Contaminant Bioaccumulation in OLYM, MORA, and NOCA

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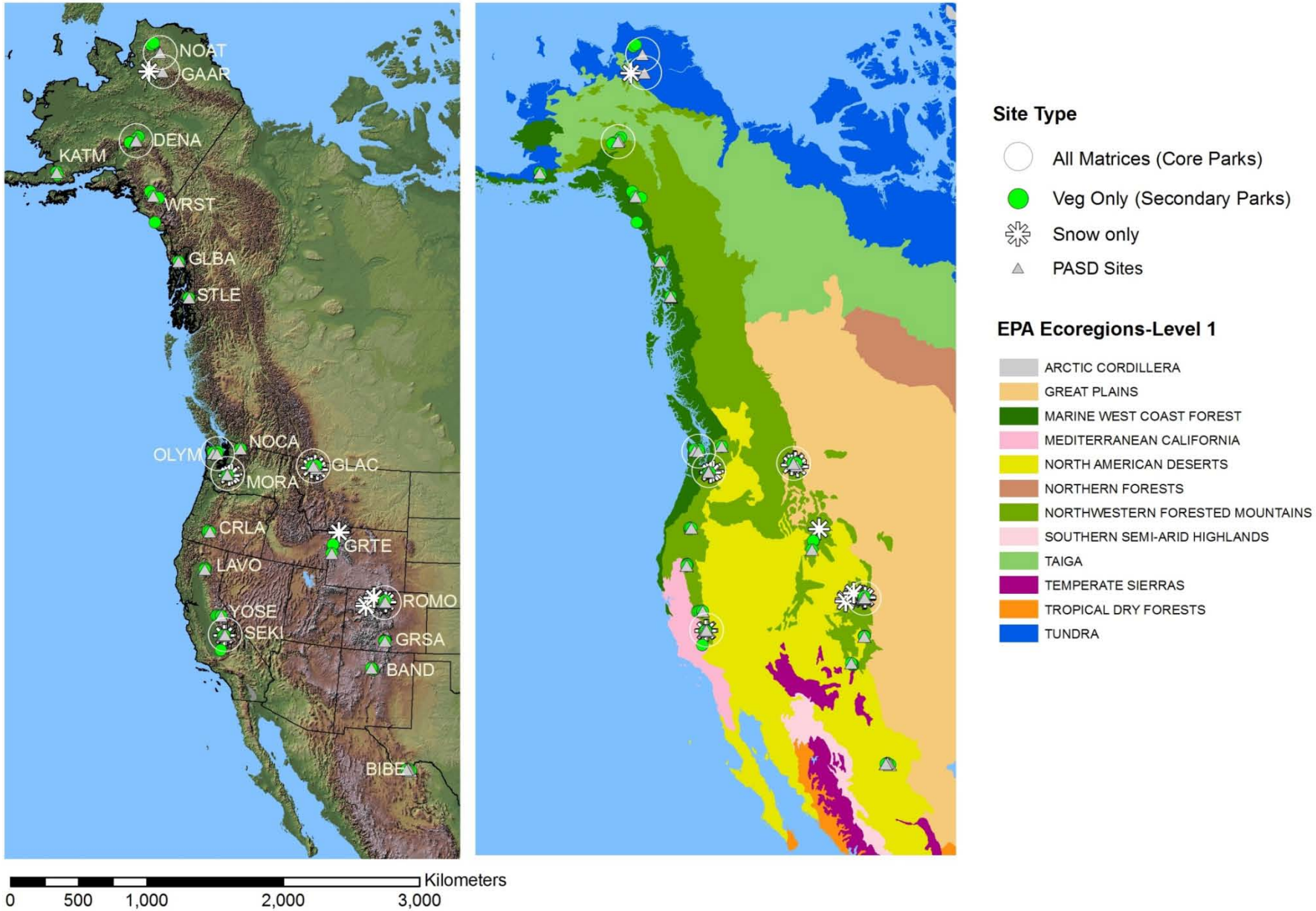
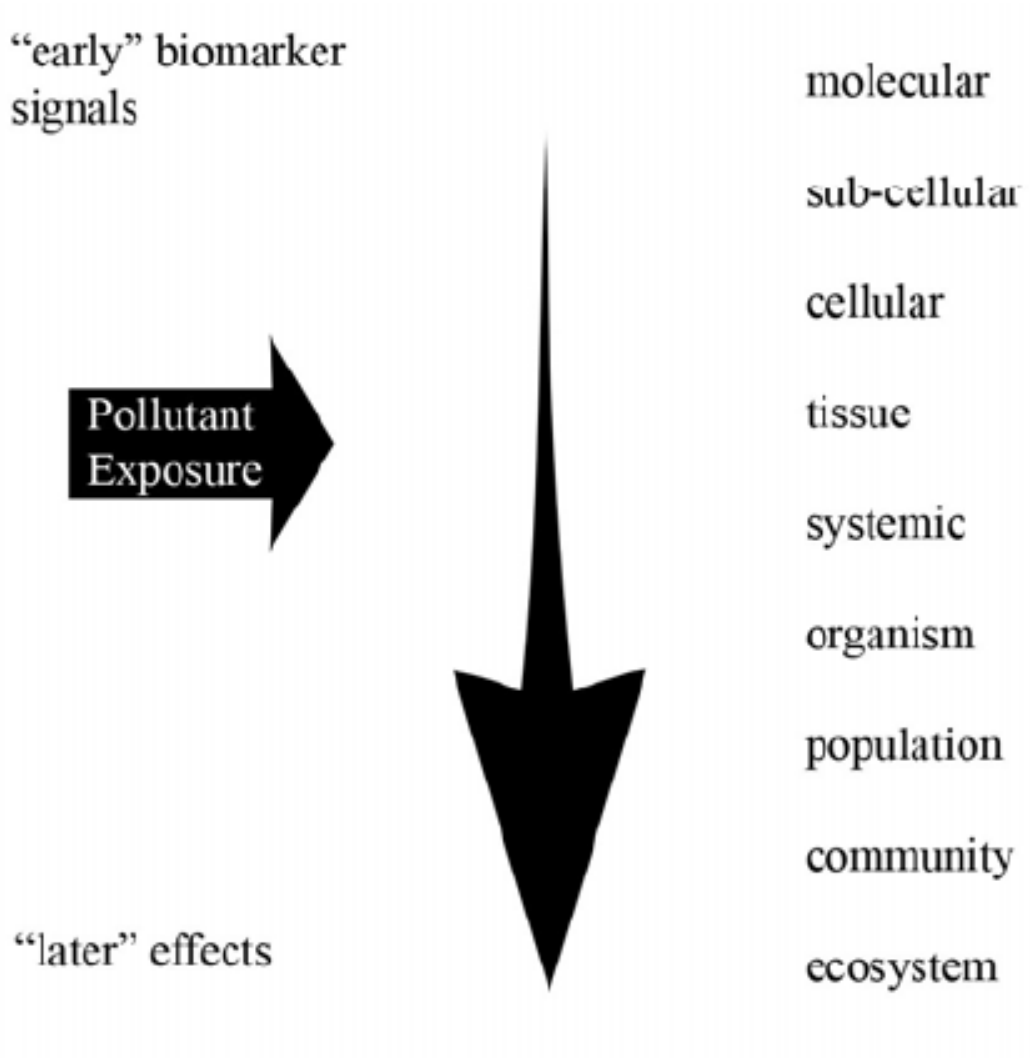
DIVERSITY OF WACAP ECOSYSTEMS



