Contaminants in Fish – Research Results

- Overview of approach to estimating human health risk from fish consumption
  - Individual chemical risk
  - Total cancer risk – consumption suggestions
- Risk Benefits and communication
- Comparison with other fish
- Explaining variability in contamination

Estimating Toxicological Relevance

- EPA Fish Contaminant Advisory Guidance

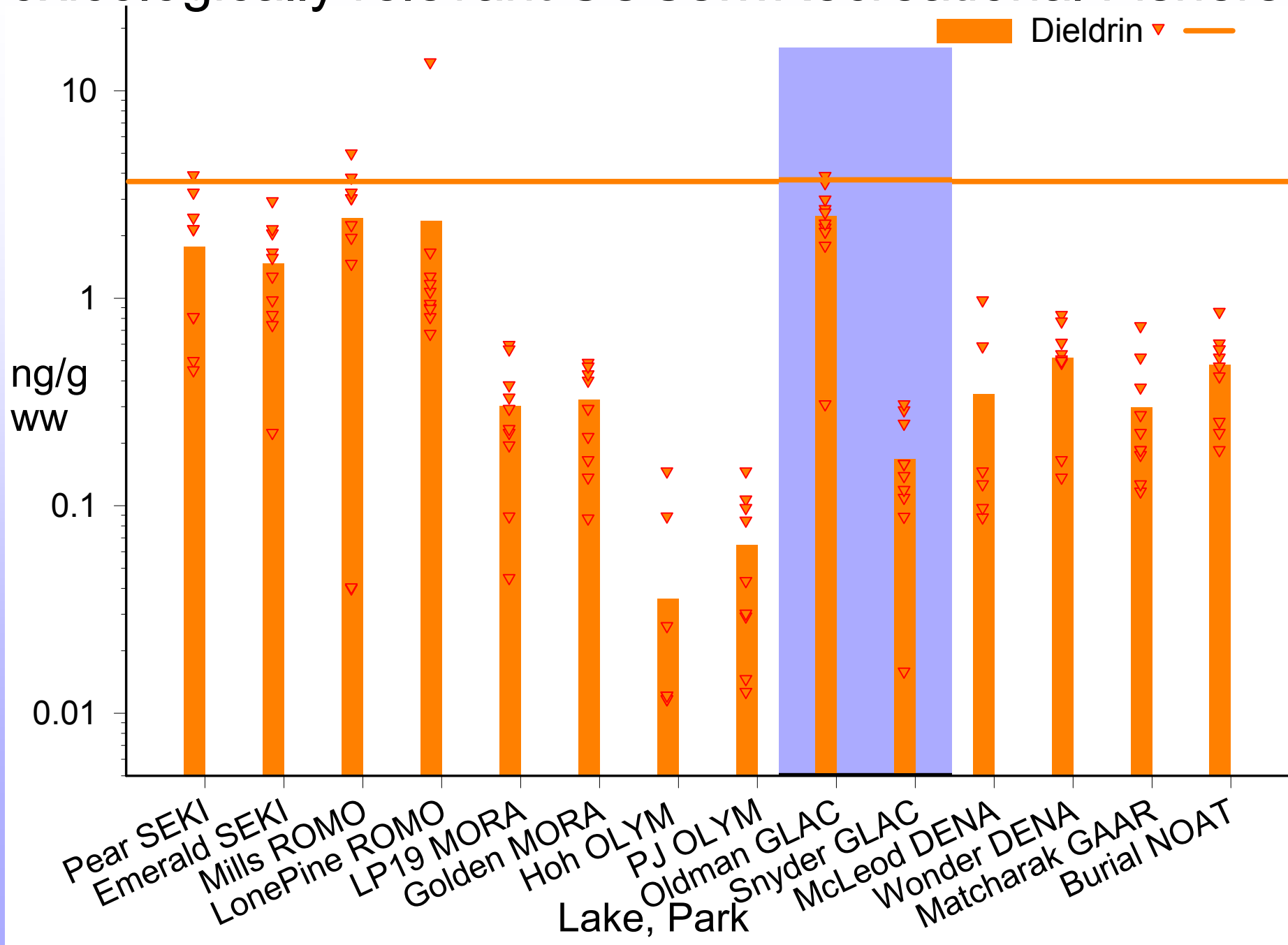
  EPA-OWS "Guidance for Assessing Chemical Contaminant Data for Use In Fish Advisories, Third Ed.," 2000.

- Probabilistic Risk Estimation – accurate for population, not individual
- Three different measures:
  - ‘Safe Consumption’ – Need toxicity, concentration, & acceptable risk
  - ‘Safe Concentration’ – Need toxicity, fish consumption, & acceptable risk
  - ‘Actual risk’ – Need toxicity, concentration, & fish consumption rate
- Measured concentration, EPA estimates for risk, consumption, & toxicity http://www.epa.gov/iris/index.html
- Generally (Consumption x Conc.) / Toxicity = Actual Risk
  - or (Risk x Toxicity)/Consumption=Safe Concentration
  - or (Risk x Toxicity)/Concentration=Safe Consumption

Assessing Toxicological Relevance

- Two Risk Endpoints: 1. Chronic, 2. Cancer
- Add Cancer risks, not Chronic
- Chronic is threshold…above=measurable risk, below=none
- Cancer risk is linear…little exposure=little risk, large=large risk
- Three risk calculations; conc., consumption, risk
- Lifetime consumption, lifetime risk
- Factored for 150lb adult
- Concentrations adjusted for filet vs whole fish (↓32%)
  - Recreational fishers – 2.3 8oz meals/mo…muscle filet
  - Subsistence fishers – 19 8oz meals/mo…whole fish

