

# Toxic Air Contaminants in Fish from High Elevation Lakes in Washington's National Parks

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- Study – what, why, where, and how
  - air toxics in fish and sediments
  - high alpine lakes
- Results
- Initial evaluation of data
  - Explain variability in data
  - What does the data mean
    - Compare to standards and guidelines; background levels
    - Assess effect on survival

# Global Distillation Model

Contaminants from warmer climates volatilize, move through the atmosphere, and condense and deposit in cooler climates

Depends upon:

- temperature

- volatility

- long half-lives

Well documented - particularly in arctic regions - suspected to occur in lower latitudes

# Organochlorines & Mercury

- Organochlorines – PCBs and Insecticides
  - 3 unique properties
    - intermediate volatility- globally mobile
    - long half lives- don't go away
    - lipid soluble- tend to bioaccumulate
- Mercury – Three Forms
  - Most long range transport and deposition is as elemental Hg
  - Most regional transport and deposition is as reactive gaseous Hg and particulate Hg
- Methyl Mercury
  - Most toxic and dangerous form
  - Generally microbially mediated production
  - Almost exclusive form found in fish tissue

# Background Rational

- Organochlorine deposition is dominated by a process known as ‘cold condensation’
- This process is driven by temperature, and somewhat by precipitation
- Likely to occur in alpine regions of North America
- Snow, Ice and Tree Bark are good surfaces for deposition which dominate these basins
- Mercury bio-accumulation is driven more by current local sources



# Study Design

- Fish and Amphibians considered to be the most sensitive endpoint, tissue collected at multiple sites
- Sample all 3 Western Washington Class 1 National Parks
  - Mount Rainier NP
  - North Cascades NP
  - Olympic NP
- Site selection to span a range of climatic conditions; rainfall, temperature, average basin aspect

# 2002 Sampling

- Sampled 14 lakes in 3 National Parks
- Elevations ranged from 3200-6300 ft
- Fish were collected with a light-weight gillnet, weights and lengths recorded
- Amphibians were rarely found
- Composite samples of 5 fish, males preferred
- Analysis at ppb level for Organochlorines and Mercury

# 2003 Sampling

- Re-Sampled fish tissue at 5 lakes
  - Mount Rainier NP
  - North Cascades NP
- Also sampled sediment for Total and Methyl Mercury and same Organochlorines
- Collected Brain and Liver tissue from fish for Fish Health Assessment