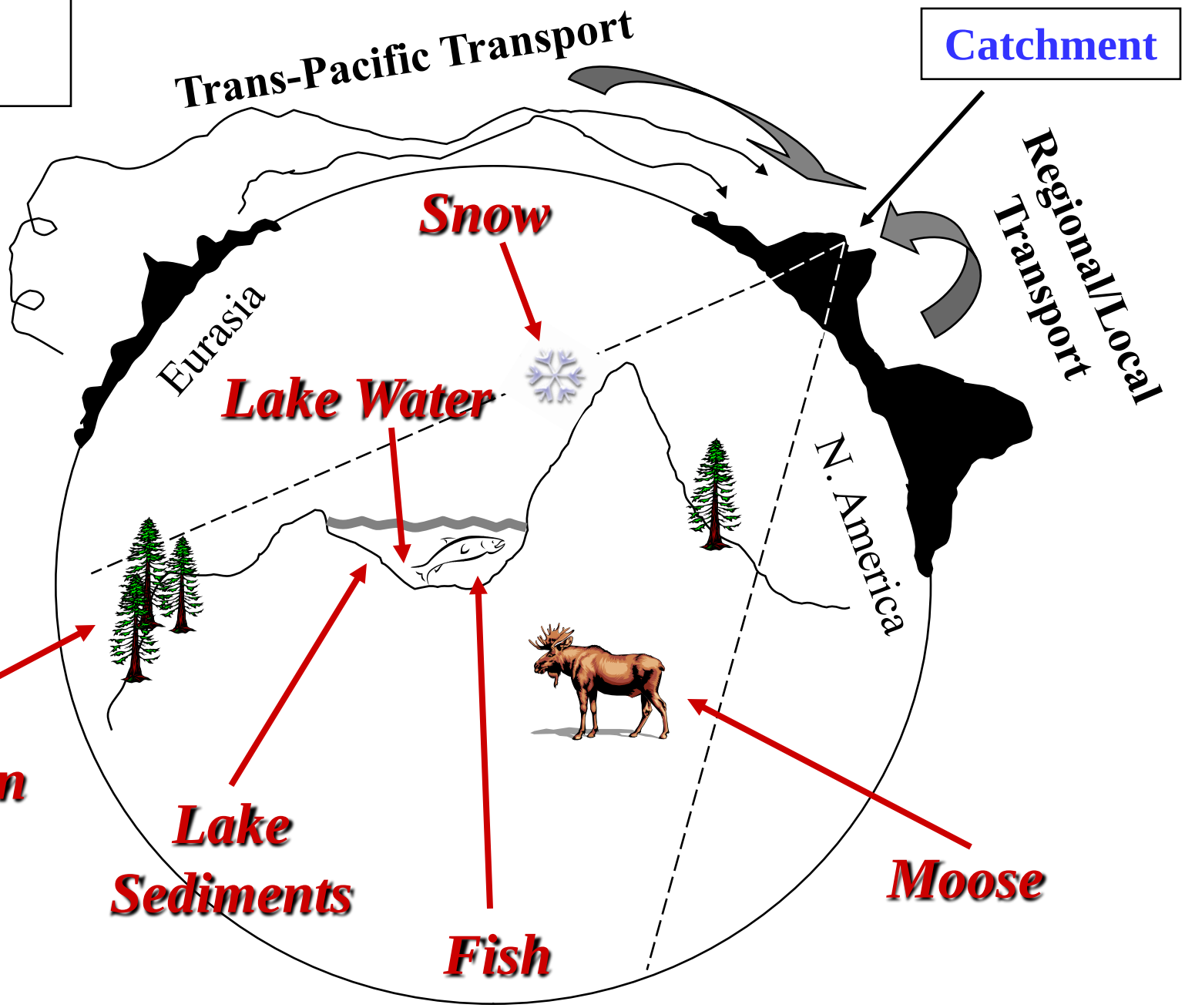
EXPOSURE AND EFFECTS



WACAP Matrices

- Organics
- Metals

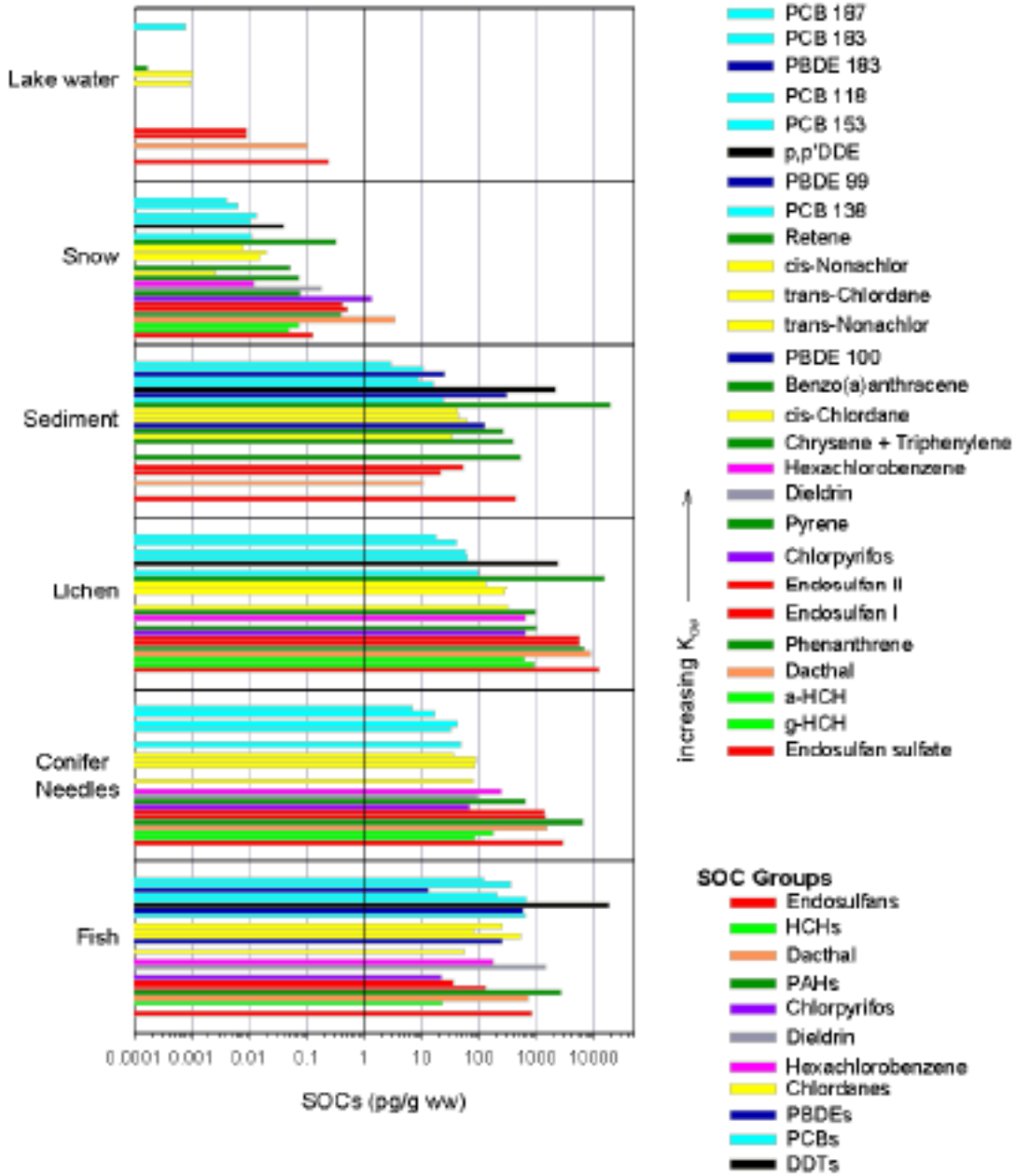
- 2003
- 2004
- 2005



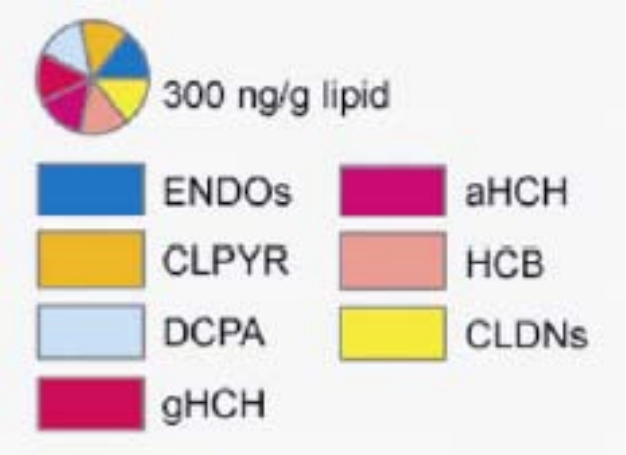
SEMI-VOLATILE ORGANIC COMPOUNDS (SOCs) MEASURED

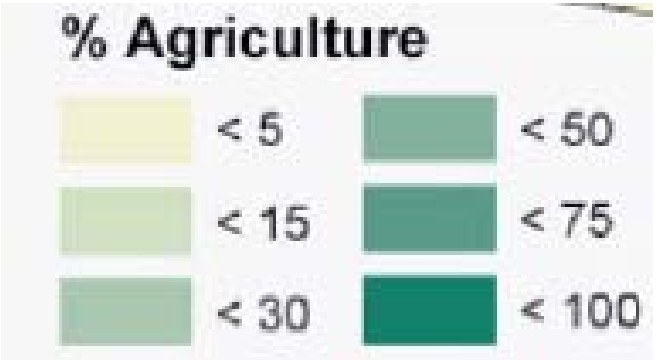
Electron Impact Ionization	Electron Capture Negative Ionization
PAHs: Acenaphthylene, Acenaphthene, Fluorene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, Retene, Benz[a]anthracene, Chrysene, Triphenylene, Benzo[b]fluoranthene, Benzo[k]fluoranthene, Benzo[e]pyrene, Benzo[a]pyrene, Indeno[1,2,3-cd]pyrene, Dibenz[a,h]anthracene, Benzo[ghi]perylene **Pesticides and degradation products:** o,p'-DDT*, p,p'-DDT, o,p'-DDD*, p,p'-DDD, o,p'-DDE, p,p'-DDE, Diazinon, Demeton S, Ethion, Etradiazole, Malathion*, Parathion and Methyl - Parathion, Phorate, Metolachlor*, Methoxychlor, Acetochlor*, Alachlor, Prometon, Pebulate, EPTC, Carbofuran, Carbaryl, Propachlor, Atrazine and degradation products, Simazine, Cyanazine **Surrogates:** d_{10}-Fluorene, d_{10}-Phenanthrene, d_{10}-Pyrene, d_{12}-Triphenylene, d_{12}-Benzo[a]pyrene, d_{12}-Benzo[ghi]perylene, d_{14}-EPTC, d_{10}-Phorate, d_5-Atrazine, d_{10}-Diazinon, d_7-Malathion, d_{10}-Parathion, d_8-p,p'-DDE, d_8-p,p'-DDT, d_6-Methyl Parathion, d_{13}-Alachlor, d_{11}-Acetochlor **Internal Standards:** d_{10}-Acenaphthene, d_{10}-Fluoranthene, d_{12}-Benzo[k]fluoranthene	**PCBs:** PCB 74 (2,4,4',5-Tetrachlorobiphenyl), PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl), PCB 118 (2,3',4,4',5-Pentachlorobiphenyl), PCB 138 (2,2',3,4,4',5'-Hexachlorobiphenyl), PCB 153 (2,2',4,4',5,5'-Hexachlorobiphenyl), PCB 183* (2,2',3,4,4',5',6-Heptachlorobiphenyl), and PCB 187 (2,2',3,4',5,5',6-Heptachlorobiphenyl) **Pesticides and degradation products:** Hexachlorocyclohexanes (HCH) - α*, β, γ-(lindane), and δ, Chlordanes – cis*, trans*, oxy*, Nonachlor – cis, trans, Heptachlor*, Heptachlor Epoxide*, Endosulfans - I, II, and sulfate, Dieldrin, Aldrin, Endrin, Endrin Aldehyde, Hexachlorobenzene, Dacthal, Chlorothalonil, Chlorpyrifos and oxon, Trifluralin, Metribuzin, Triallate, Mirex **Polybrominated Diphenyl Ethers** **Surrogates:** $^{13}C_{12}$ PCB 101 (2,2',4,5,5'-Pentachlorobiphenyl), $^{13}C_{12}$ PCB 180 (2,2', 3,4,4',5,5'-Heptachlorobiphenyl), d_{10} - Chlorpyrifos, $^{13}C_6$-HCB, d_6-γ-HCH, d_4-Endosulfan I, d_4-Endosulfan II **Internal Standards:** d_{14}-Trifluralin