Toxicologically relevant SOCs…Recreational Fishers



Toxicologically relevant SOCs…Subsistence Fishers

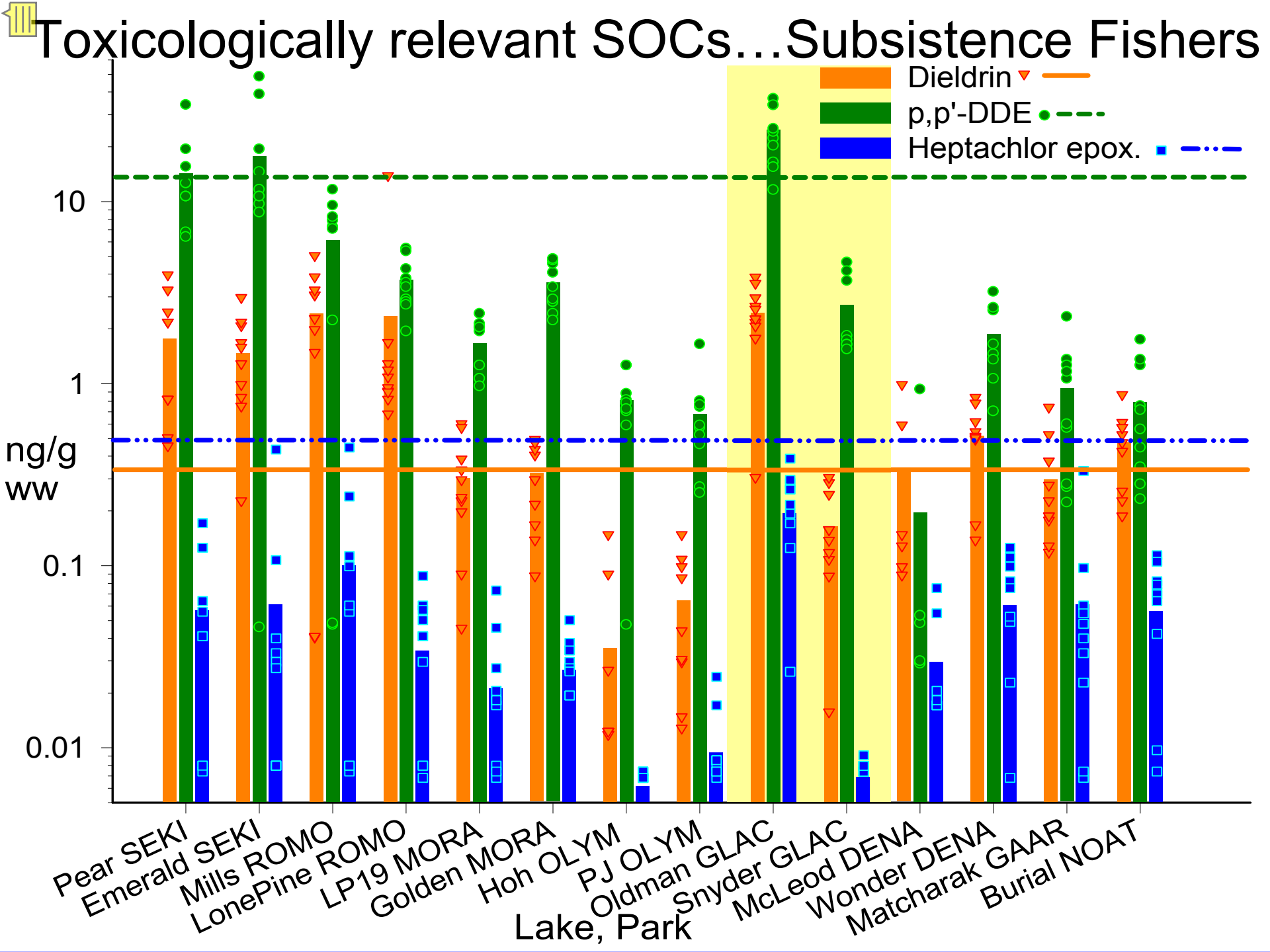


Table S4. Estimated Fish Consumption Guidelines:

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	fish/mo Whole Fish	#fish/mo Fileted, Cooked
Emerald Lake, Sequoia NP	3.0*	4.0	9.4	18
Pear Lake, Sequoia NP	2.7*	3.5	8.1	16
Mills Lake, RockyMtn NP	2.2*	2.9	3.2	6.2
LonePine Lake, RockyMtn NP	2.3*	3.1	3.8	7.3
LP19 Lake, MtRanier NP	15*	19	27	53
Golden Lake, MtRanier NP	12*	16	25	49
Hoh Lake, Olympic NP	77	102	214	415
PJ Lake, Olympic NP	43	57	145	282
Oldman Lake, Glacier NP	1.7*	2.3	0.7	1.3
Snyder Lake, Glacier NP	23	30	90	175
McLeod Lake, Denali NP	12*	16	25	49
Wonder Lake, Denali NP	7.7*	10	1.7	3
Matcharak Lake, Gates of the Arctic NP	12*	16	2	4
Burial Lake, Noatak Nat.l Preserve	9.1*	12	2.7	5

* - recommendation lower than typical subsistence fishers consumption rate (19 m

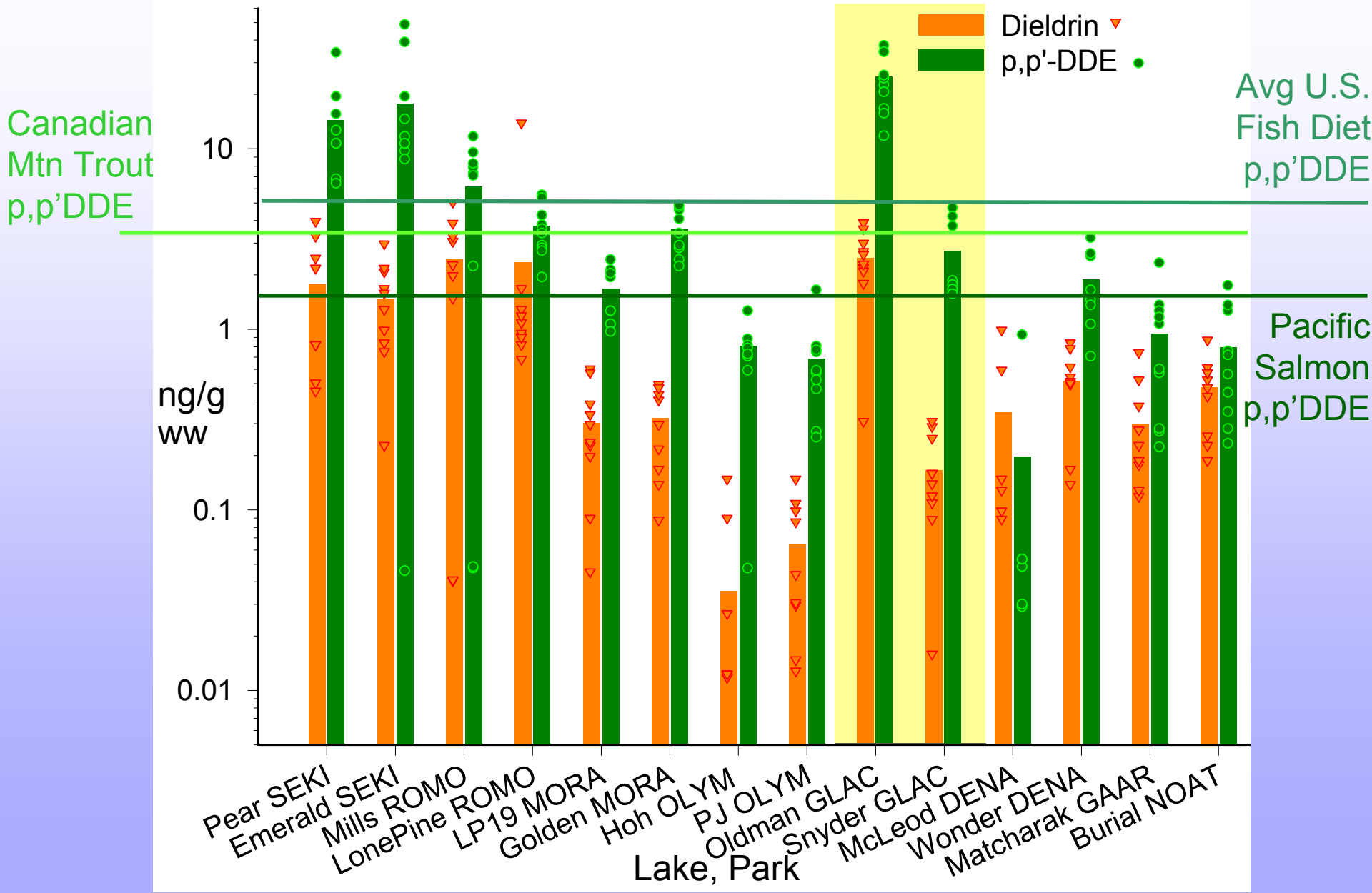
Risk/Benefit

- We estimated risk, not benefit
- Fish - high protein, low fat, NO SUGARs
  good source of vitamin E, omega-3 FAs
- Diabetes & CHD primary/fastest growing chronic diseases
  Diet w/↑Fish, ↓fat/sugar = ↓ Diabetes & CHD
- Pre-natal VitaminE, omega-3s, & fish 2x/wk ↑ infant develop.
- Farmed fish w/higher risk still a net benefit for average US
- GLAC fish very low in Hg….very good!
- Individual risk/benefit different
- Risk variability – large, Benefits – moderate
  - cancer models ~5-10X
  - individuals toxic response ~ 10X
  - measured concentrations ~ 10X
  - consumption habits ~ 10-15X

