



COLORADO LAKE NUTRIENT CRITERIA DEVELOPMENT - UPDATE



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Overview

- Goal – Propose statewide criteria in June 2010
- General Approach
 - Associate criteria with attainment of uses
 - Primary focus on chlorophyll standard; also propose phosphorus standard (nitrogen?)
 - Draw on 20+ years of site-specific experience
 - Supplement with monitoring record – various agencies and other sources; 80+ lakes



Characterization of Lake and Reservoir Data Set

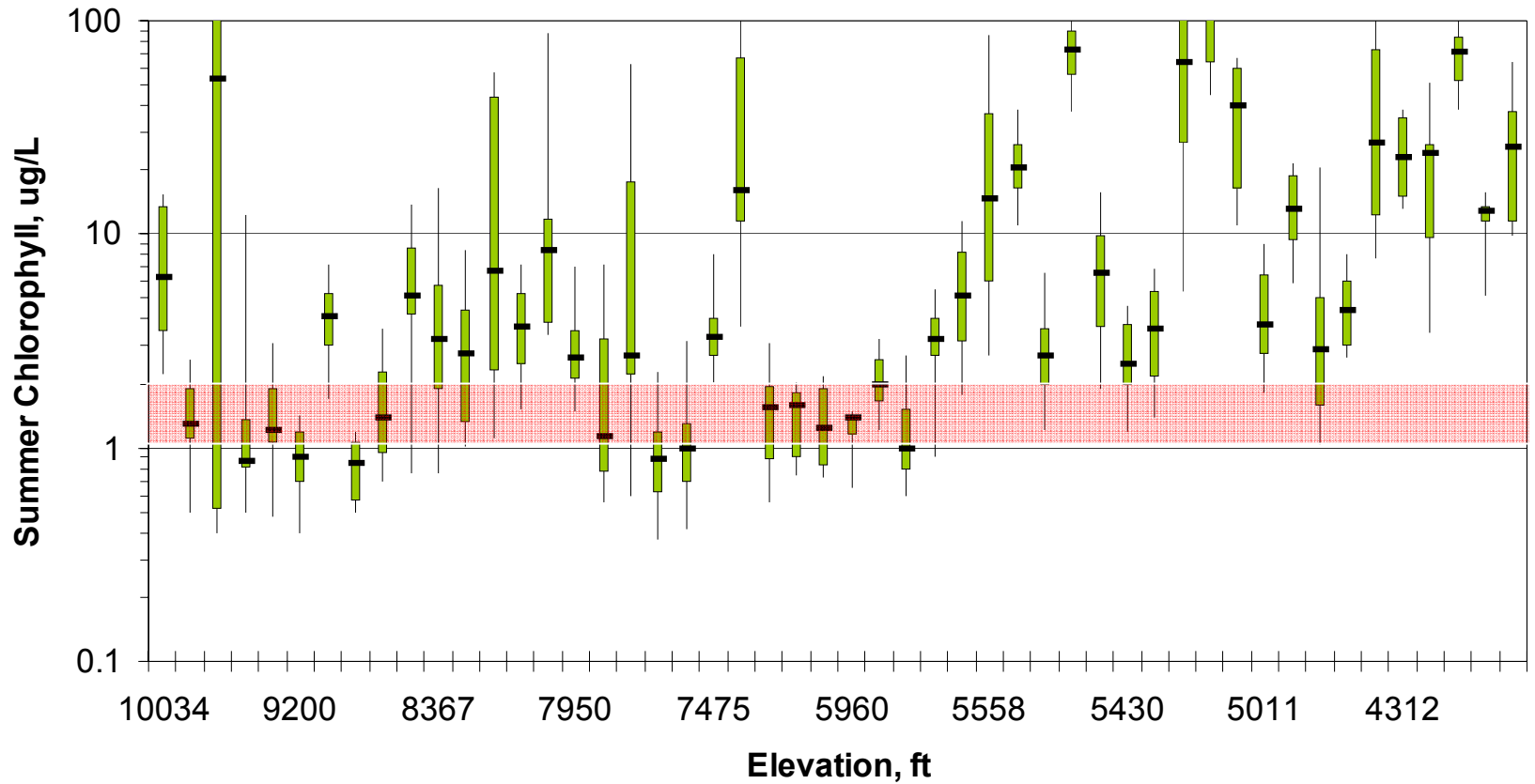
- 84 “lakes” (mainly reservoirs) with chlorophyll and nutrient data from summer (Jul-Sep)
 - Elevation: 3800 – 10,000 ft
 - Size: 100 – 17,000 acres
 - Broad geographic coverage
 - Focus on lakes with at least 5 summer samples (N=50)
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Colorado 304a Criteria