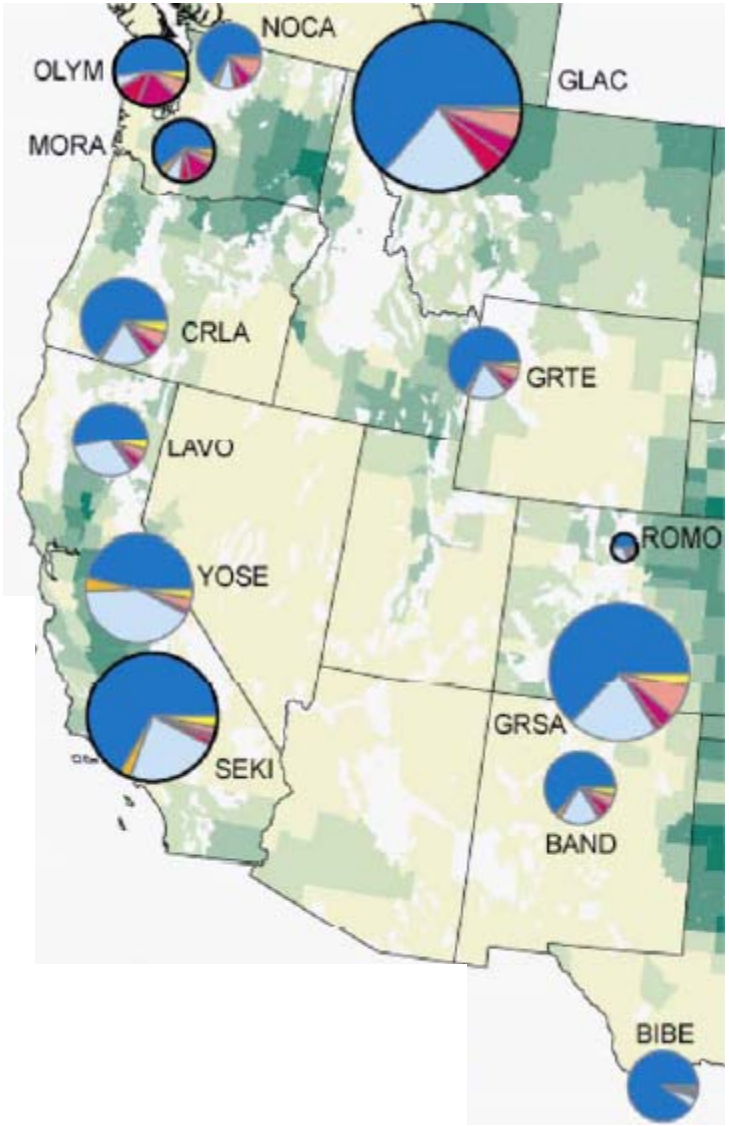
BIOACCUMULATION IN THE ECOSYSTEM



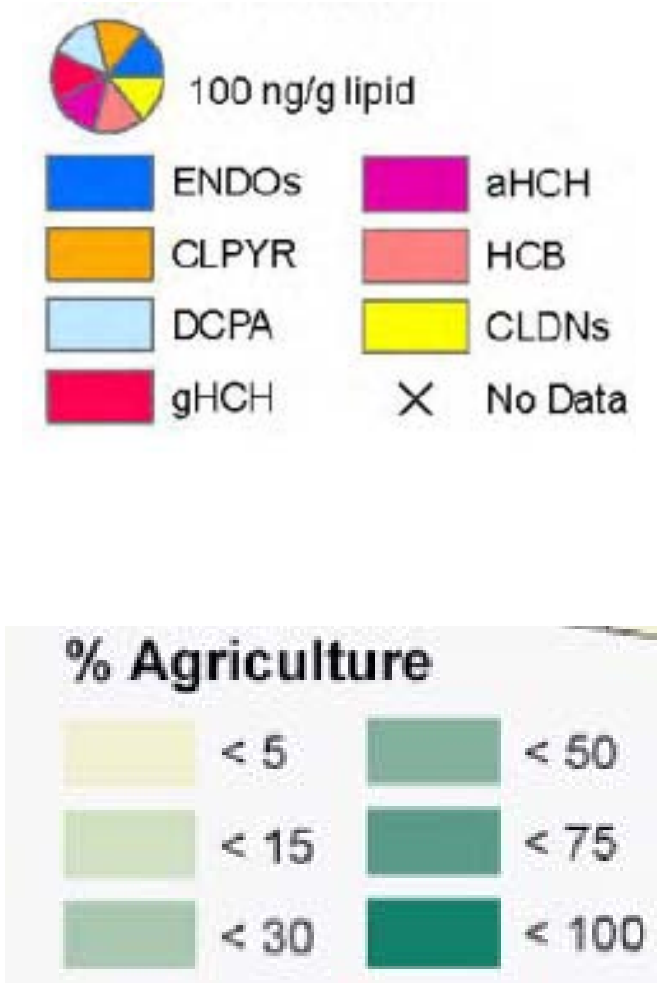
PESTICIDES in LICHEN

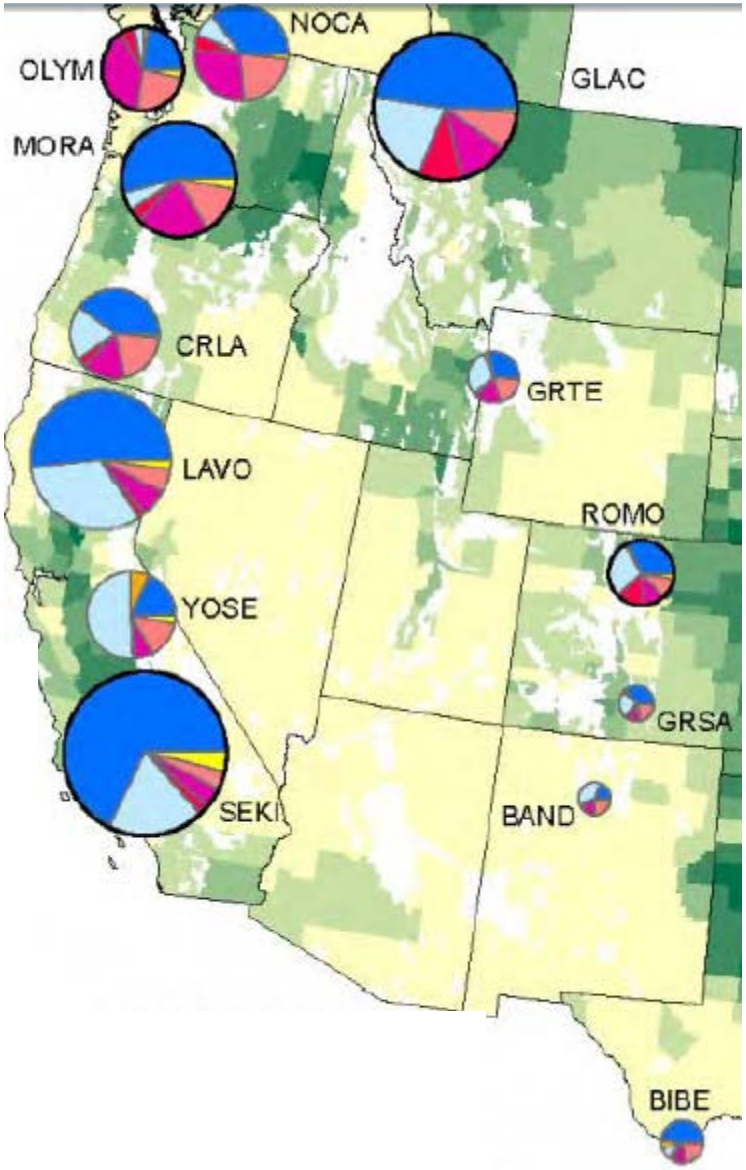




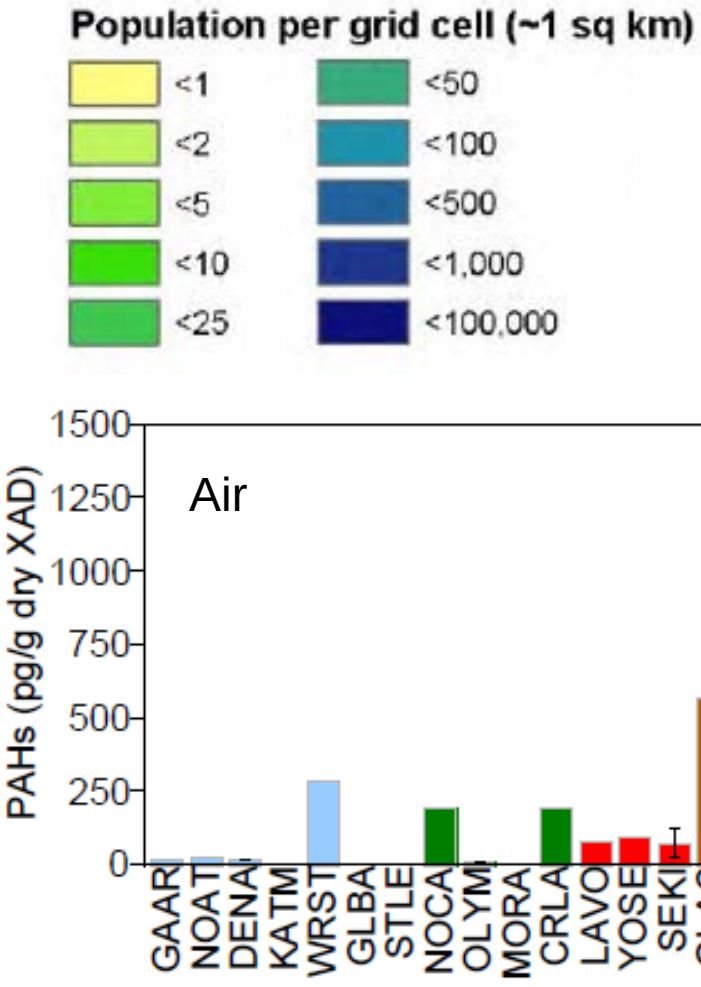


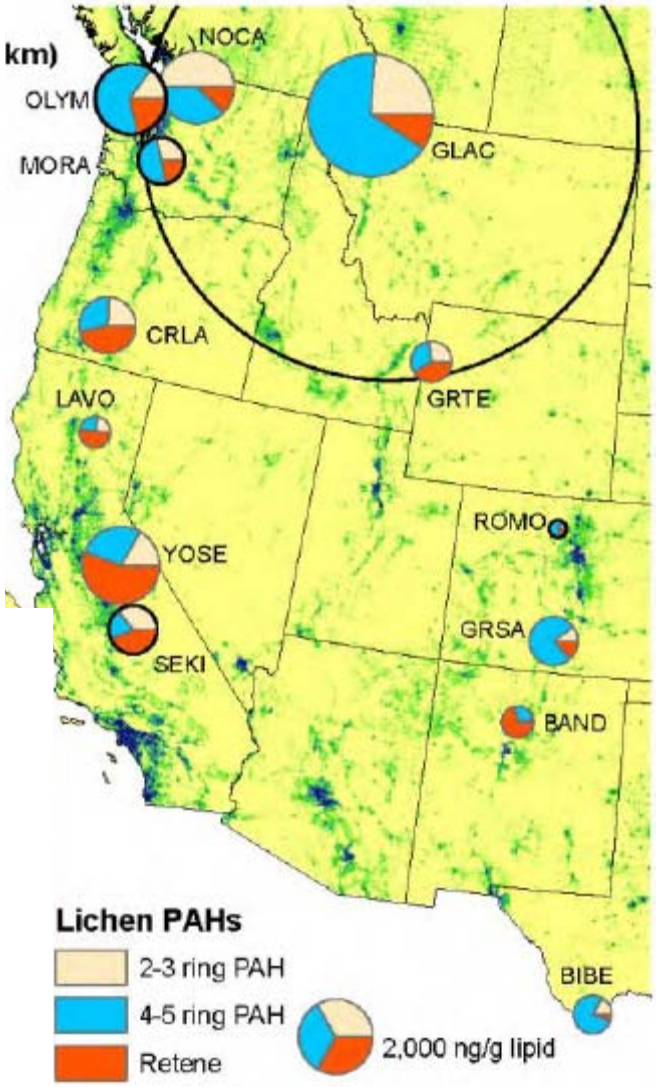
PESTICIDES in CONIFER





POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)





ACCUMULATION OF PESTICIDES in FORESTS

	Endosulfans Accumulated in Second-Year Conifer Needles (g/ha)*		
Forest location	**Low Productivity Forest**	**Average Productivity Forest**	**High Productivity Forest**
Remote	0.0016	0.010	0.080
Near Source	0.0091	0.058	0.45
2002 US Endosulfan Application Rates**	**(g/ha)****		
Not applied	0		
Lowest	0.0085 to 0.049		
Low	0.05 to 0.15		
Medium	0.16 to 0.55		
Highest	0.55 to 2.19		
Highest	≥ 2.20		

Comparable to low to medium application rates on crops

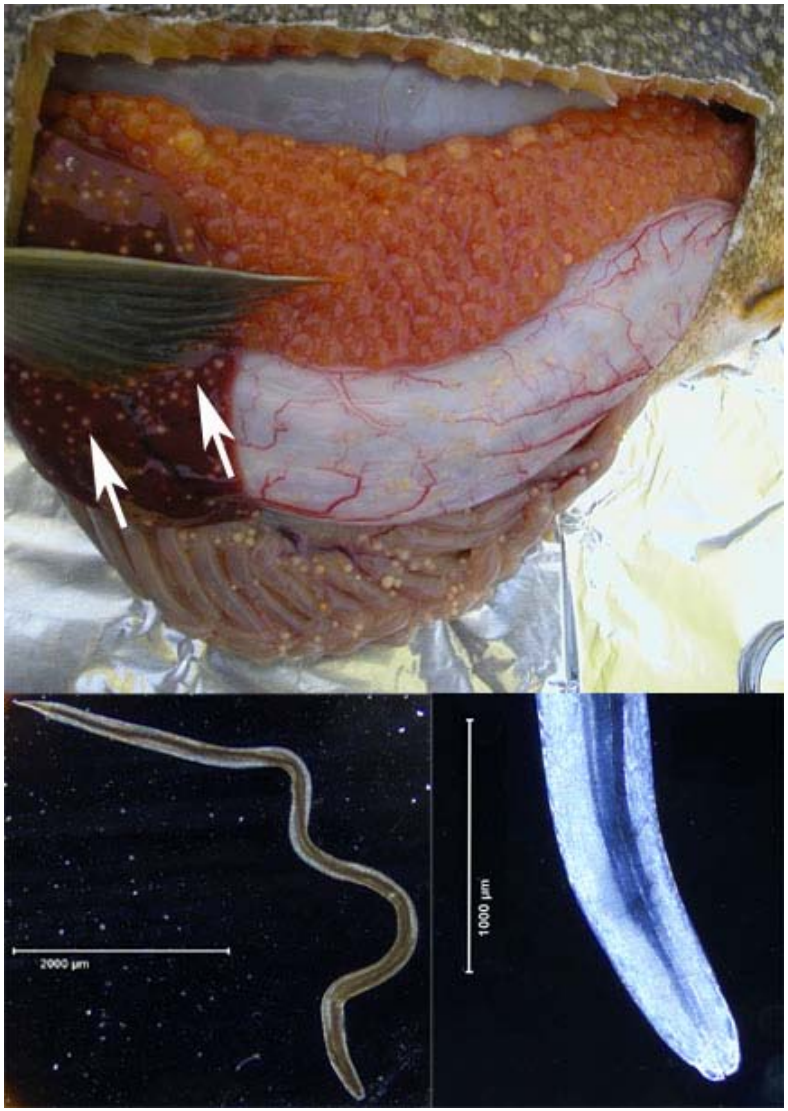
Do Airborne Contaminants Affect Fish in the Lakes of Western US National Parks?

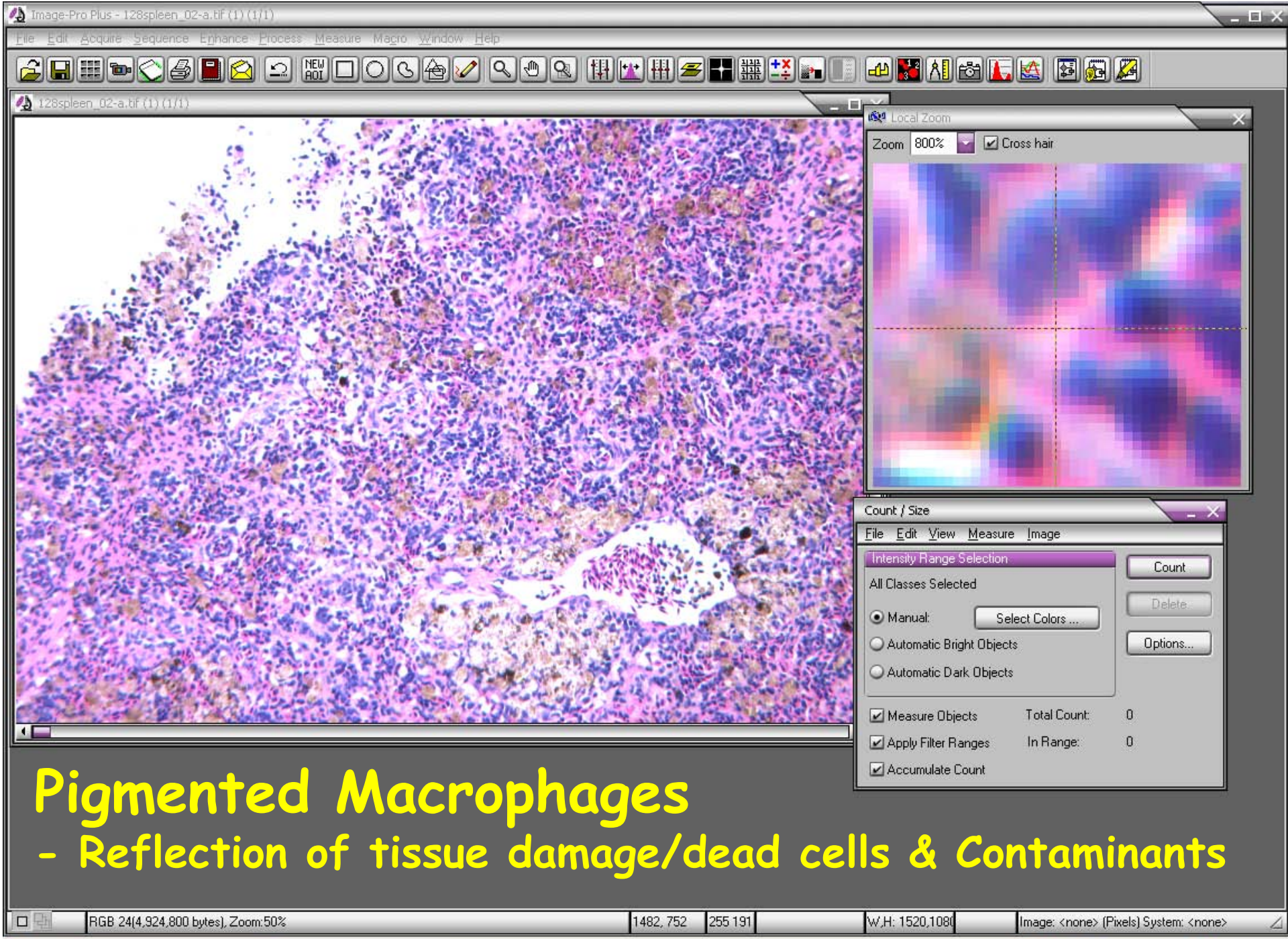
Macroscopic Health

Fish were in good condition

Most were nearing sexual maturation

Internal & External Assessment of Fish Health





Pigmented Macrophages

- Reflection of tissue damage/dead cells & Contaminants

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untitled006 (1/1)

Local Zoom

Zoom 800% Cross hair

Count / Size

File Edit View Measure Image

Intensity Range Selection

All Classes Selected

Manual: Select Colors ...