Where to go from here

- Communicate Risk & Benefit
  - Expert? MTDPH?
- Risk could decrease (decades)…or increase?
- Likelyhood of realized risk is low (if fishing is infrequent)
- More information needed
  - Consumption habits most influential, likely cheapest
  - Actual risk likely slightly higher than this estimate (PCBs, dioxins…)
  - Bio-monitor/specimen bank speed future prob.solv, large cost/benef.
- Other lakes can be preliminarily screened w/WACAP models
- EPA Guidance can help
- Education? – Science in action
- Risk reduction
  - Smaller fish, skin off, drain fat
  - Less than 2.3 meals/mo from Oldman (1.3 fish/mo)

SOC concentrations in Western Lake Fish



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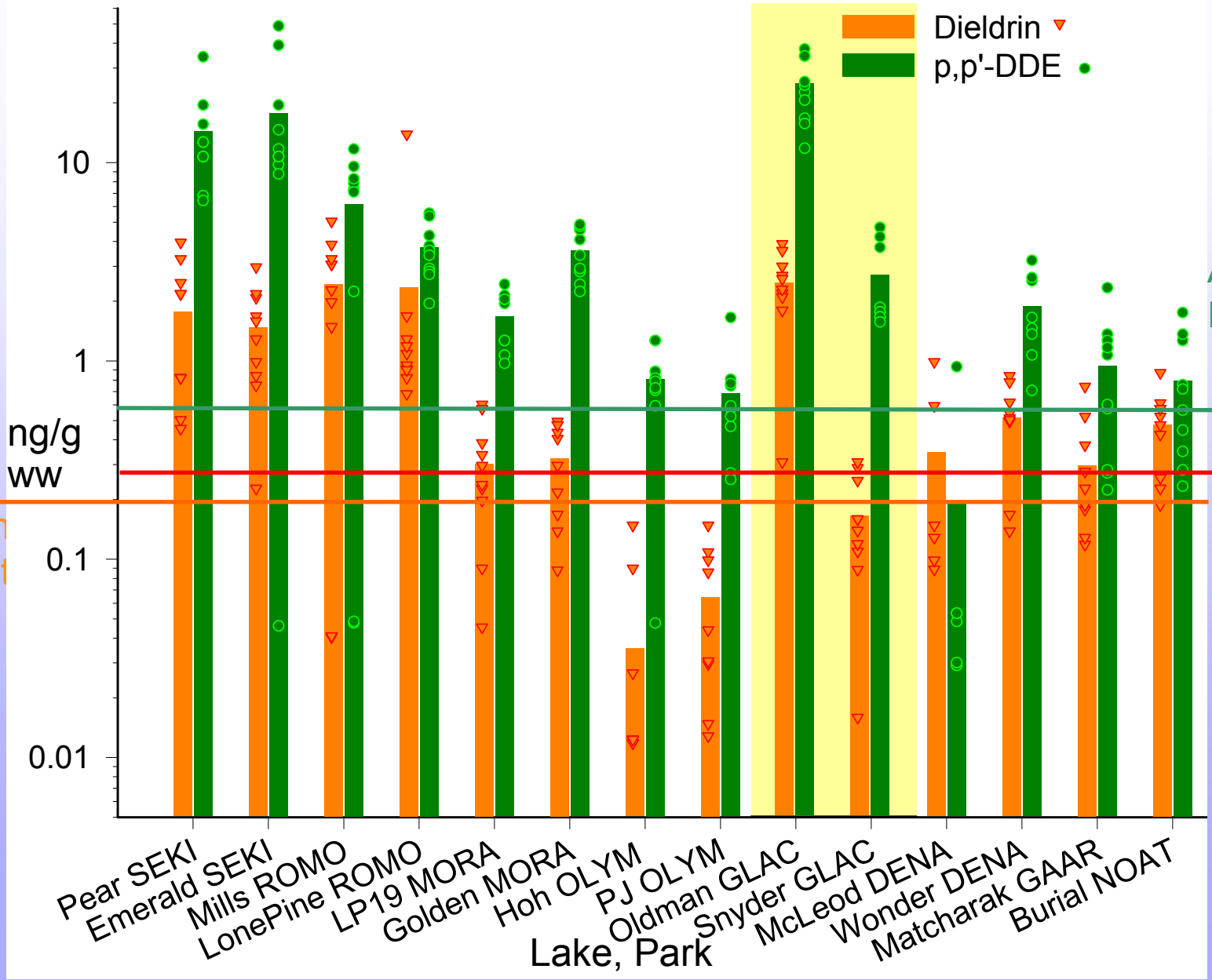
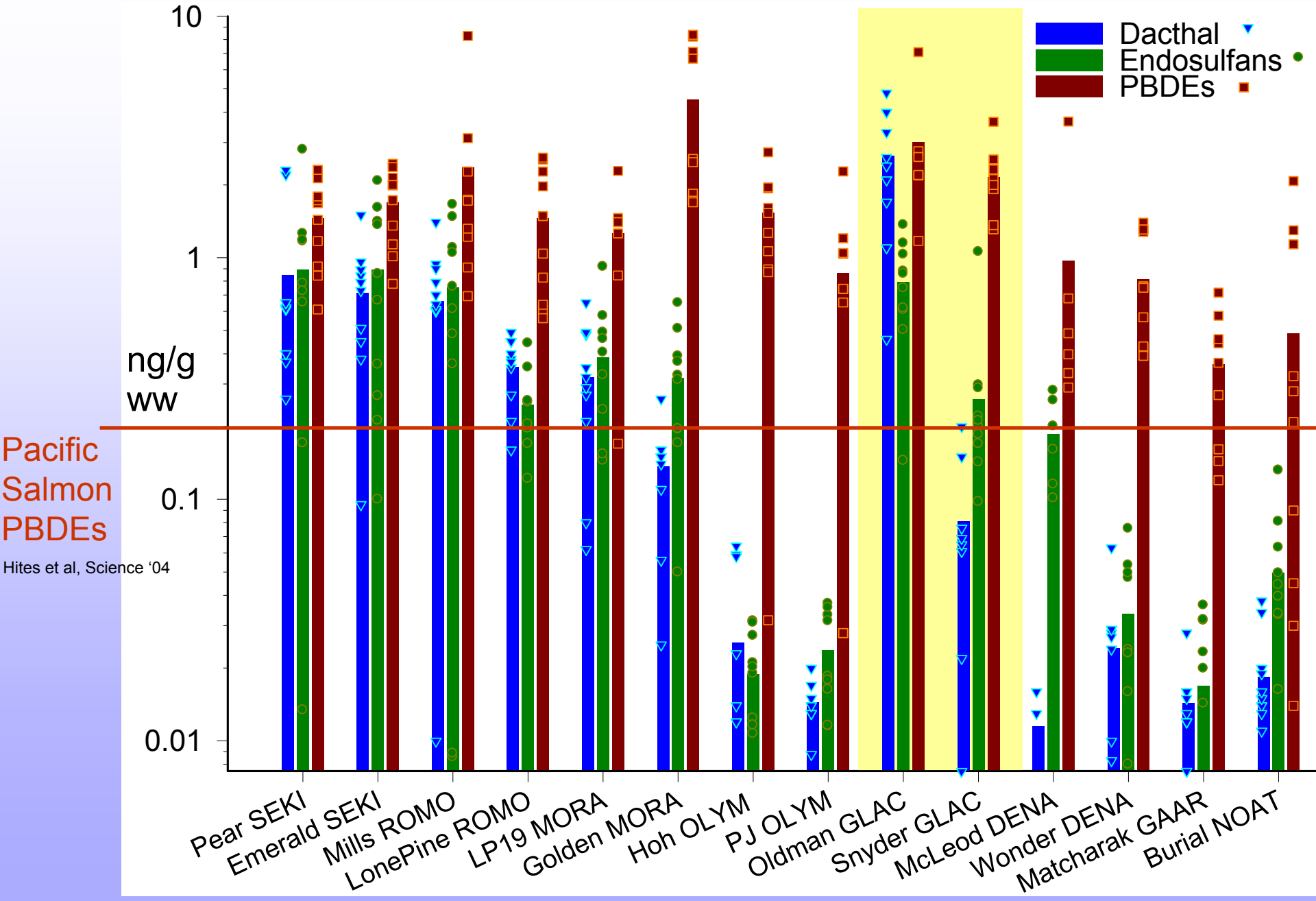
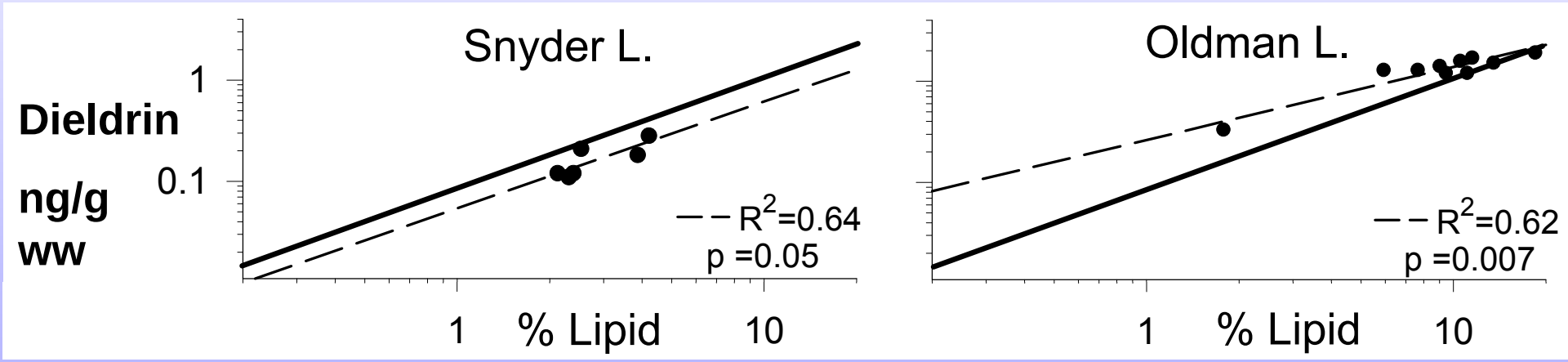