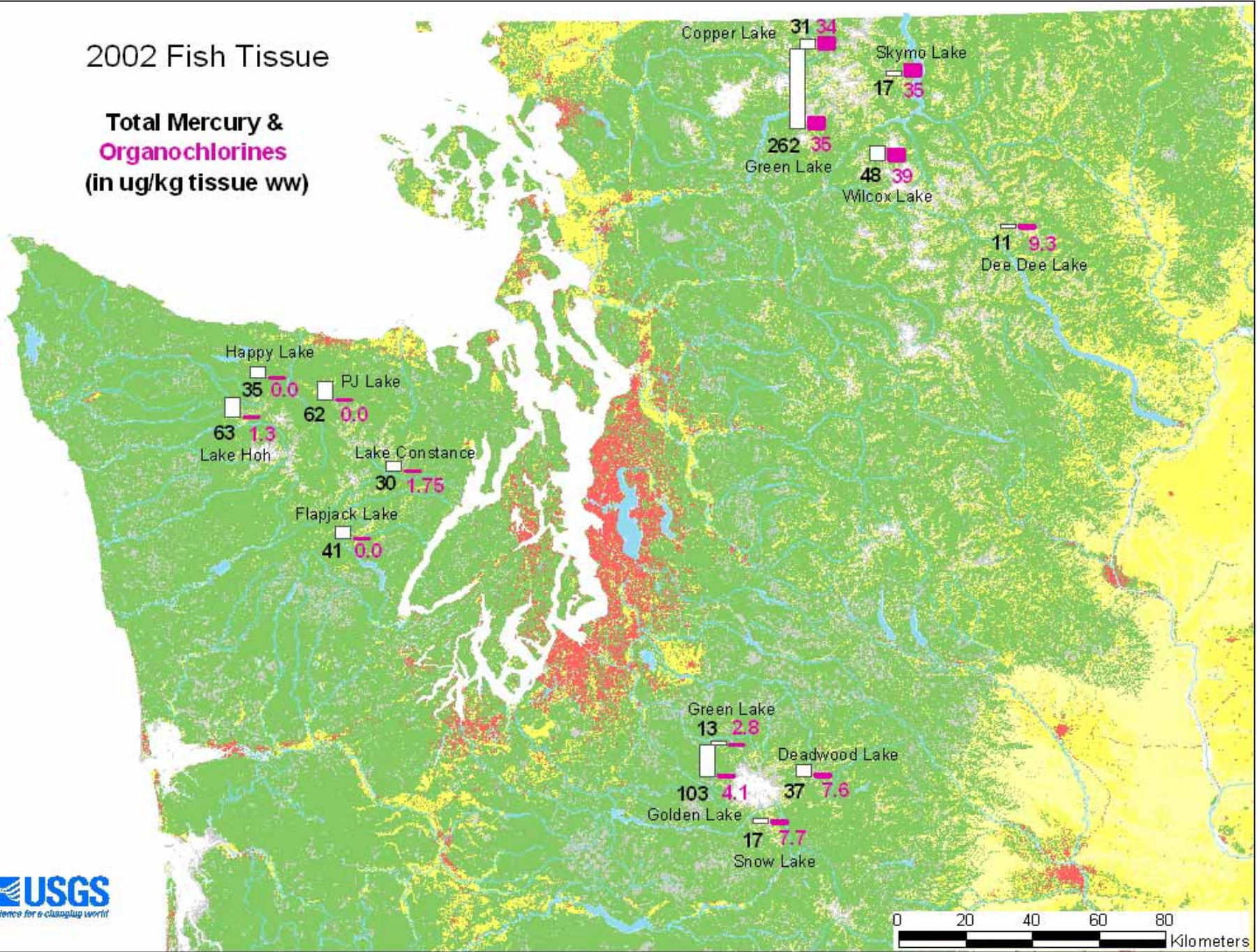






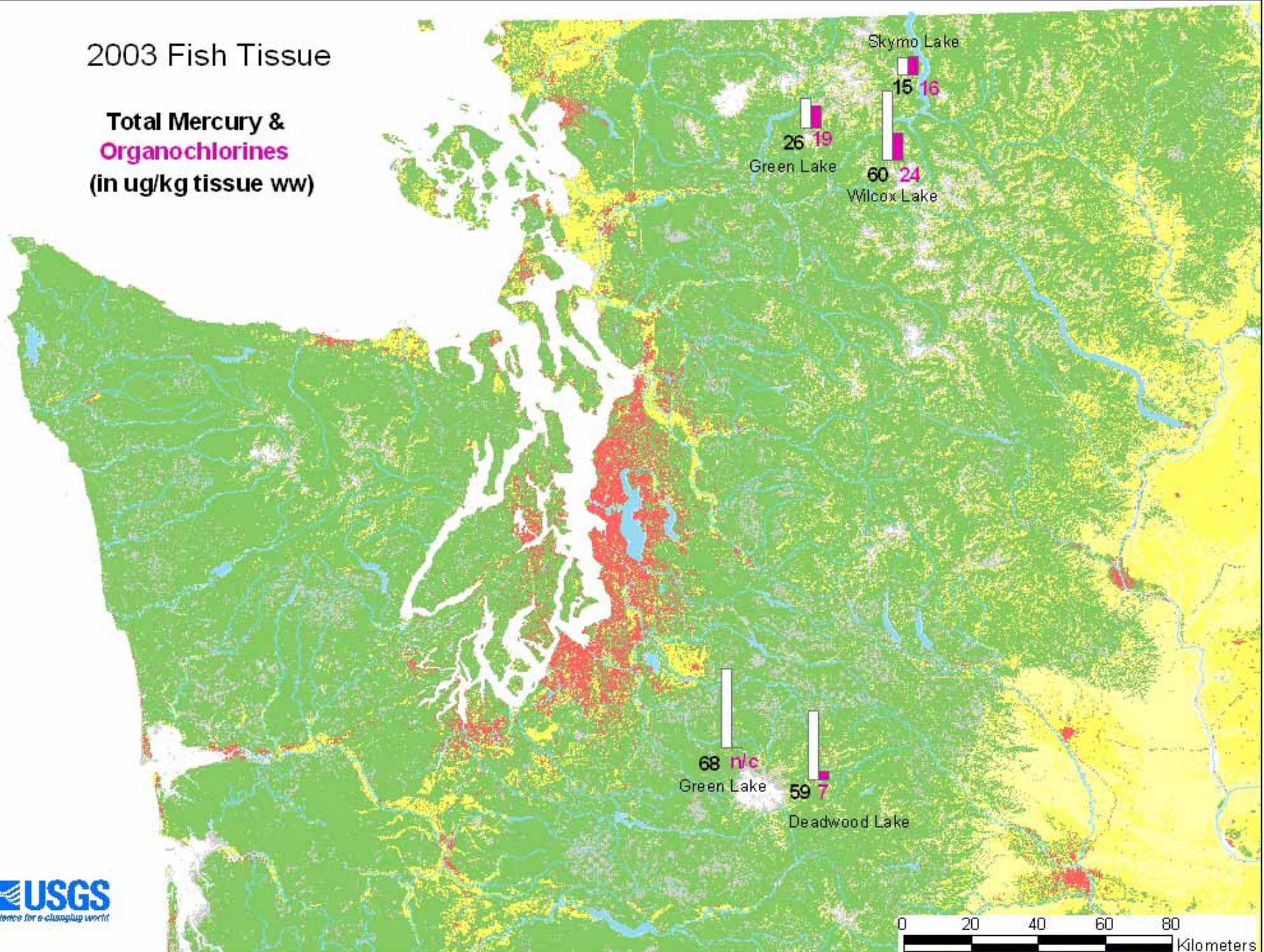
# 2002 Fish Tissue

**Total Mercury &  
Organochlorines**  
(in ug/kg tissue ww)



# 2003 Fish Tissue

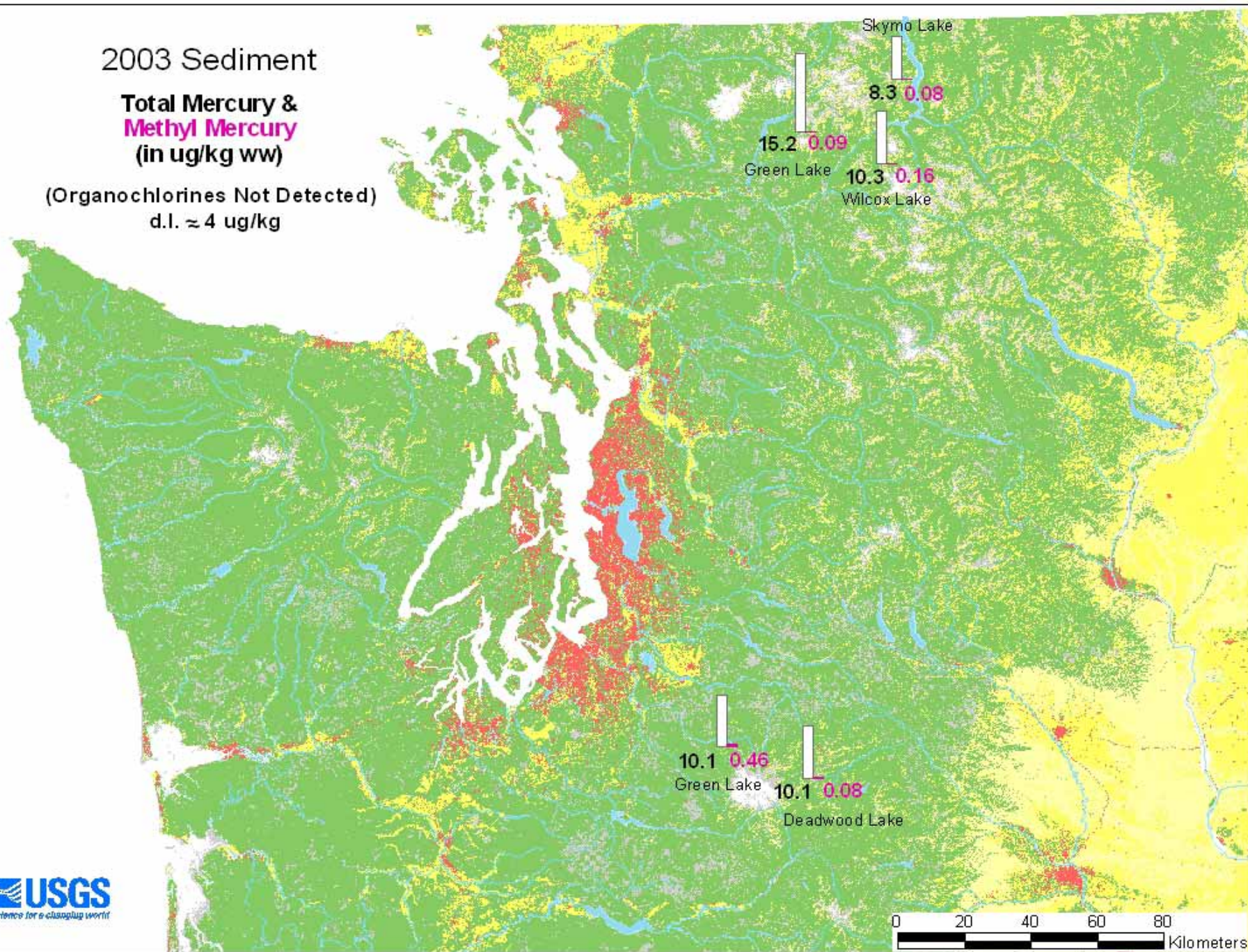
**Total Mercury &  
Organochlorines**  
(in ug/kg tissue ww)



# 2003 Sediment

**Total Mercury &  
Methyl Mercury  
(in ug/kg ww)**

(Organochlorines Not Detected)  
d.l.  $\approx$  4 ug/kg



# Lab Results

Fish	Sediments
<p data-bbox="19 421 510 485">Organochlorines</p> <ul data-bbox="104 521 913 892" style="list-style-type: none"><li data-bbox="104 521 913 656">–Only 2 of the 28 detected; detection limits <math>\approx</math> 4 ppb</li><li data-bbox="104 685 913 892">–Detections consisted of DDE at all sites, and total PCB's in 4 North Cascades Lakes</li></ul>	<p data-bbox="971 421 1846 485">Organochlorines not detected</p>
<p data-bbox="19 949 266 1013">Mercury</p> <ul data-bbox="104 1049 894 1278" style="list-style-type: none"><li data-bbox="104 1049 894 1113">–Detected in all tissue samples</li><li data-bbox="104 1142 894 1278">–One site in 2002 surprisingly high</li></ul>	<p data-bbox="971 949 1218 1013">Mercury</p> <ul data-bbox="1056 1049 1865 1349" style="list-style-type: none"><li data-bbox="1056 1049 1865 1185">–Detected at low end of background soil concentrations</li><li data-bbox="1056 1213 1865 1349">–Methyl mercury a very low percentage of total</li></ul>

# Multivariate Statistical Approach

- Hypothesis generating method
- Which, if any, environmental variables approximate the pattern of chemical concentrations observed
- Tested likely environmental variables for relationships;
  - individually via regression- no relationships observed
  - in combination using a Multivariate approach;  
Nonmetric Multidimensional Scaling (NMS) tool