Automatic Bright Objects

Automatic Dark Objects

Count

Delete

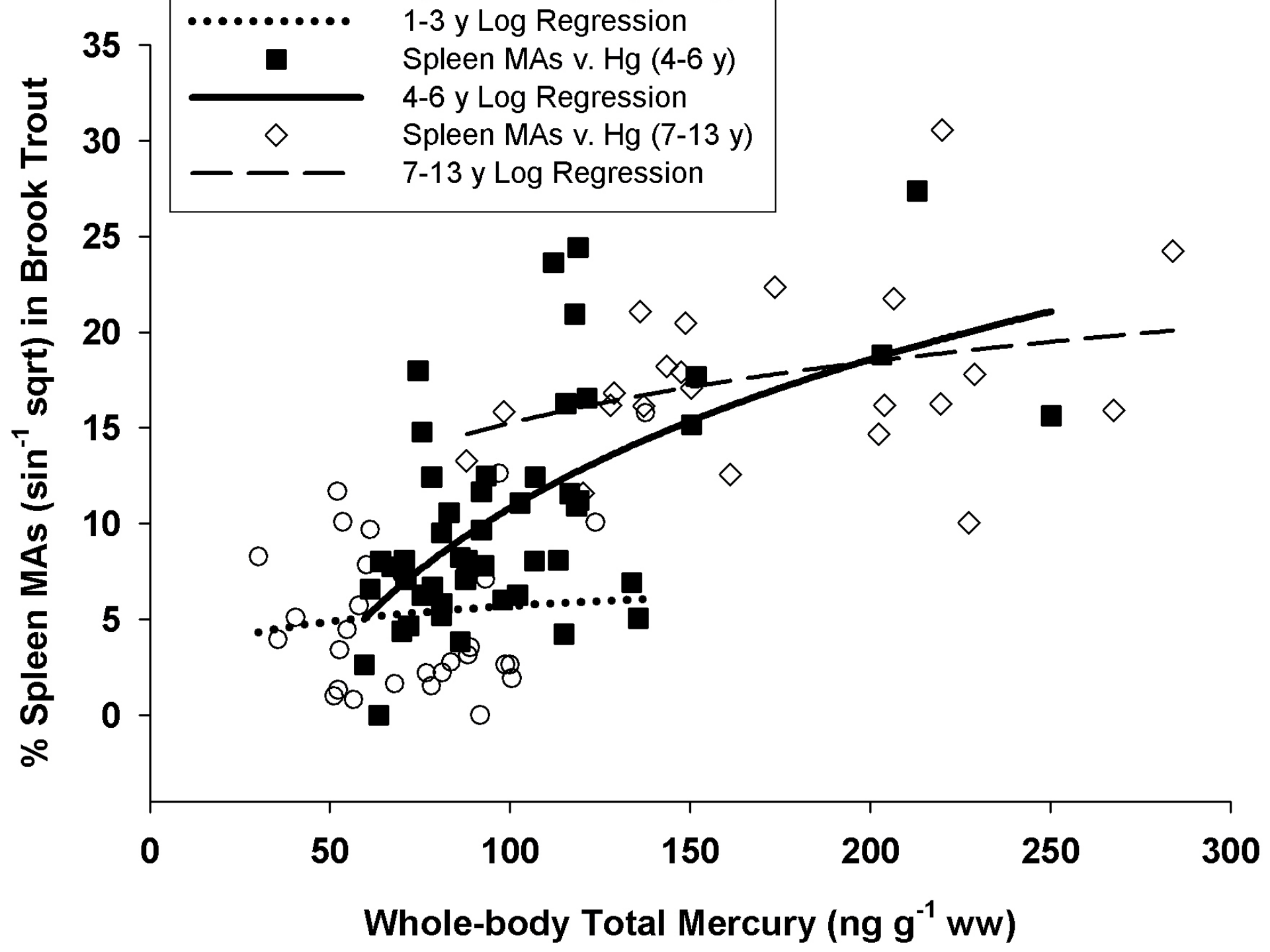
Options...

Measure Objects Total Count: 1546

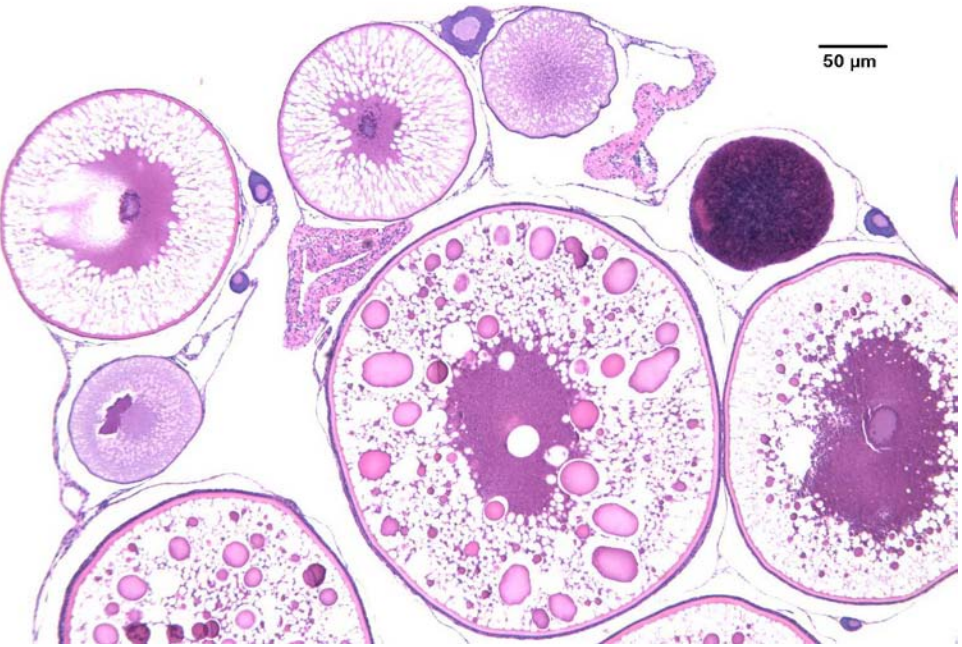
Apply Filter Ranges In Range: 1546

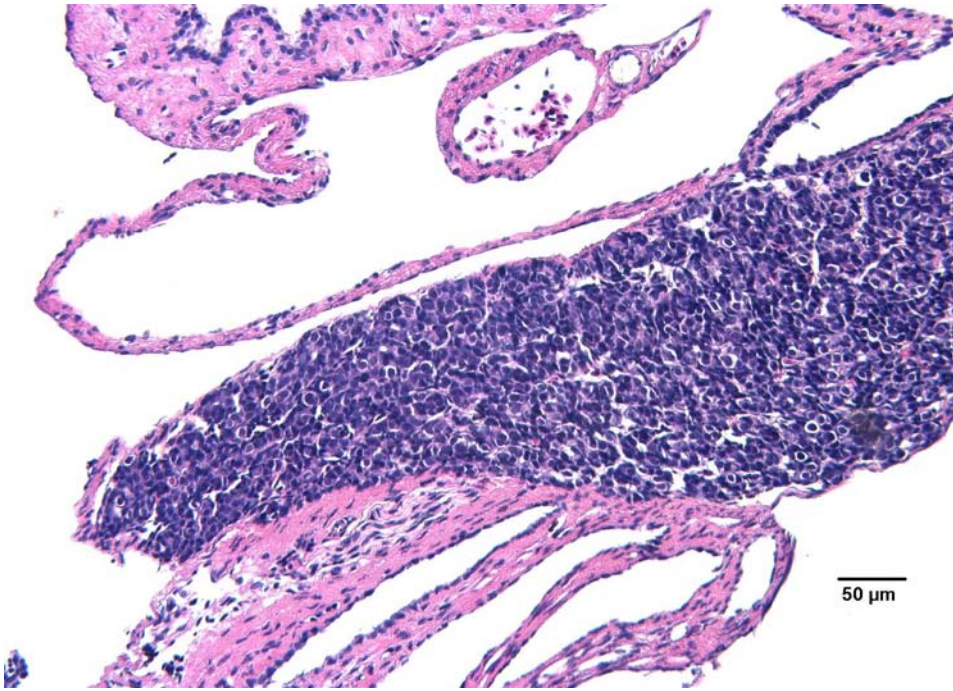
Accumulate Count

RGB 24(4,924,800 bytes), Zoom:50% 1268, 227 127 111 W,H: 1520,1080 Image: <none> (Pixels) System: <none>

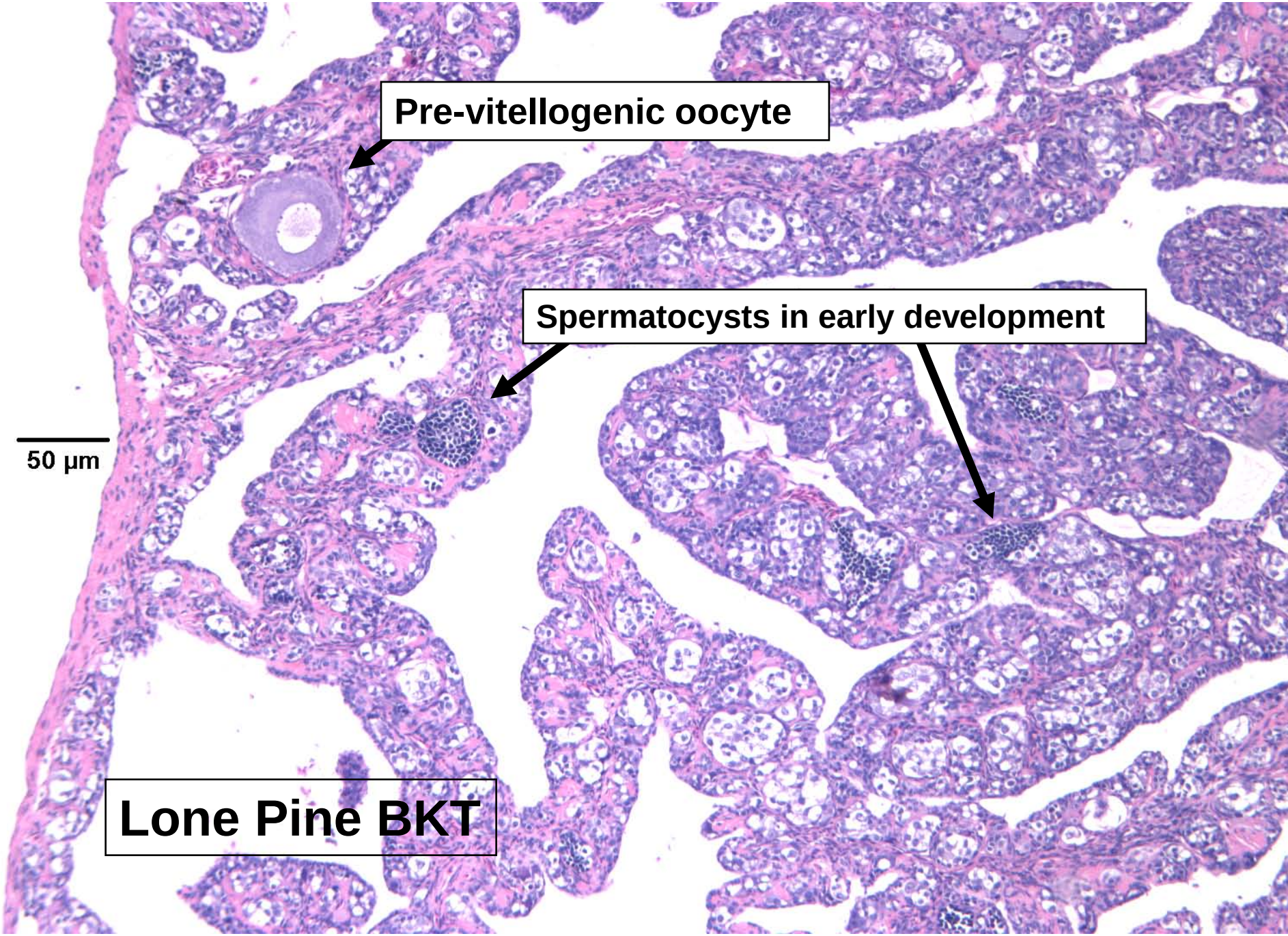

1-3 y Log Regression
Spleen MAs v. Hg (4-6 y)
4-6 y Log Regression
Spleen MAs v. Hg (7-13 y)
7-13 y Log Regression
% Spleen MAs (sin-1 sqrt) in Brook Trout
35
30
25
20
15
10
5
0
0
50
100
150
200
250
300
Whole-body Total Mercury (ng g-1 ww)