Current-use SOC concentrations in Western Lakes



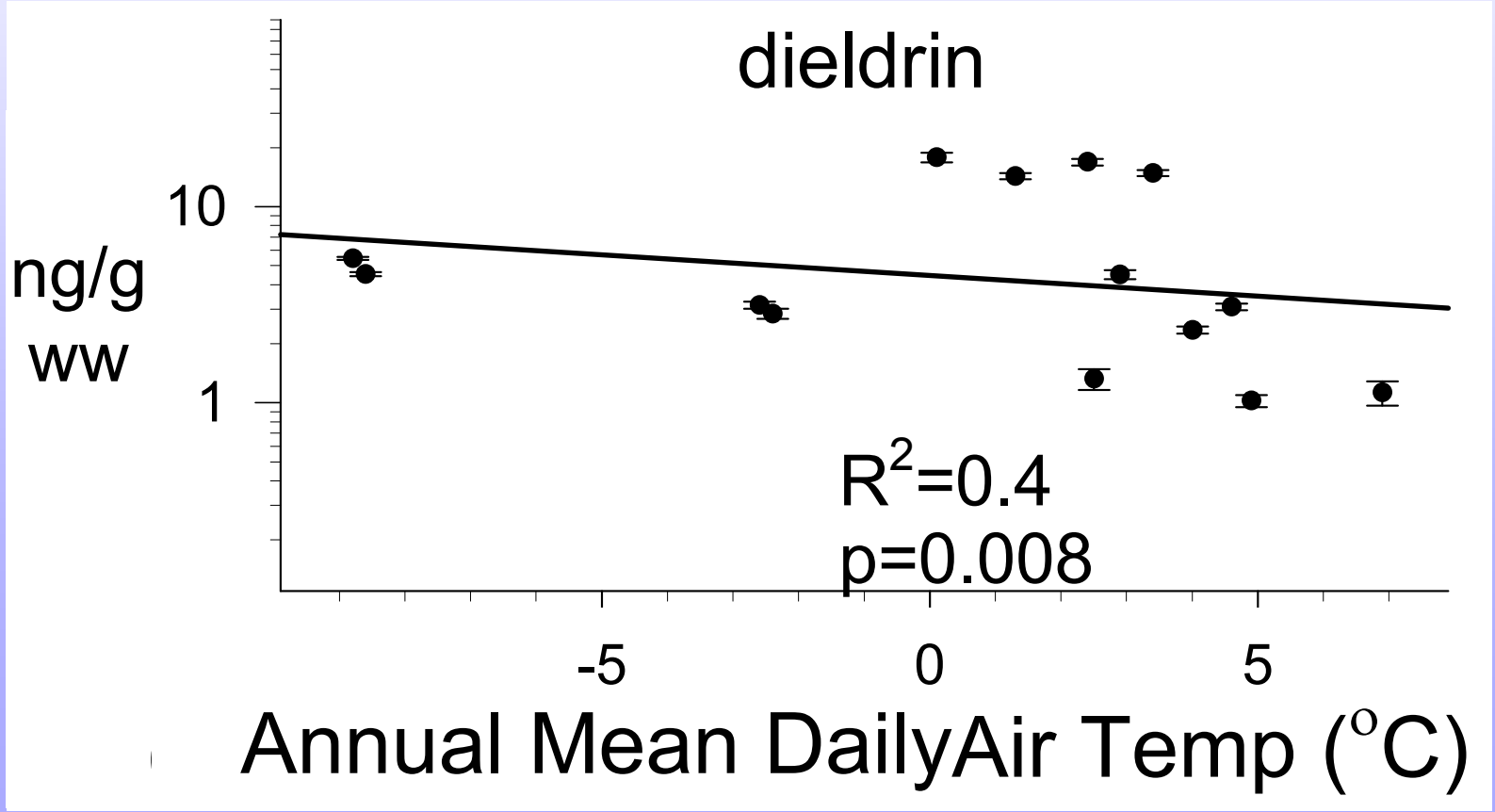
Fish characteristics effects on SOC concentrations

- Lipid rich (fatty) fish reliably had highest concentrations
- Heavier fish also had higher concentrations



