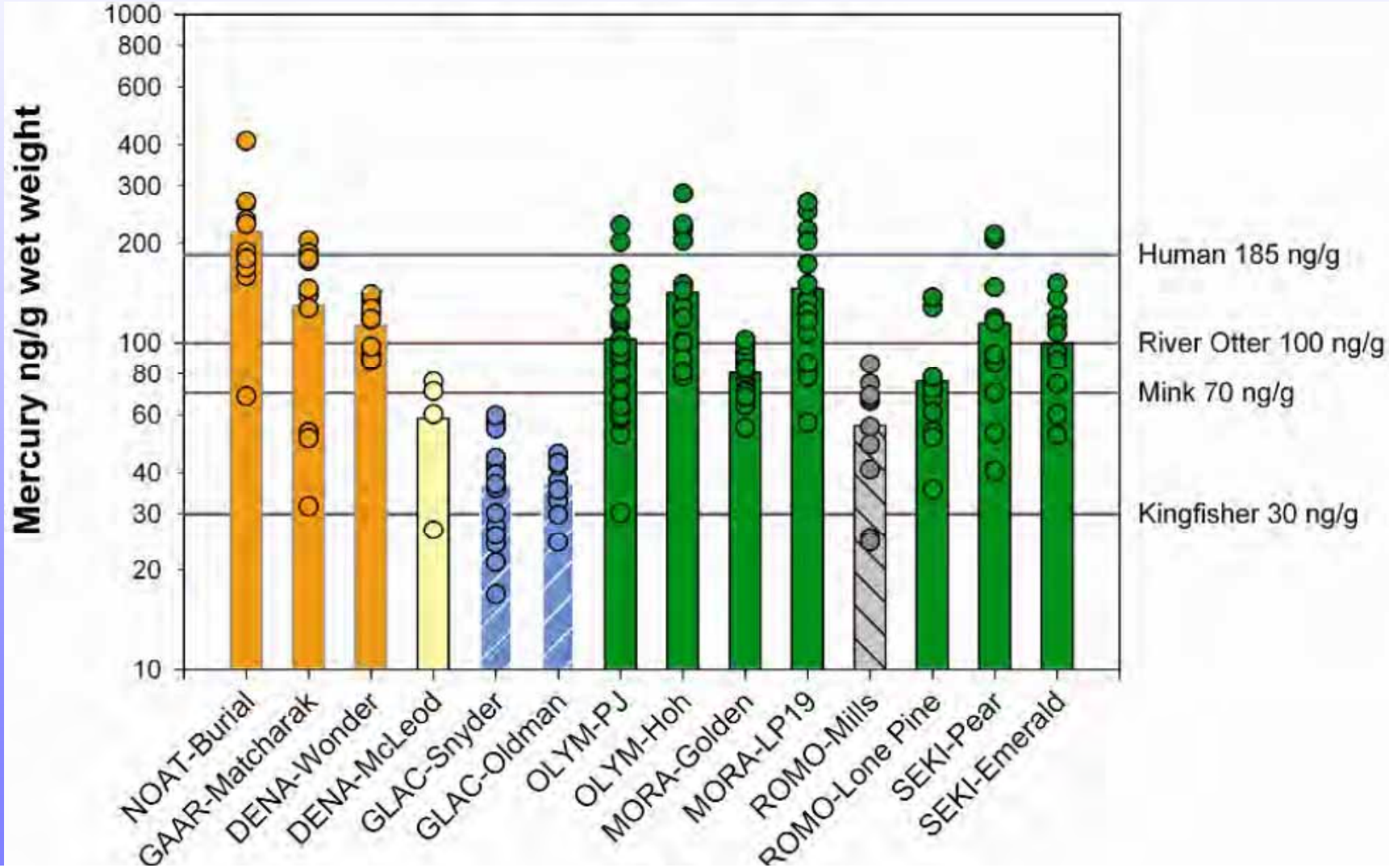

Potential Ecosystem Impacts

- SEKI lakes were single fish class, short, omniverous aquatic foodwebs with limited piscivores. Nutrient limited.
- Loop analysis suggested contaminant downward stresses on fish population but older population
- Loop analysis more uncertain about effect on piscivores, but generally suggest lower populations and older age structures

Questions