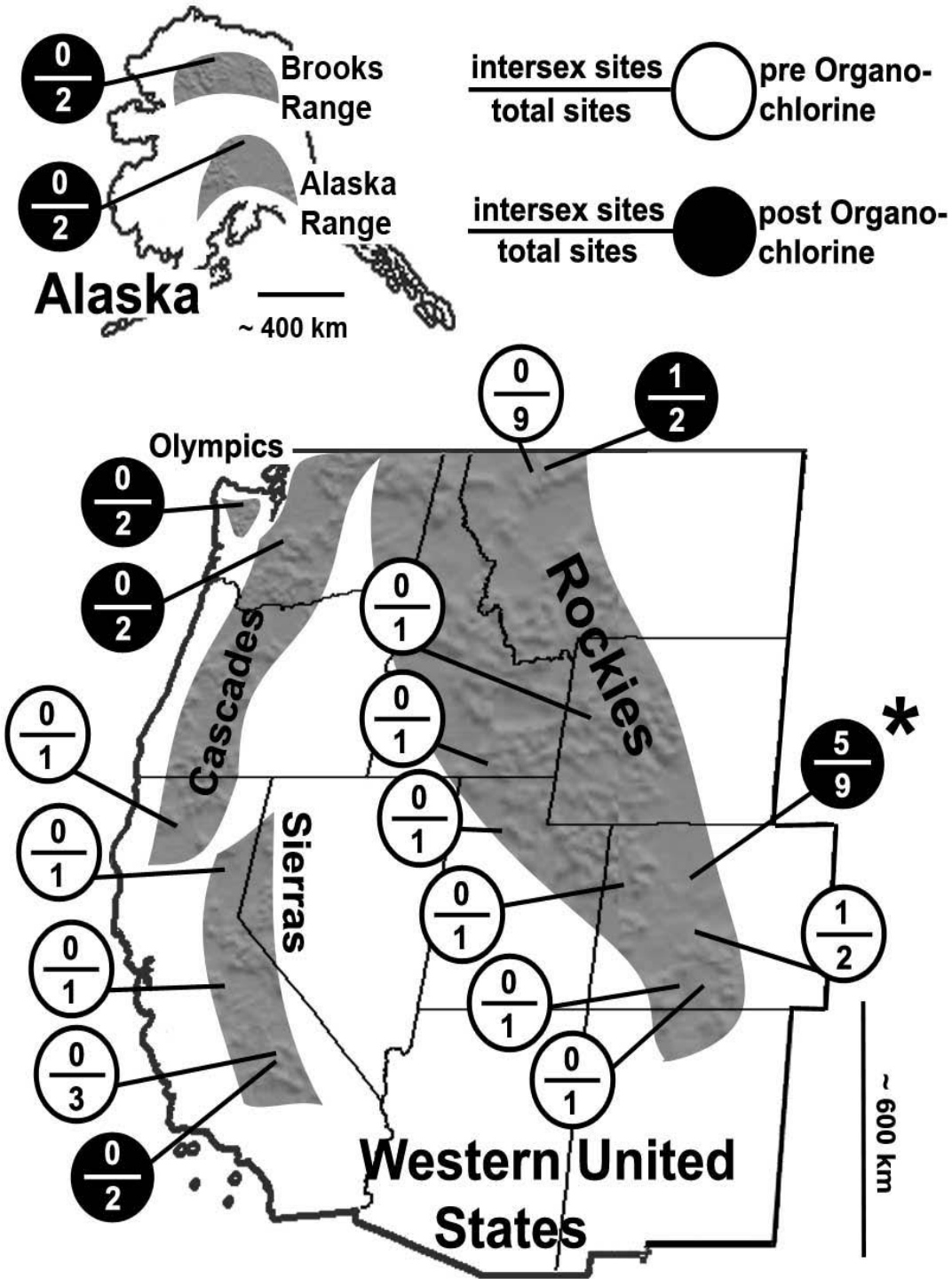
Normal Brook Trout Gonads





Female **Male**


Pre-vitellogenic oocyte
Spermatocysts in early development
50 µm
Lone Pine BKT

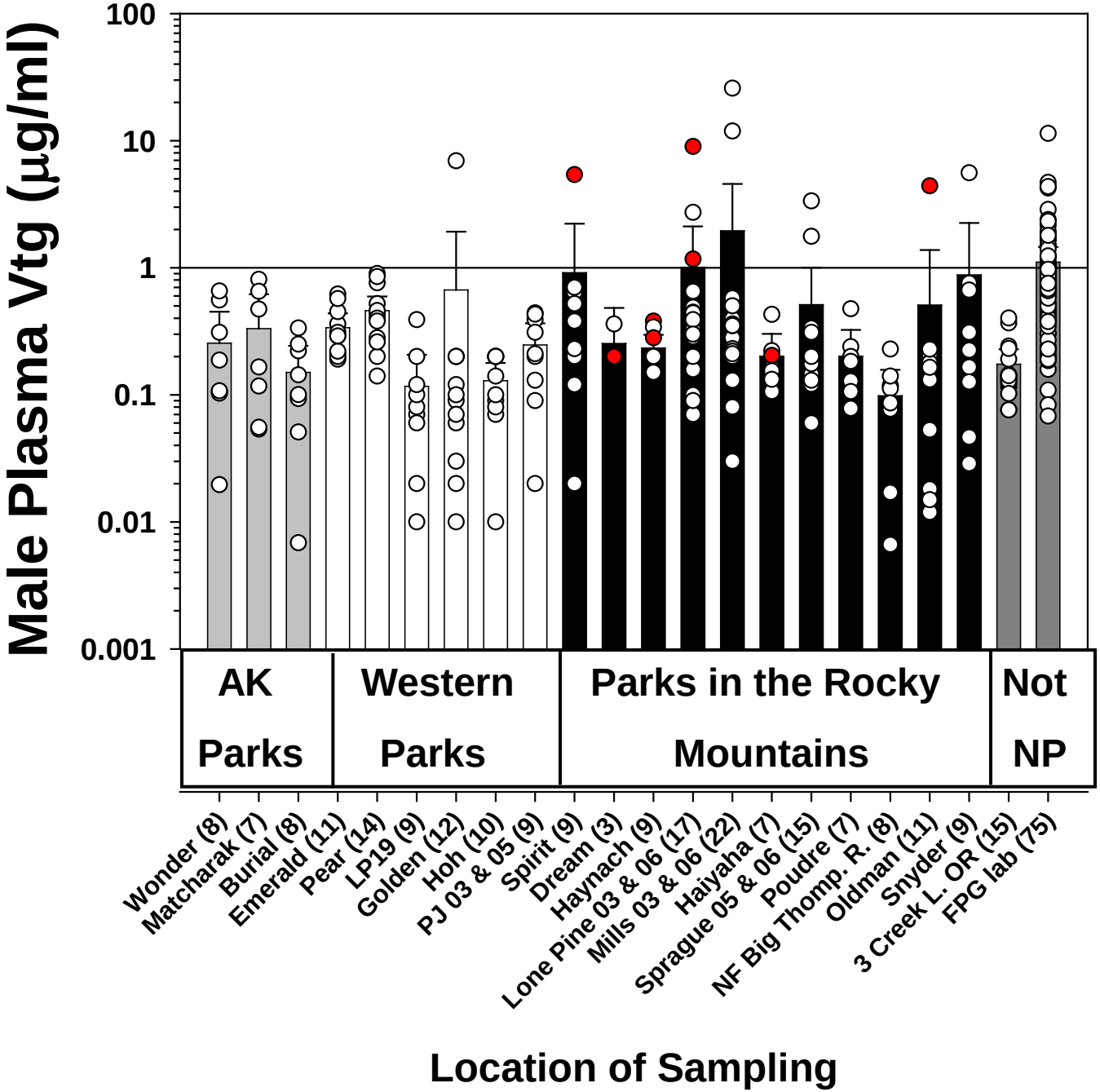

Brooks Range
Alaska Range
Alaska
~ 400 km
intersex sites / total sites
pre Organo-chlorine
intersex sites / total sites
post Organo-chlorine
Olympics
Cascades
Sierras
Rockies
Western United States
~ 600 km
0/2
0/2
0/9
1/2
0/2
0/2
0/1
0/1
0/1
0/1
0/1
0/1
0/1
0/1
0/1
0/1
0/1
0/3
0/2
5/9
*
1/2

Historic Intersex Male (Collection Sites)

- Rocky Mtns:
  - Historic: 1 site of 14 with intersex
    - 1889
  - Current: 6 sites of 11 with intersex
- West Coast / Alaska
  - Historic: 0 sites of 6 with intersex
  - Current: 0 sites of 10 with intersex

Vitellogenine

- Egg yolk precursor synthesized in liver
- Synthesized in response to estrogen
- Good biomarker of estrogenic compounds in the environment
  - Birth control pills
  - Nonophenols from detergents
  - Pesticides like DDT metabolites

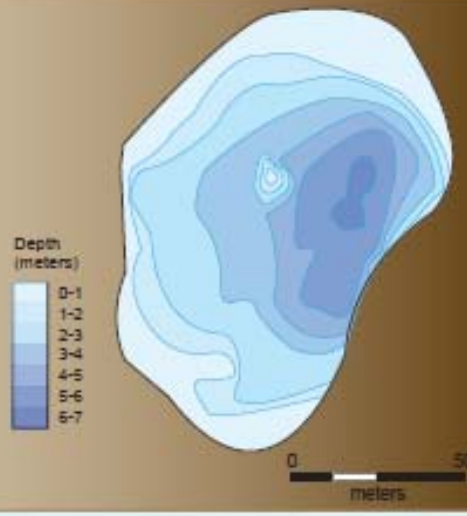

Male Plasma Vtg (µg/ml)
100
10
1
0.1
0.01
0.001
AK Parks
Western Parks
Parks in the Rocky Mountains
Not NP
Wonder (8)
Matcharak (7)
Burial (8)
Emerald (11)
Pear (14)
LP19 (9)
Golden (12)
Hoh (10)
PJ 03 & 05 (9)
Spirit (9)
Dream (3)
Haynach (9)
Lone Pine 03 & 06 (17)
Mills 03 & 06 (22)
Haiyaha (7)
Sprague 05 & 06 (15)
Poudre (7)
NF Big Thomp. R. (8)
Oldman (11)
Snyder (9)
3 Creek L. OR (15)
FPG lab (75)
Location of Sampling

Olympic National Park: *Site Characteristics*

OLYM

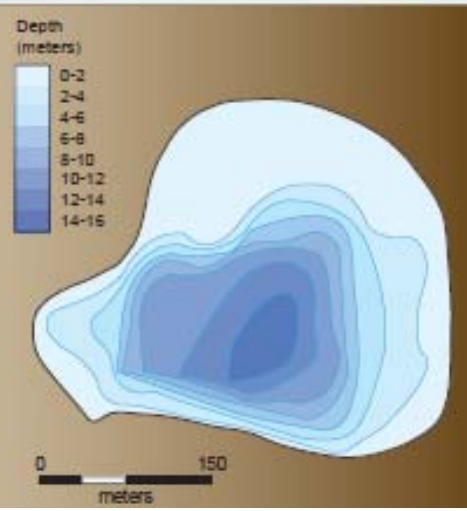
PJ Lake

Location: 47.95N 123.42W
Elevation: 1383.8 m
Maximum Depth: 6.4 m
Surface Area: 0.8 ha
Watershed Area: 56.2 ha



Hoh Lake

Location: 47.90N 123.79W
Elevation: 1379.2 m
Maximum Depth: 14.9 m
Surface Area: 7.7 ha
Watershed Area: 43.9 ha

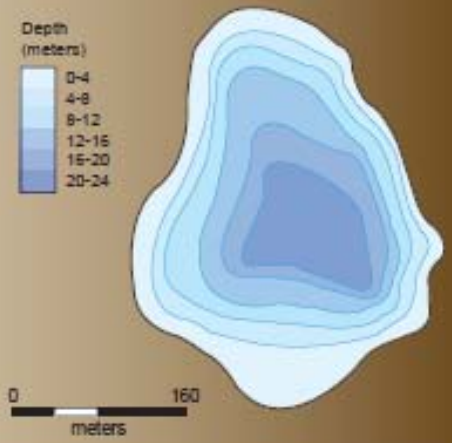


Mount Rainier National Park: *Site Characteristics*

MORA

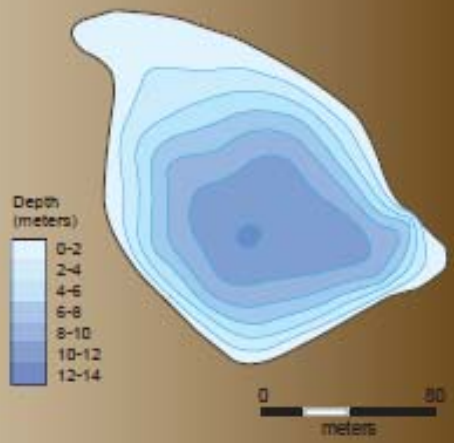
Golden Lake

Location: 46.89N 121.90W
Elevation: 1368.6 m
Maximum Depth: 23.9 m
Surface Area: 6.6 ha
Watershed Area: 106.1 ha