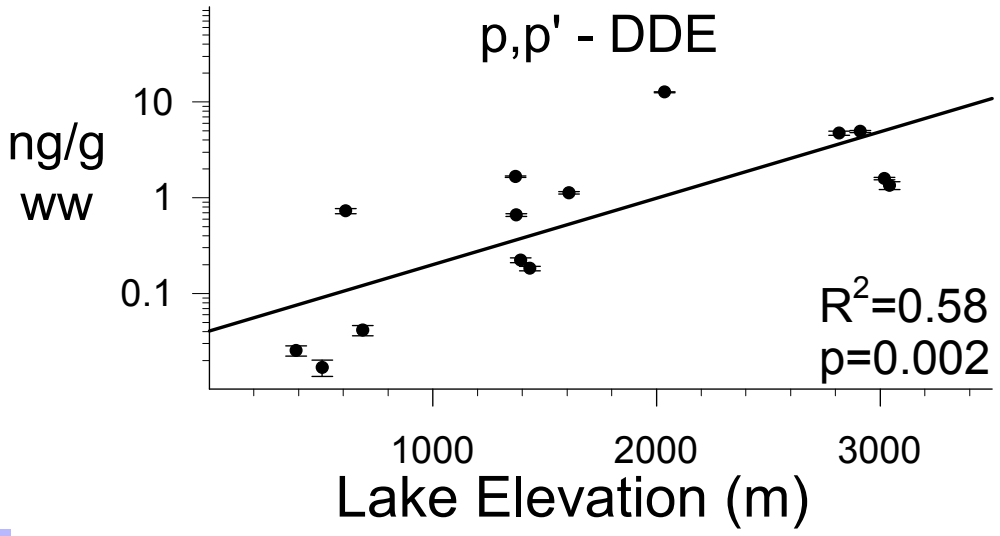
Air Temp Helped Explain HUP Concentrations

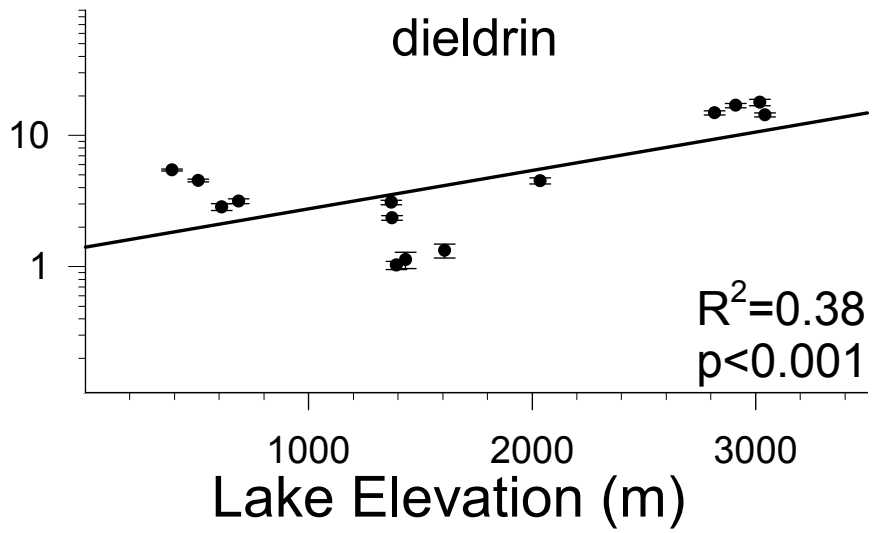
- Colder lakes had higher concentrations
- Temperature was most significant factor for:
  - HCHs, HCB, chlordanes, dieldrin, heptachlor epoxide



Lake elevation explained fish SOC concentrations

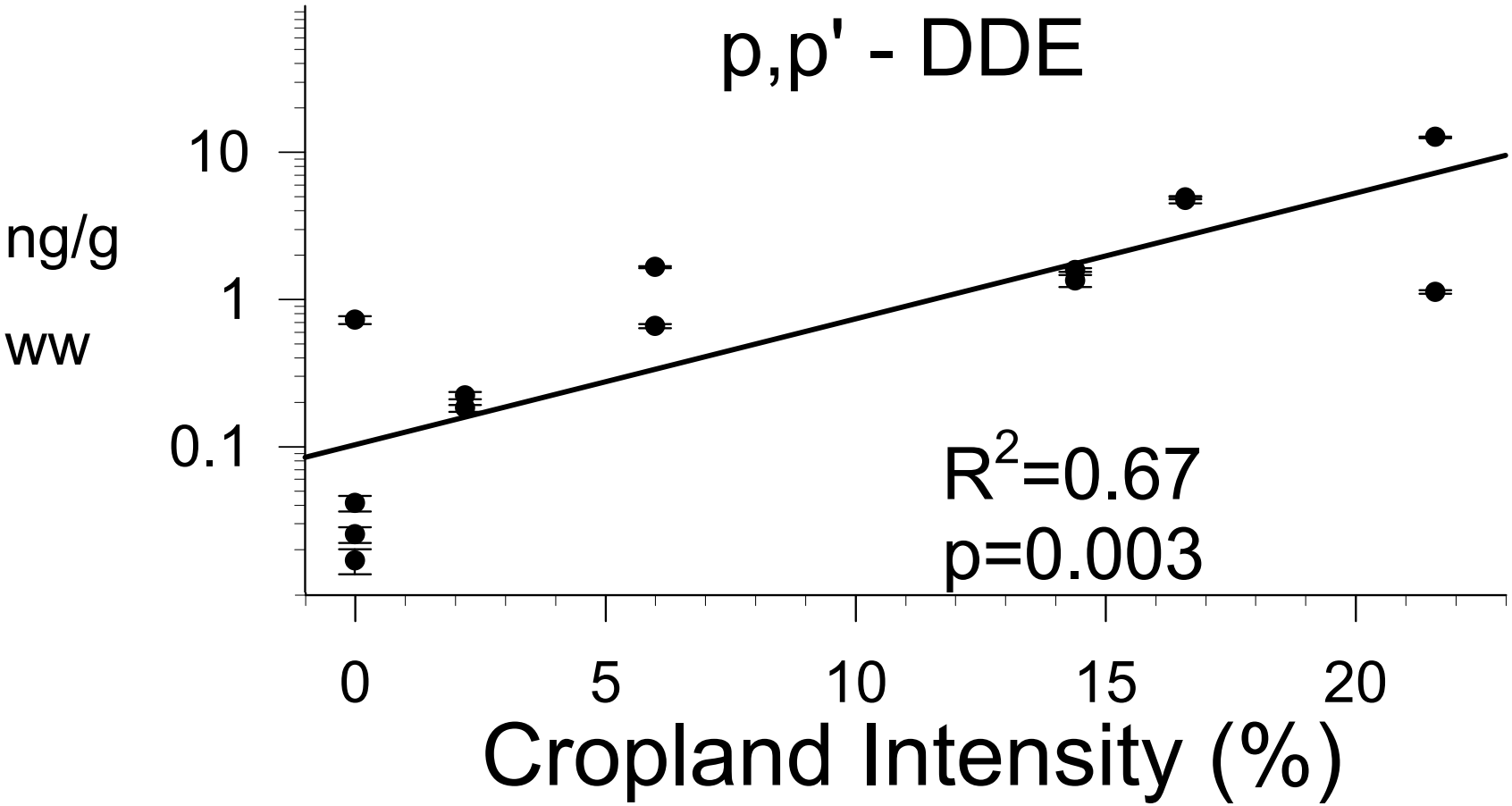
- Higher lakes had higher concentrations
- Elevation had most significant effect on these less volatile SOCs





Cropland Intensity explained fish pesticide concentrations

- Cropland w/in 150km was associated with higher fish concentrations for some pesticides
- Explained most ppDDE variation between fish from different lakes