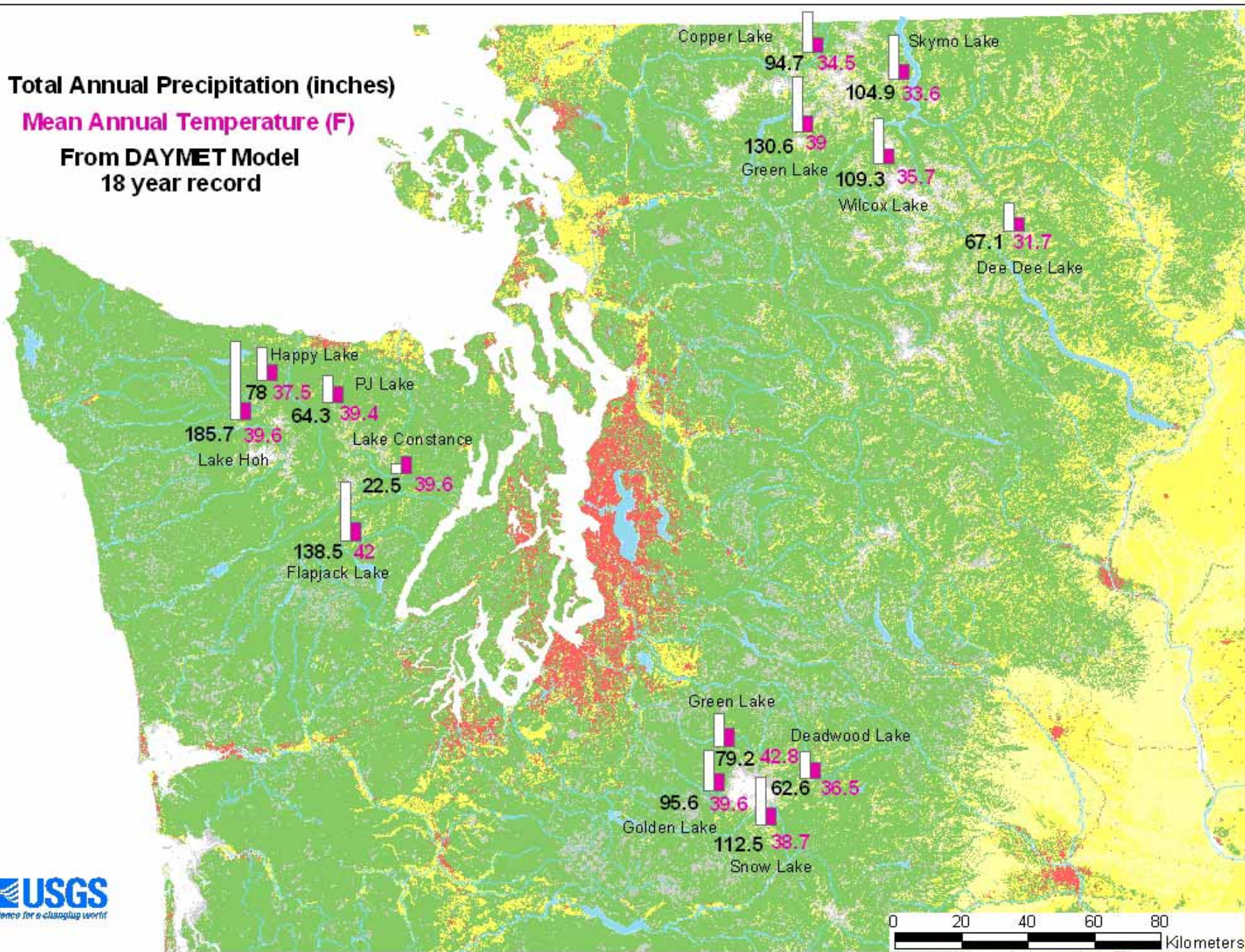
# Environmental Variables Evaluated

- Expected Relationships driving the pattern
  - Fish length, surrogate for age
  - % Lipids in tissue
  - Neither pattern observed here
- Other environmental variables evaluated
  - Mean Annual Temperature (MAT)
  - Total Annual Precipitation (TAP)
  - Elevation
  - Average Basin Aspect- average direction water drains
  - Relief Index- 3 Dimension, contour area/ 2 dim. Planar area
  - Percent permanent snow and ice- ie. good surface for adsorption of chemicals
  - Also retained expected variables in multivariate approach