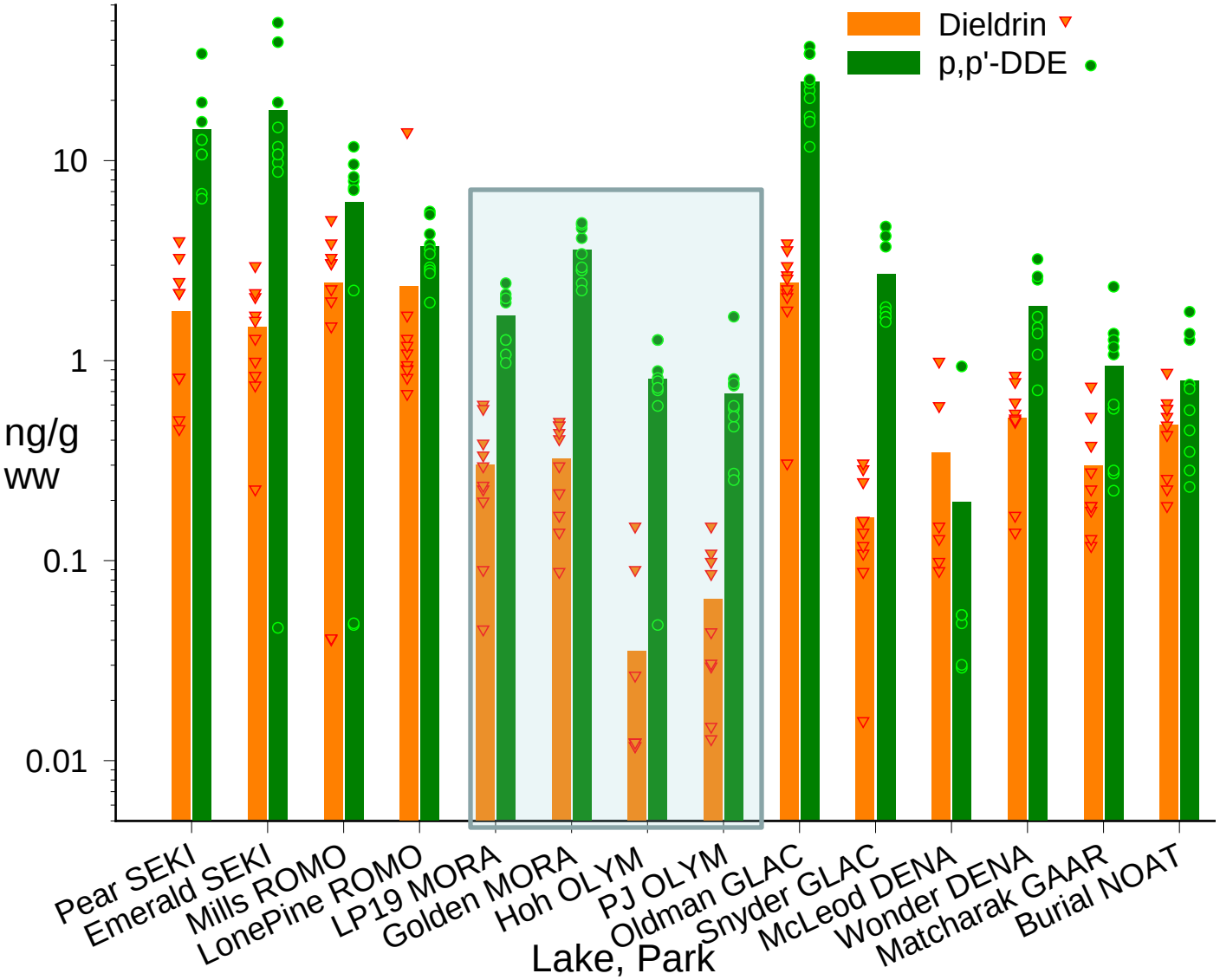


LP19

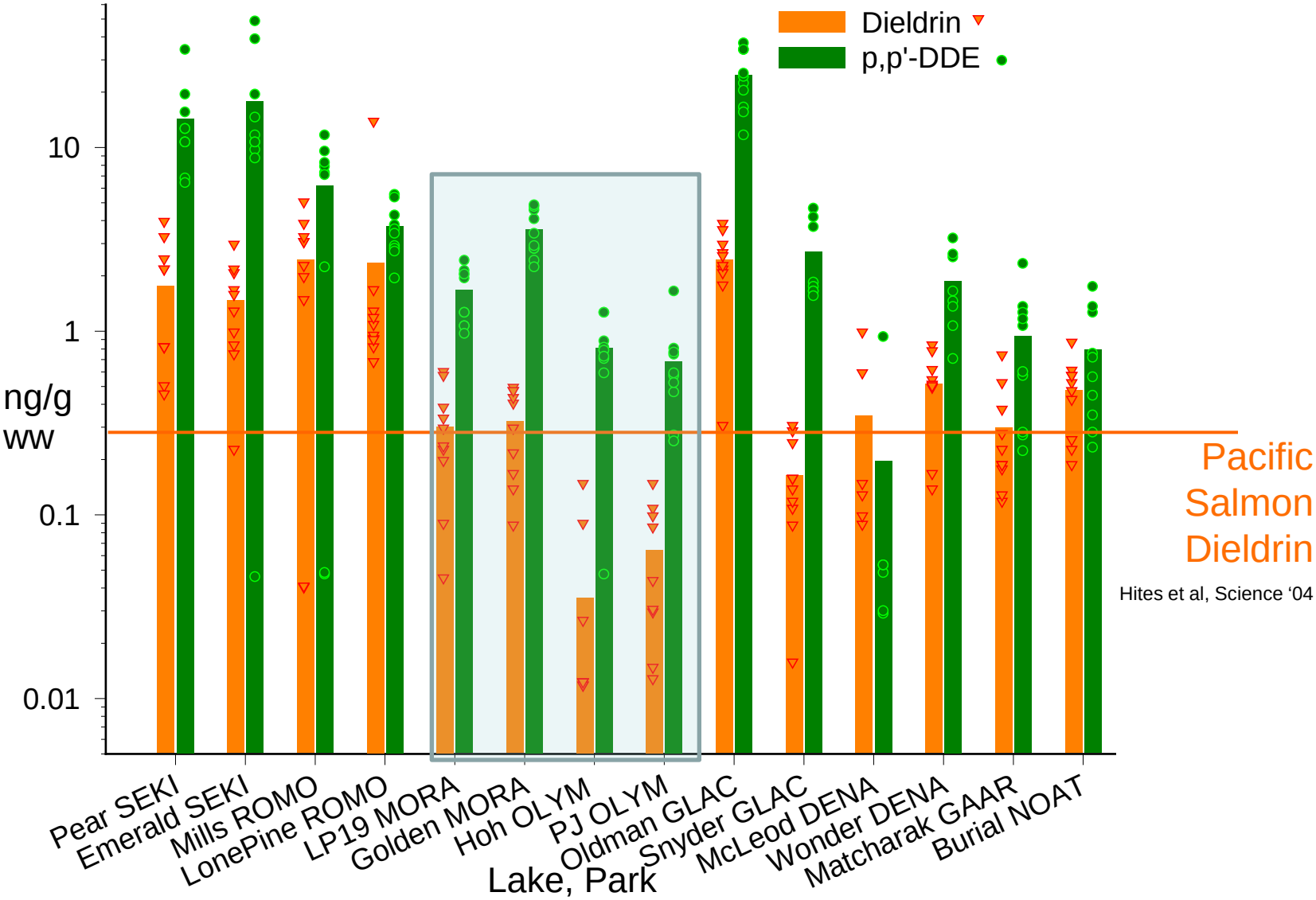
Location: 46.82N 121.89W
Elevation: 1371.6 m
Maximum Depth: 12.1 m
Surface Area: 1.8 ha
Watershed Area: 44.9 ha