- Colorado lakes fall into several ecoregions
- Recommended chlorophyll: *very low*

Ecoregion	Basin	TP	NO3	Chl	Secchi
Southern Rockies	All; high elevation	14.8	10	1.7	4.2
Wyoming Basin	Yampa	10.0	50	1.4	3.0
Colorado Plateau	Colorado	3.0	10	1.4	3.2
AZ/NM Plateau	San Juan, RG	15.0	20	2.0	2.9
Western High Plains	South Platte, Arkansas	24.0	10	2.4	1.5
SW Tablelands	Arkansas	20.0	10	1.2	1.7

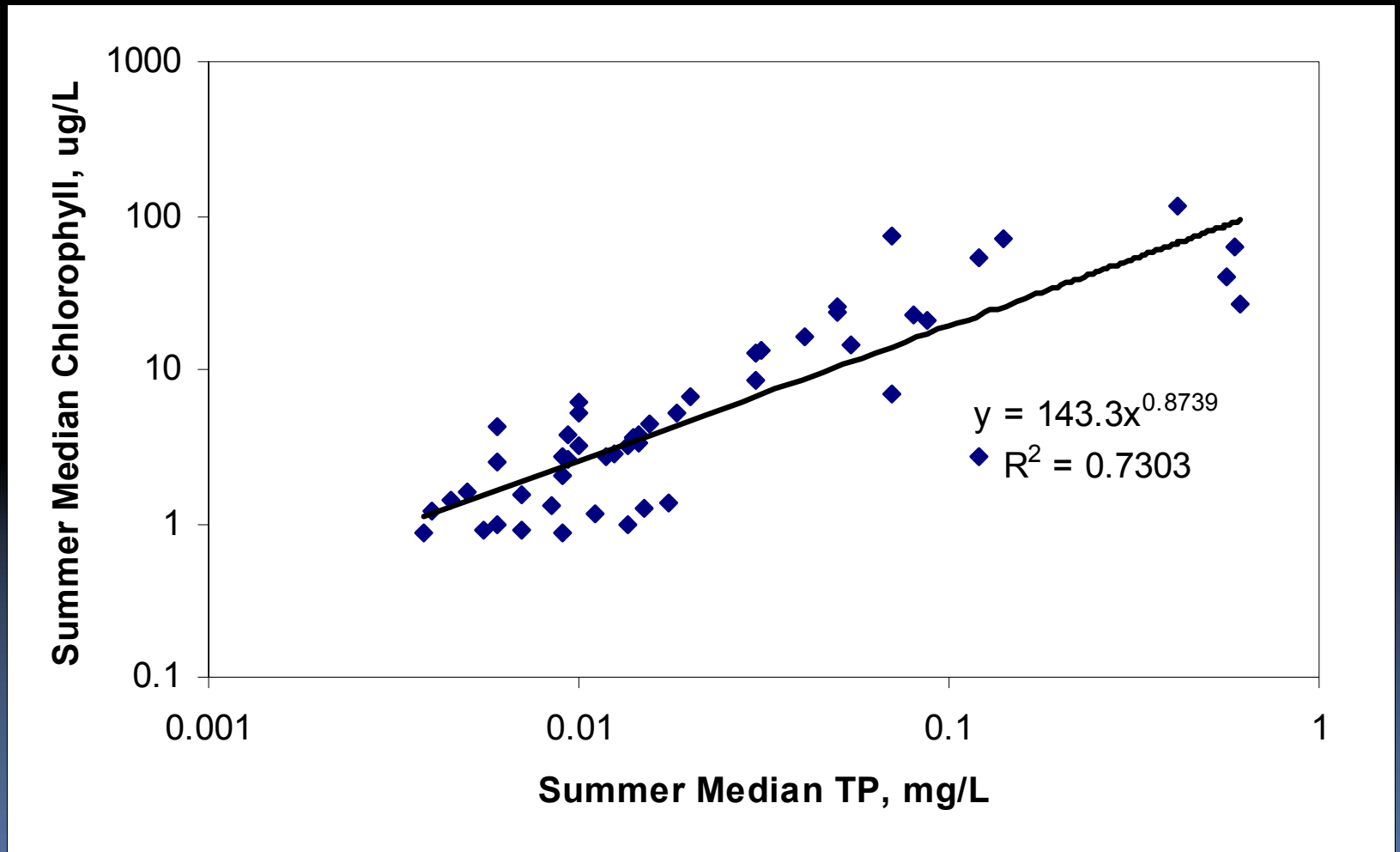
Chlorophyll and Elevation



Aspirations for Nutrient Criteria

- 304a are offered as guidance; other scientifically-defensible approaches could be developed....
- 25th percentile approach difficult to sell to stakeholders focused on use protection
- Appropriateness of reference concept to (man-made) reservoirs