# Total Annual Precipitation (inches)

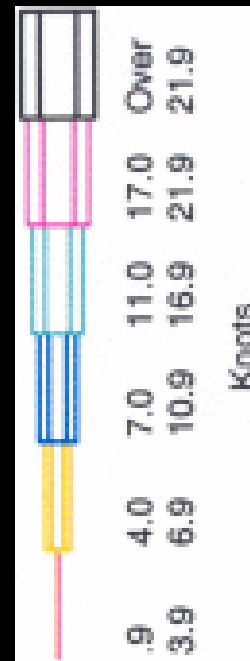
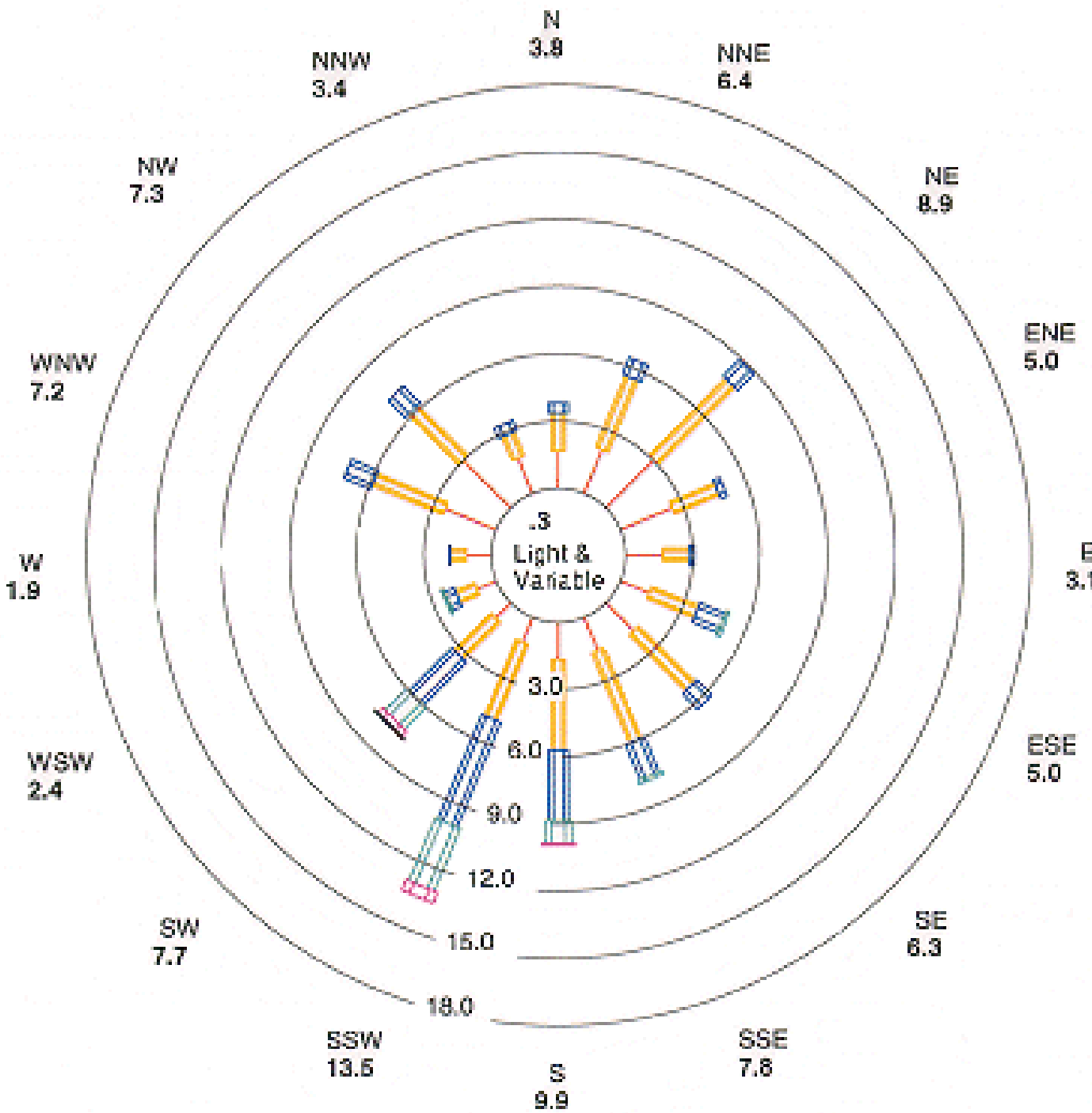
## Mean Annual Temperature (F)