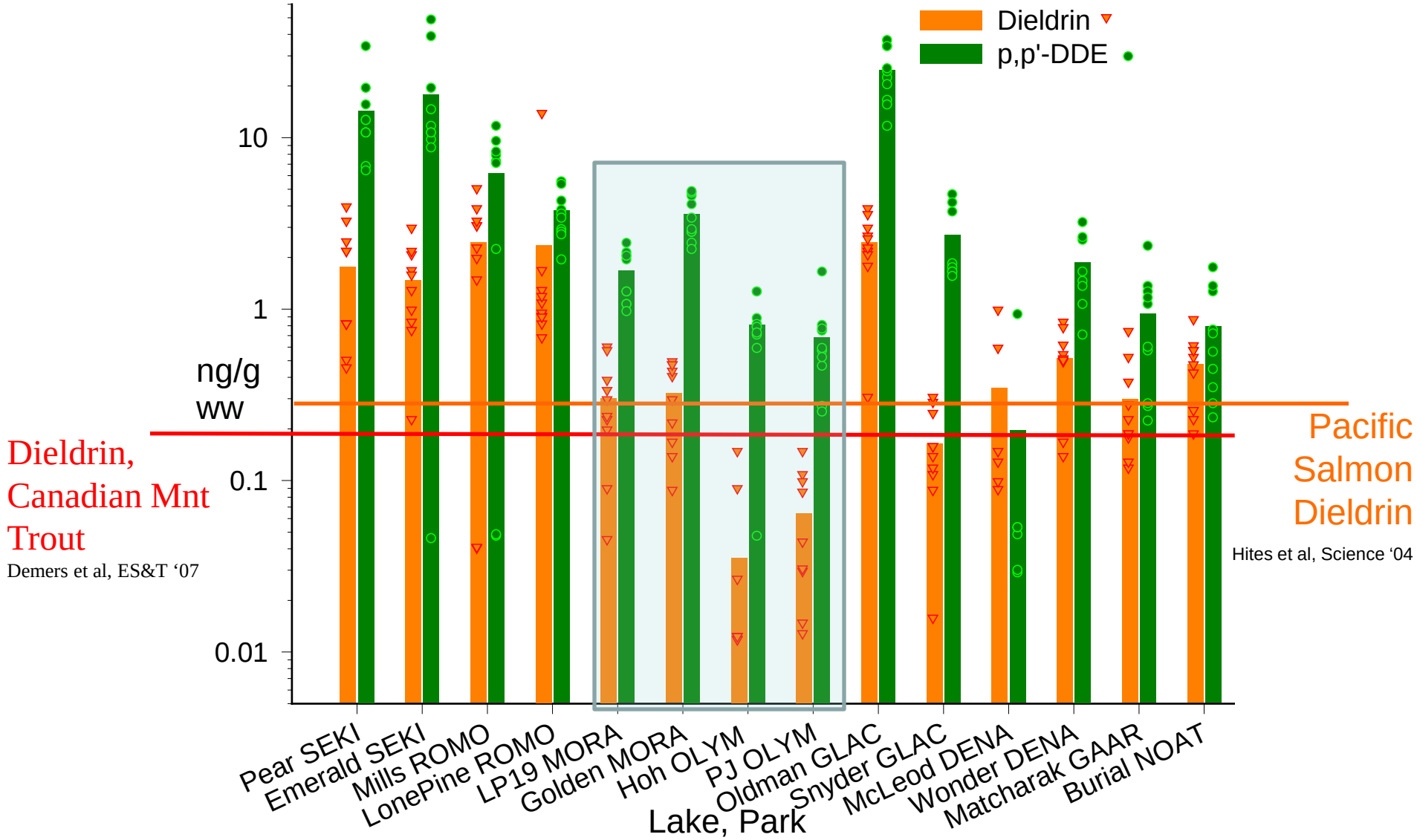
SOC concentrations in Western Lakes



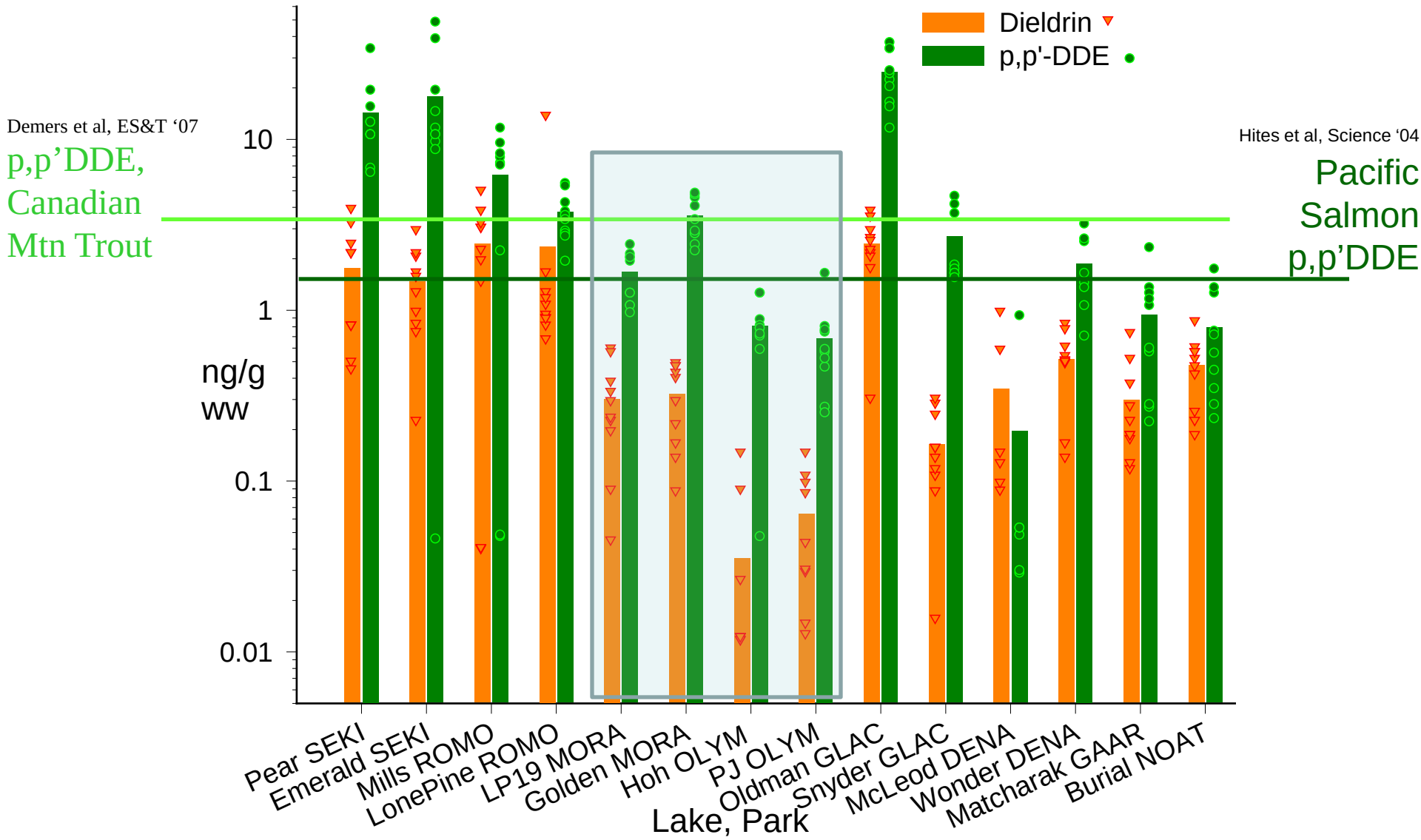
SOC concentrations in Western Lakes



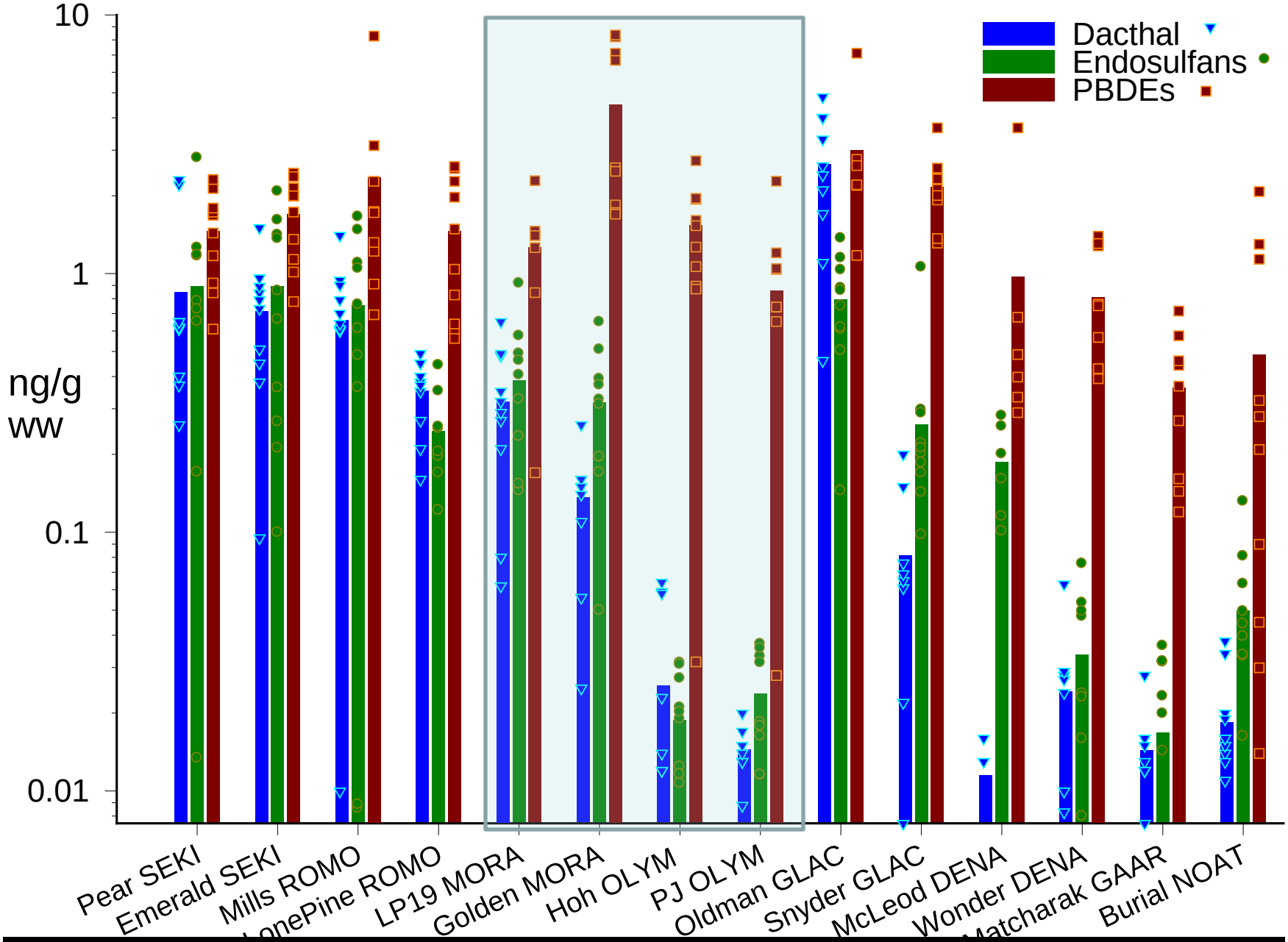
SOC concentrations in Western Lakes



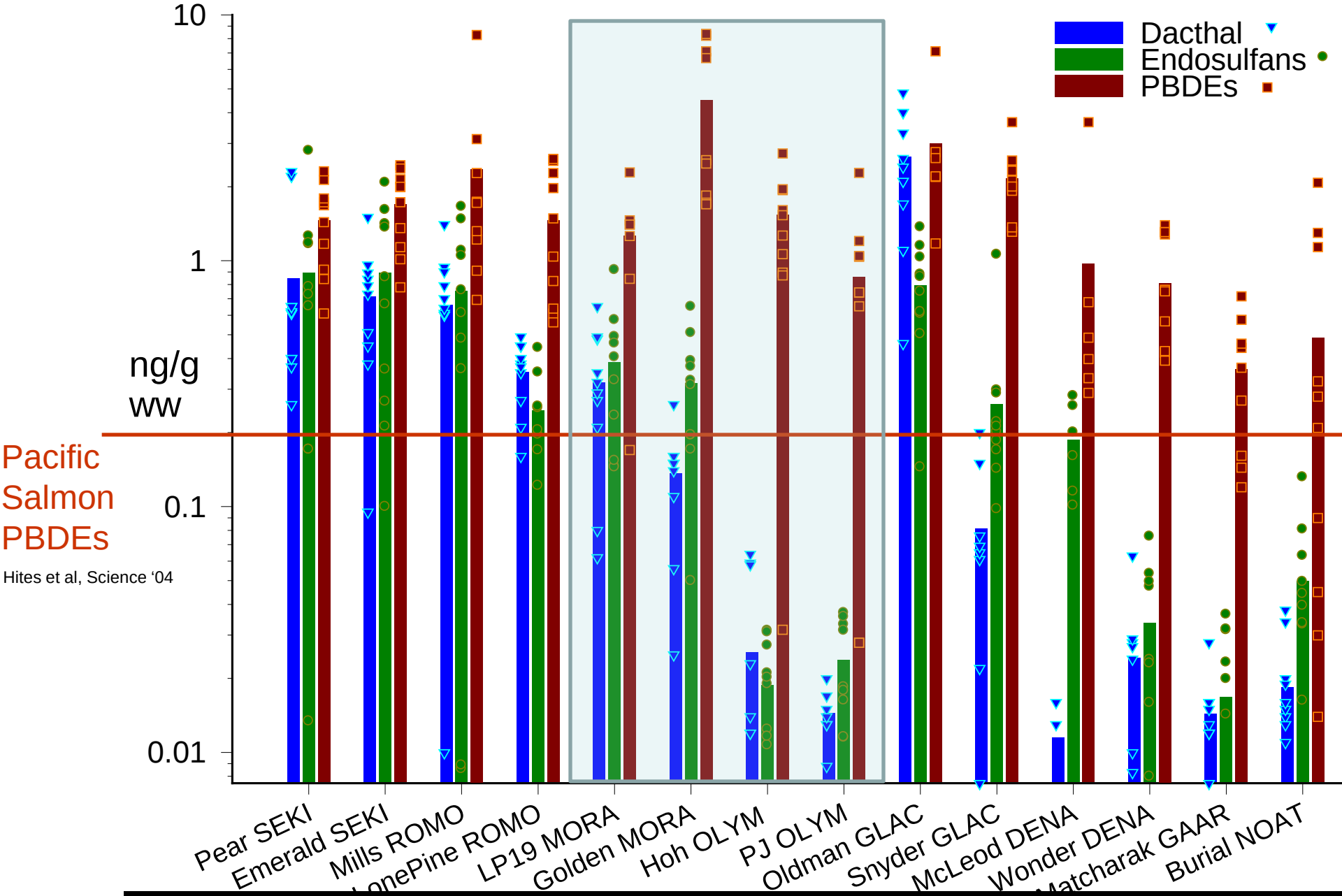
SOC concentrations in Western Lakes



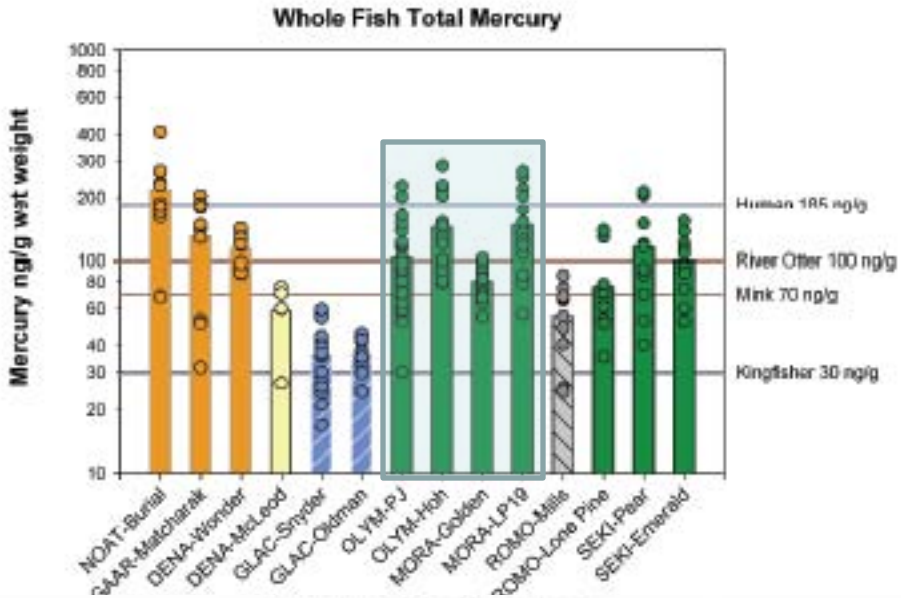
Current-use SOC concentrations in Western Lakes