Questions

Explaining variablility in fish SOC concentration

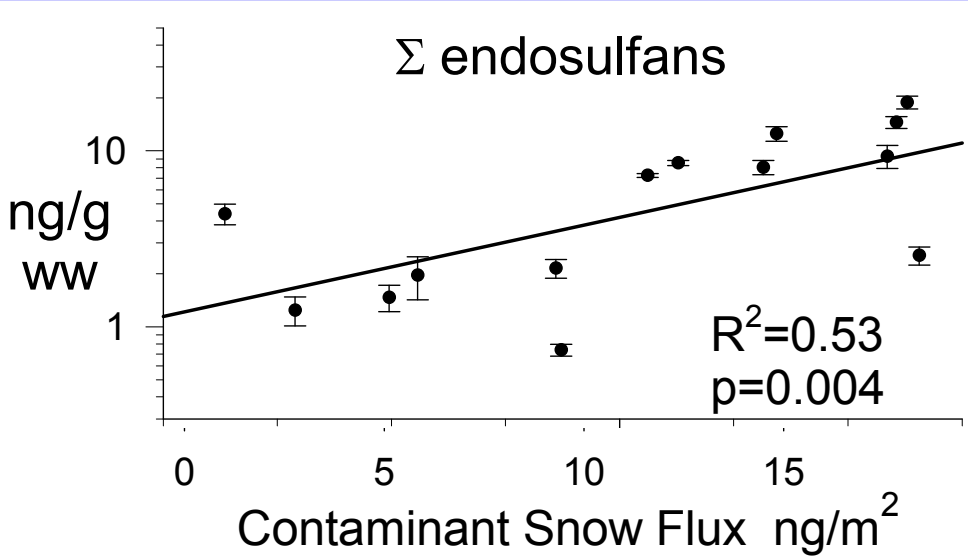
- Approach
  - Test effect of fish characteristics on fish SOCs at each lake
  - Adjust SOC concentrations to account for fish characteristics
  - Test effect of lake characteristics across lakes

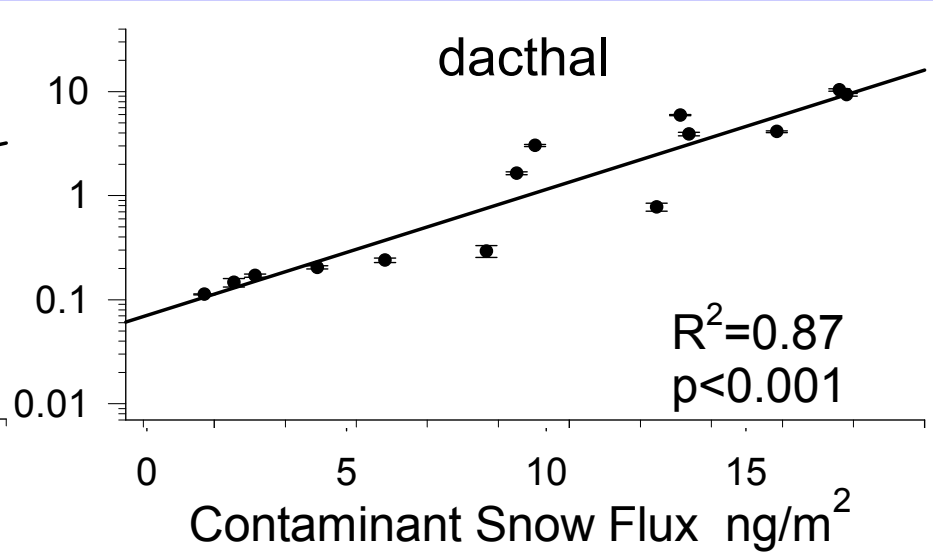
- Fish characteristics
  - Lipid concentration
  - Age
  - Growth rate
  - Mass
  - Length
  - Condition factor

- Lake characteristics
  - elevation
  - air temperature
  - precipitation
  - surface area
  - productivity
  - hydraulic residence time
  - regional cropland intensity
  - local population density
  - measured snow deposition of the SOC

Snow Flux Helped Explain CUP Concentrations

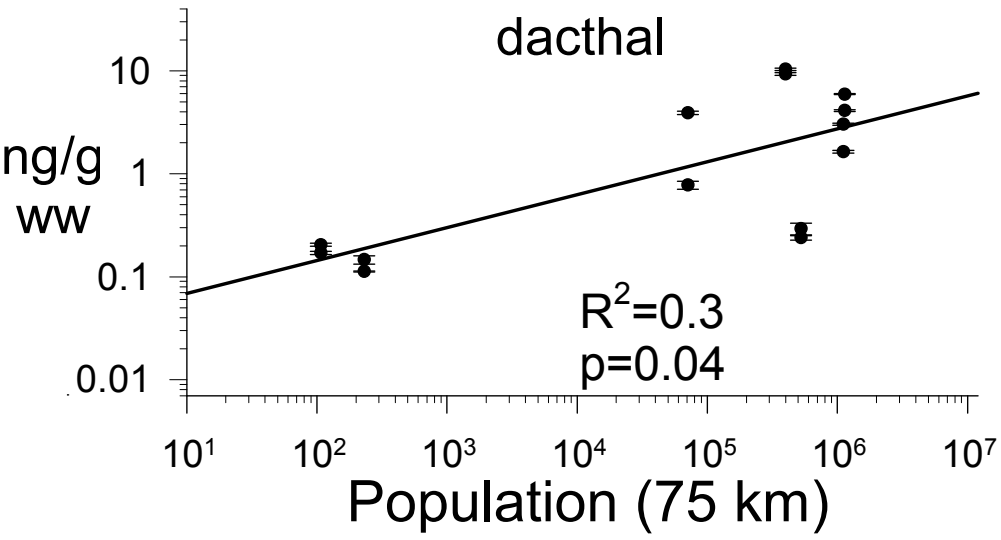
- Higher snow flux of CUPs to an ecosystem was associated with higher fish CUP concentrations
- Snow Flux was most significant and explained the largest % of fish CUP concentrations