From DAYMET Model  
18 year record



# Ordination

- Nonmetric Multidimensional Scaling was used to ordinate sites in contaminate space
  - In this case, 3-dimensional space; ie Hg, PCBs, DDE
- Ordination method suggests a one dimensional solution fits data better than randomization at a 0.05 level
- Vectors of environmental variables were then compared to the ordination and correspondence evaluated



# Some Confounding Factors

- Fish smaller the second year of sampling
- Some samples included female fish
- Hg Deposition  $\neq$  Hg Methylation
  - Deposition + Sulfur + Carbon
  - Lake characteristics would appear to yield similar (low) methylation rate

# What do these levels mean?

- Criteria and Guidance
- Background Concentrations
  - Nationally and within Washington
- Individual or Population level Survival

# Mercury

## Mercury Criteria & Guidance

- EPA recently lowered criteria - 300 ppb
- Screening Value for Recreational Fishers 400 ppb
- Screening Value for Subsistence Fishers 49 ppb
- NAS (1972) Fish-eating wildlife protection 500 ppb

## Mercury Background Concentrations

- EPA's 1992 National Fish Contaminant Study
  - Rainbow Trout "ND"
  - Brook Trout 130 ppb
  - Cutthroat 70 ppb
- Washington DOE 2001, Fish Tissue Study
  - Median Hg all fishes (108 sites) 115 ppb

## Fish Mercury Concentrations in Washington Class 1 National Parks

- Ranged from 13 – 262 ppb
- West side average 64 ppb
- East side average 33 ppb
- Olympic NP Average 46 ppb
- North Cascades NP Ave. 59 ppb
- Mount Rainier NP Ave. 50 ppb

# Organochlorine

## Organochlorine Criteria and Guidance

- EPA Cancer Risk Guidelines
  - DDE's 32 ppb
  - Total PCB's 14 ppb
- BC Objective to protect aquatic Life 500 ppb
- New York criteria for total DDT's wildlife 200 ppb

## Organochlorine Background Concentrations

- Washington DOE 2001, Fish Tissue Study (6 sites)
  - Median DDE's 4 ppb
  - Median PCB's 16 ppb

## Fish Organochlorine Concentrations in Washington National Parks

- Ranged from 0 to 39 ppb
- North Cascades NP
  - Range 9 to 39 ppb
  - West side average 30 ppb
- Mount Rainier NP
  - Range 3 to 8 ppb
  - West side average 5 ppb
- Olympic NP
  - Range 0 to 2 ppb

# Individual or Population Survival?

- Originally planned to look at immune function
  - Lysozyme assay developed w/ arctic char and OC exposure
  - Concentrations found here are too low
- Currently, considering DNA microarray techniques
  - Important genes sequenced in rainbow trout
  - Several RBT DNA microarrays have been built
  - Brains sent to labs that specialize in conducting and interpreting these tests