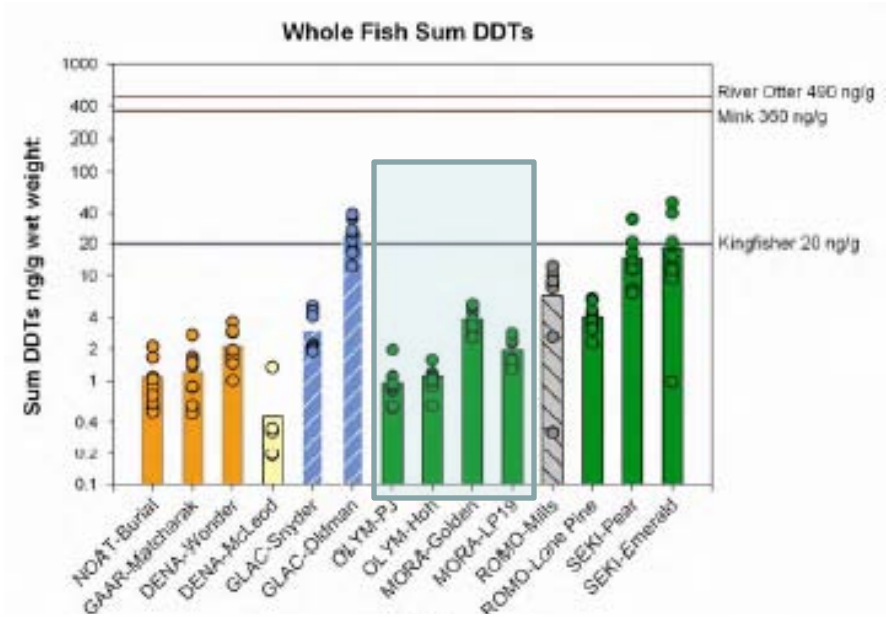


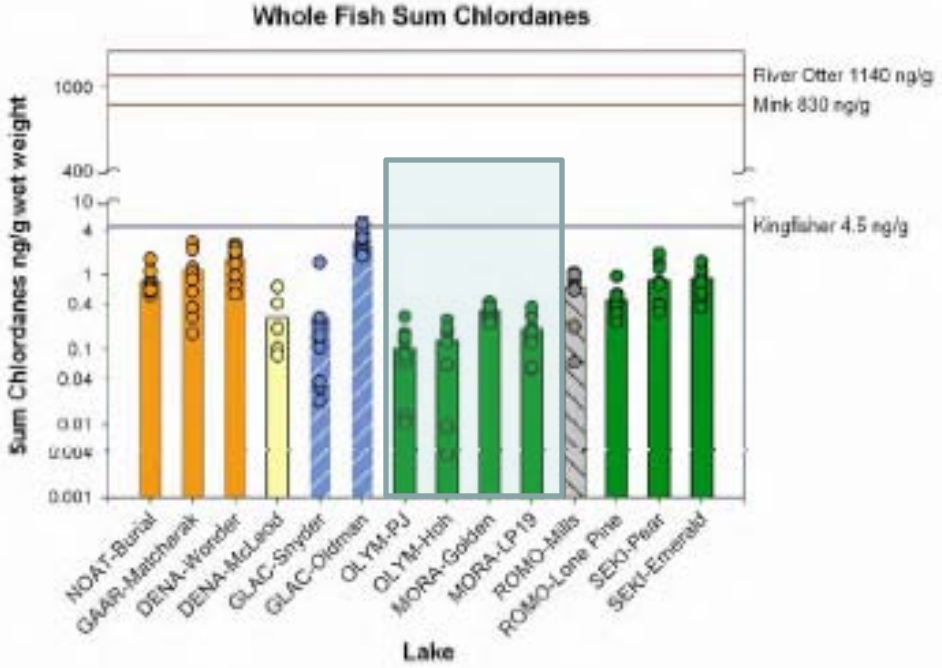
Current-use SOC concentrations in Western Lakes

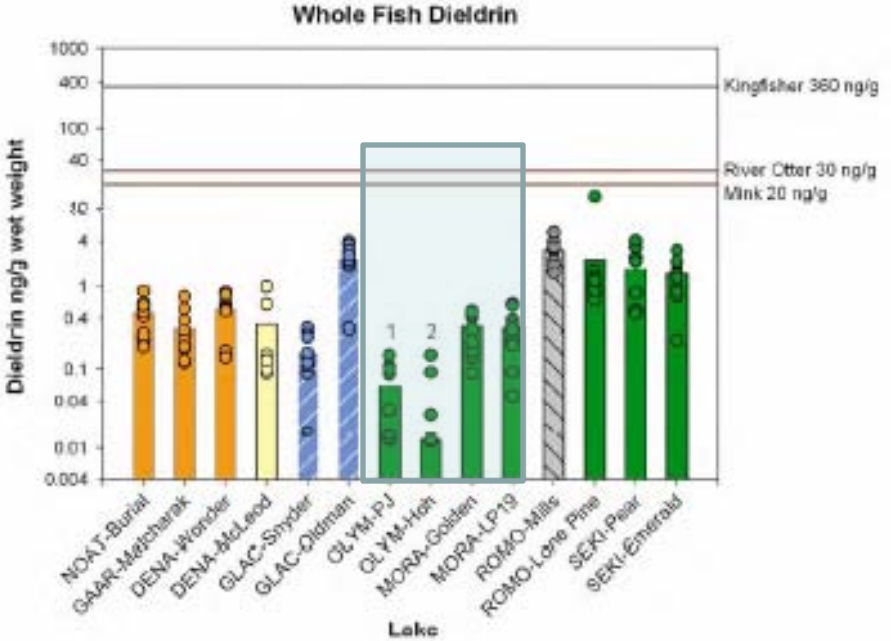


Ecological Effects?









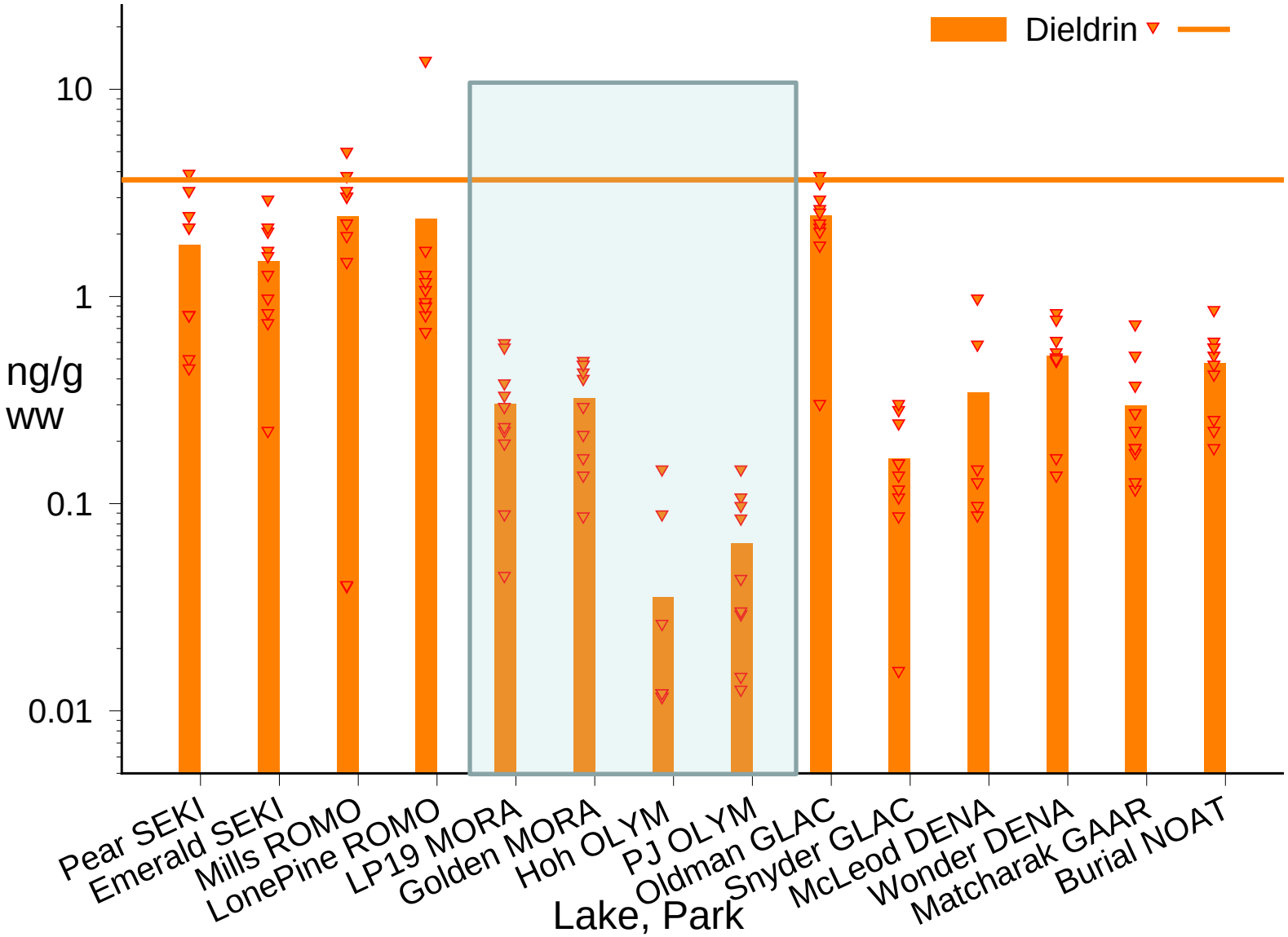
Assessing toxicological relevance.

Methods/Assumptions

- Used EPA Fish Contaminant Advisory Guidance
- No single target population – not specific advise
- Cancer risk – additive, no level w/o risk, just ‘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

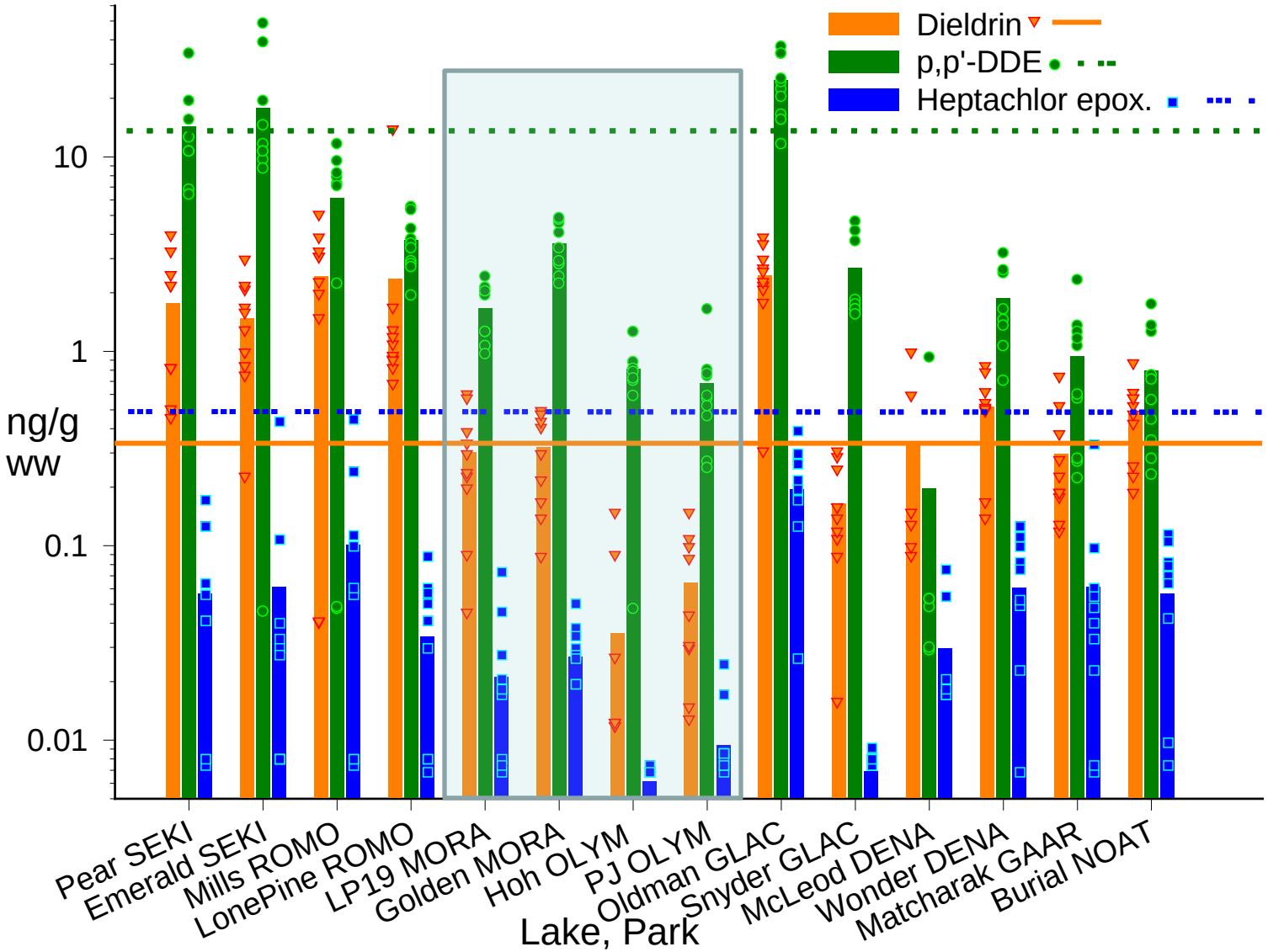
Toxicologically relevant SOCs…Recreational Fishers

No exceedences in MORA or OLYM



Toxicologically relevant SOCs…Subsistence Fishers

5 fish in Golden and 4 fish in LP19 - exceed for Dieldrin



CONCLUSIONS

- High pesticide deposition to PNW forest ecosystem – effects?

- Hg concentrations in fish from OLYM and MORA exceed wildlife and human thresholds

- Dieldrin concentrations in some fish from MORA exceed threshold for subsistence fish eaters

- No evidence of intersex in OLYM or MORA

- Macrophages present and linked to Hg exposure in fish

ACKNOWLEDGEMENTS

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Don Campbell – USGS
Dan Jaffe – UW-Bothell
Will Hafner – UW-Bothell