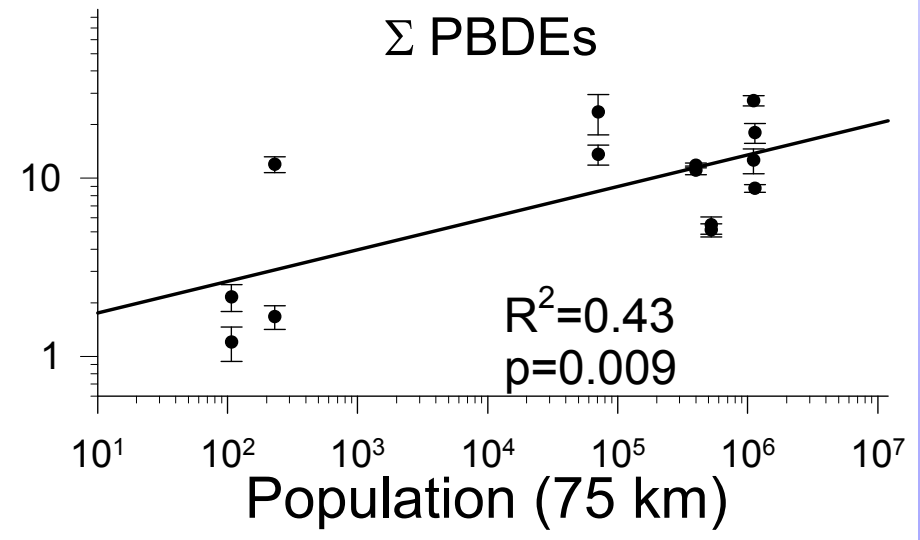




Population explained current use SOC fish concentrations

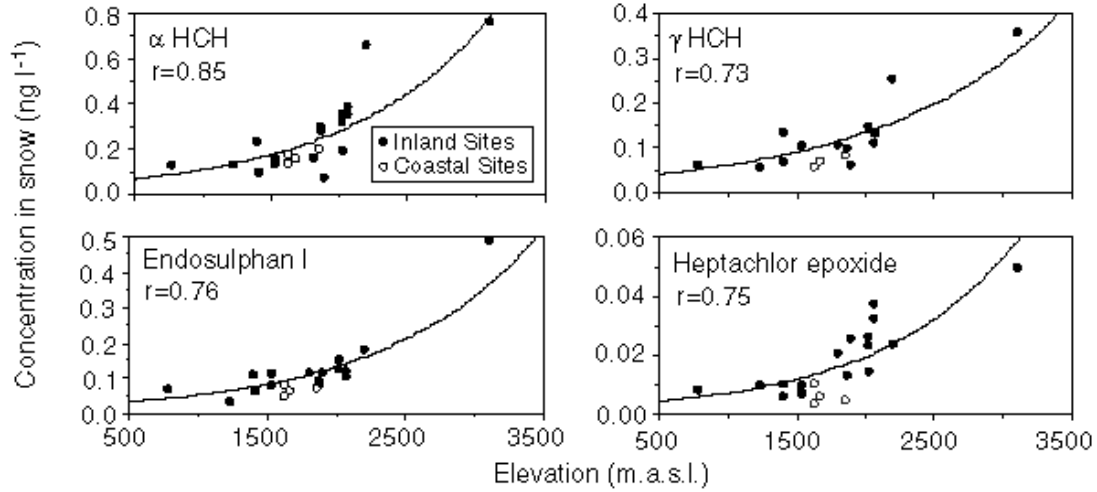
- Lakes with larger local populations had higher concentrations of some current use SOCs
- Population was 2nd most significant for these current use SOCs



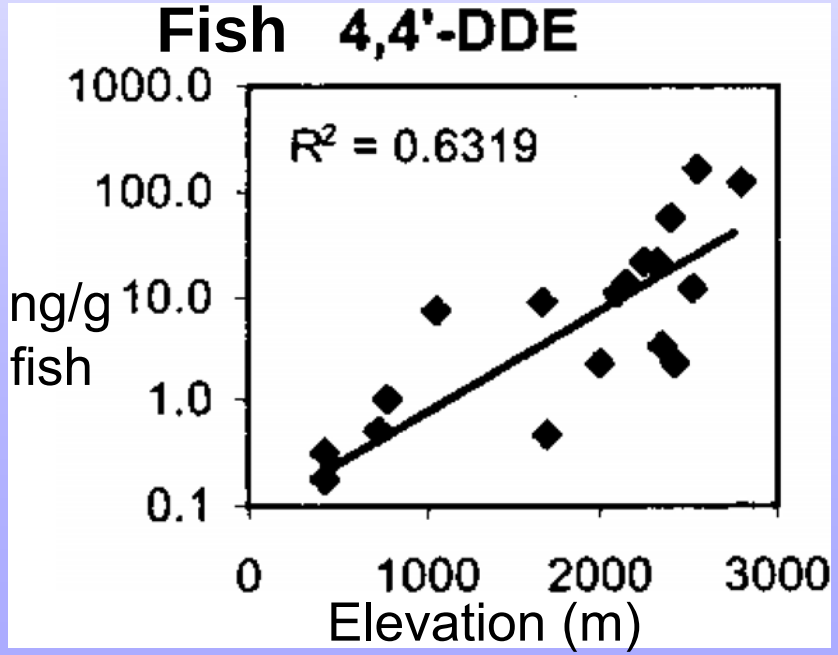


Why study SOCs in Western US?

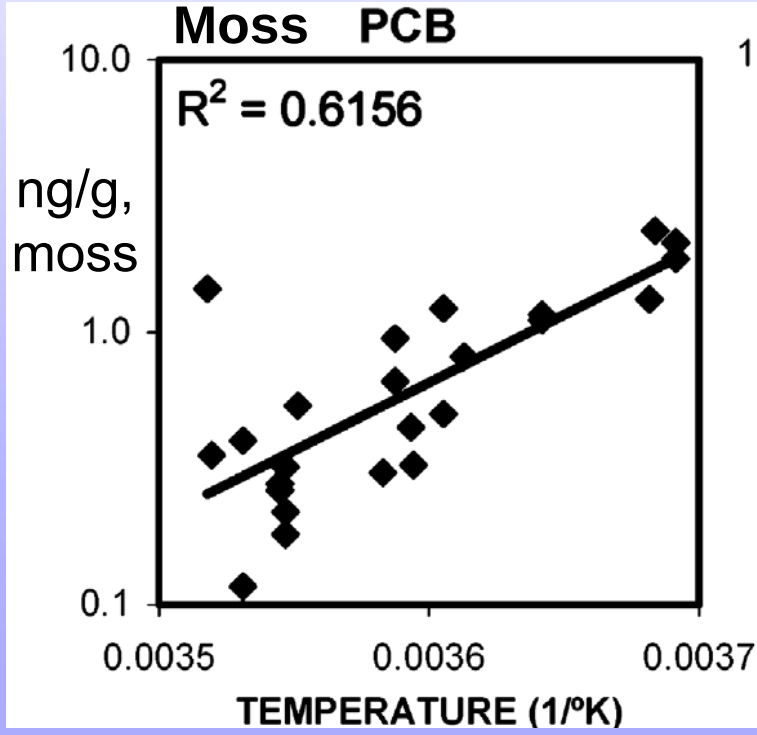
- Elevation Accumulation
  - Snow/Precipitation
  - Diel Pumping
  - Temperature/Elevation



Blais, *Nature*, **'04**



Grimalt et al, ES&T, '01



Grimalt et al, ES&T, '04

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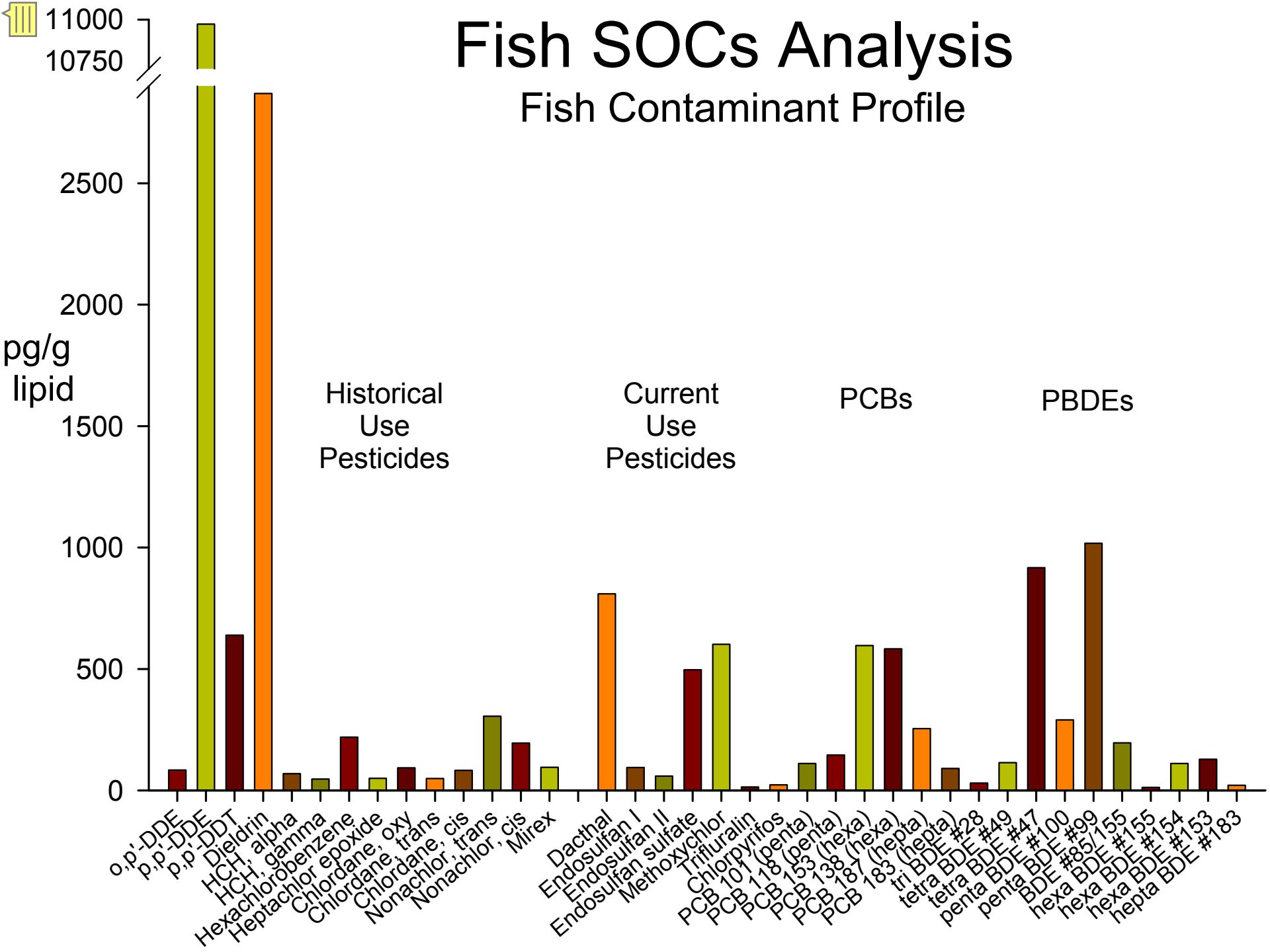
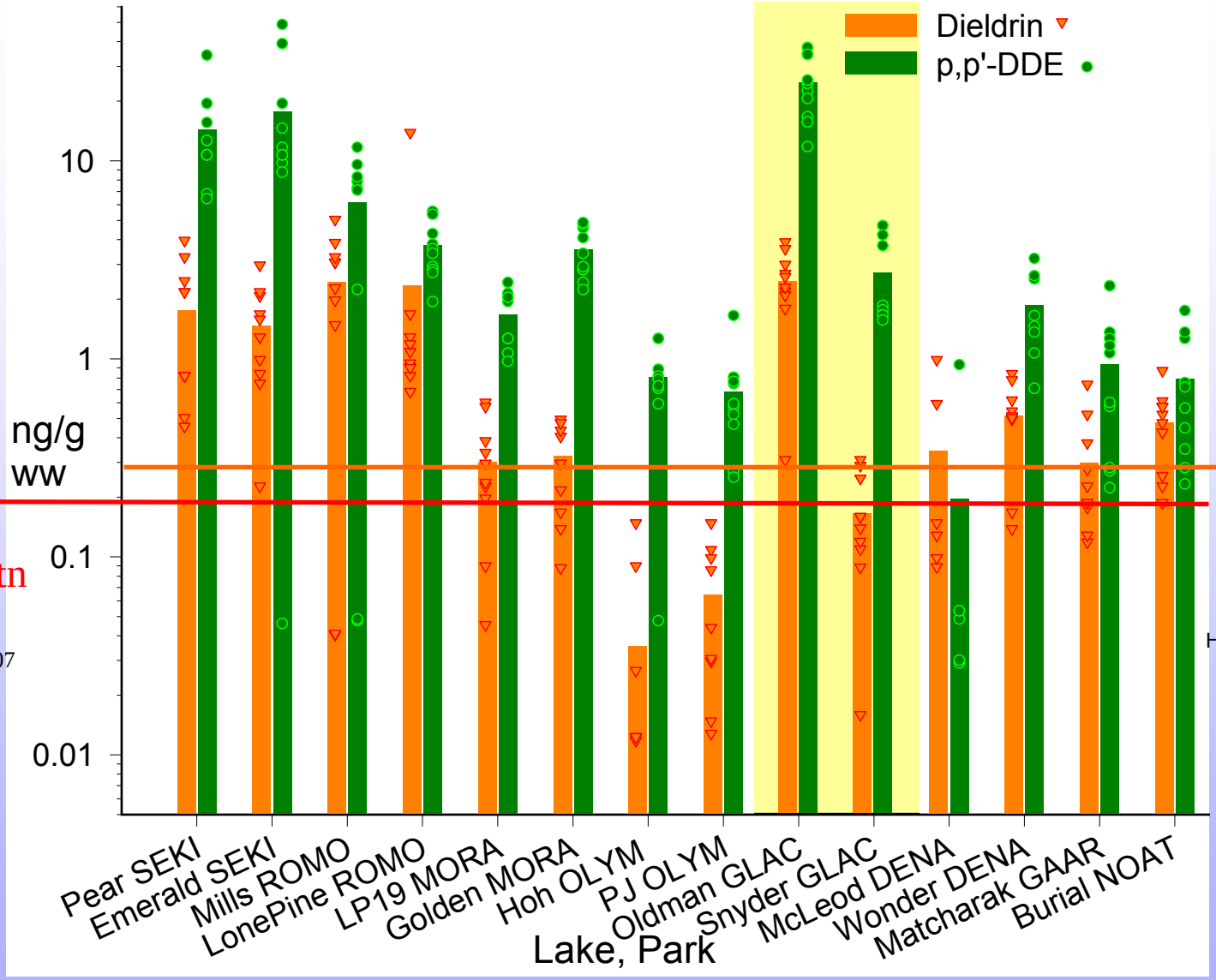
  - productivity
  - hydraulic residence time
  - regional cropland intensity
  - local population density
  - measured snow deposition of the SOC

Conclusions continued

5. After adjusting for lipid or age, lake temperature best explained historic use pesticide concentrations in fish, lake elevation best explained PCB, PBDE, mirex, and p,p'DDE concentrations, and snow flux best explained current use pesticide concentrations in fish.


Fish SOCs Analysis
Fish Contaminant Profile
pg/g lipid
11000
10750
2500
2000
1500
1000
500
0
Historical Use Pesticides
Current Use Pesticides
PCBs
PBDEs
o,p'-DDE
p,p'-DDE
p,p'-DDT
Dieldrin
HCH, alpha
HCH, gamma
Hexachlorobenzene
Heptachlor epoxide
Chlordane, oxy
Chlordane, trans
Chlordane, cis
Nonachlor, trans
Nonachlor, cis
Mirex
Dacthal
Endosulfan I
Endosulfan II
Endosulfan sulfate
Methoxychlor
Trifluralin
Chlorpyrifos
PCB 101 (penta)
PCB 118 (penta)
PCB 153 (hexa)
PCB 138 (hexa)
PCB 187 (hepta)
PCB 183 (hepta)
tri BDE #28
tetra BDE #49
tetra BDE #47
penta BDE #100
penta BDE #99
BDE #85/155
hexa BDE #155
hexa BDE #154
hexa BDE #153
hepta BDE #183

SOC concentrations in Western Lakes



Dieldrin, Canadian Mtn Trout

Demers et al, ES&T '07

Pacific Salmon Dieldrin

Hites et al, Science '04