Summer Chlorophyll-Phosphorus



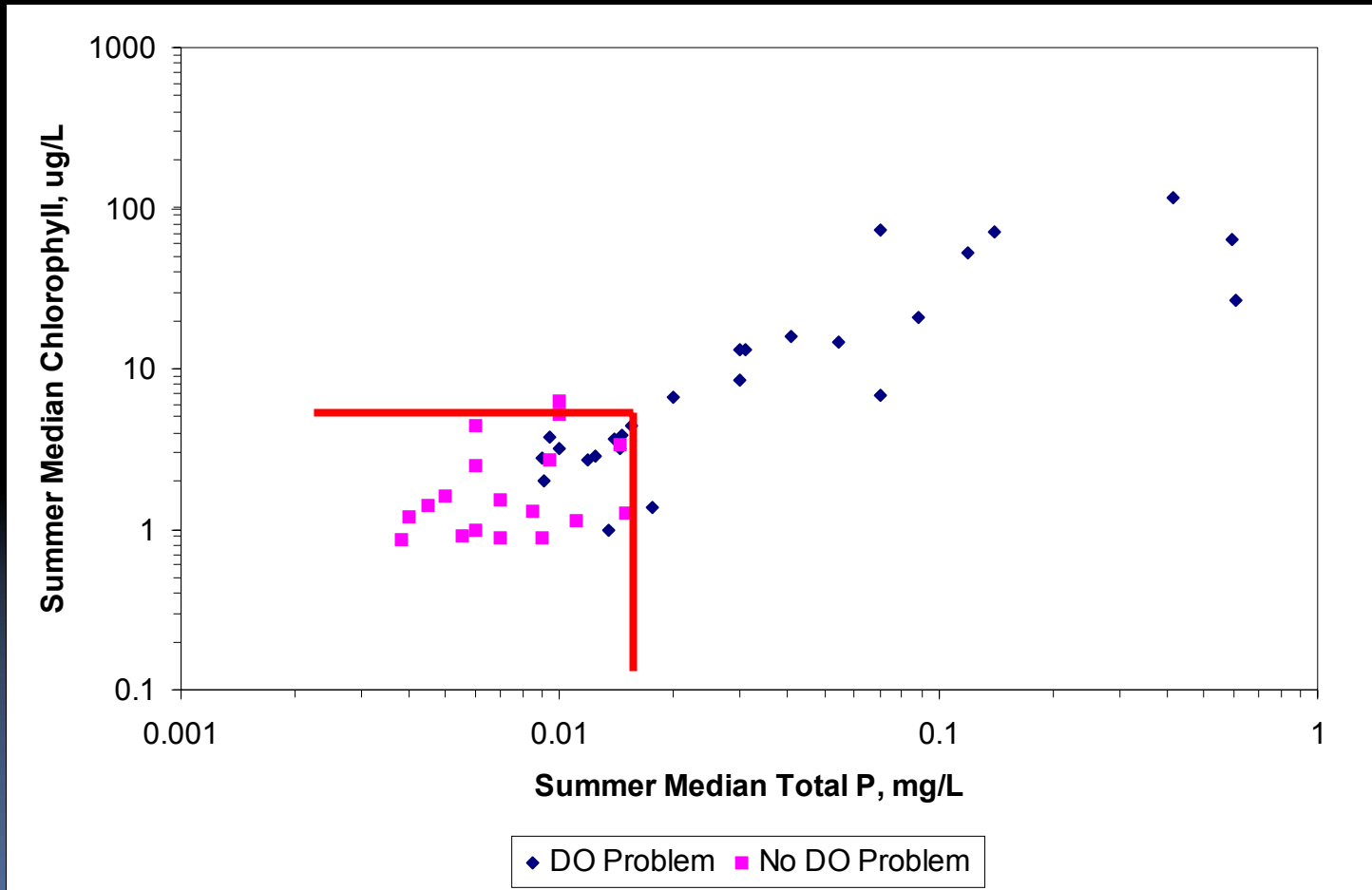
What Uses?

- Aquatic Life (Cold and warm classifications)
 - DO, pH concerns
 - Fishery quality
- Domestic Water Supply
 - Stakeholder group motivated by concerns about THMs, etc
- Recreation
 - Bloom frequency (cyanotoxins)
- Agriculture

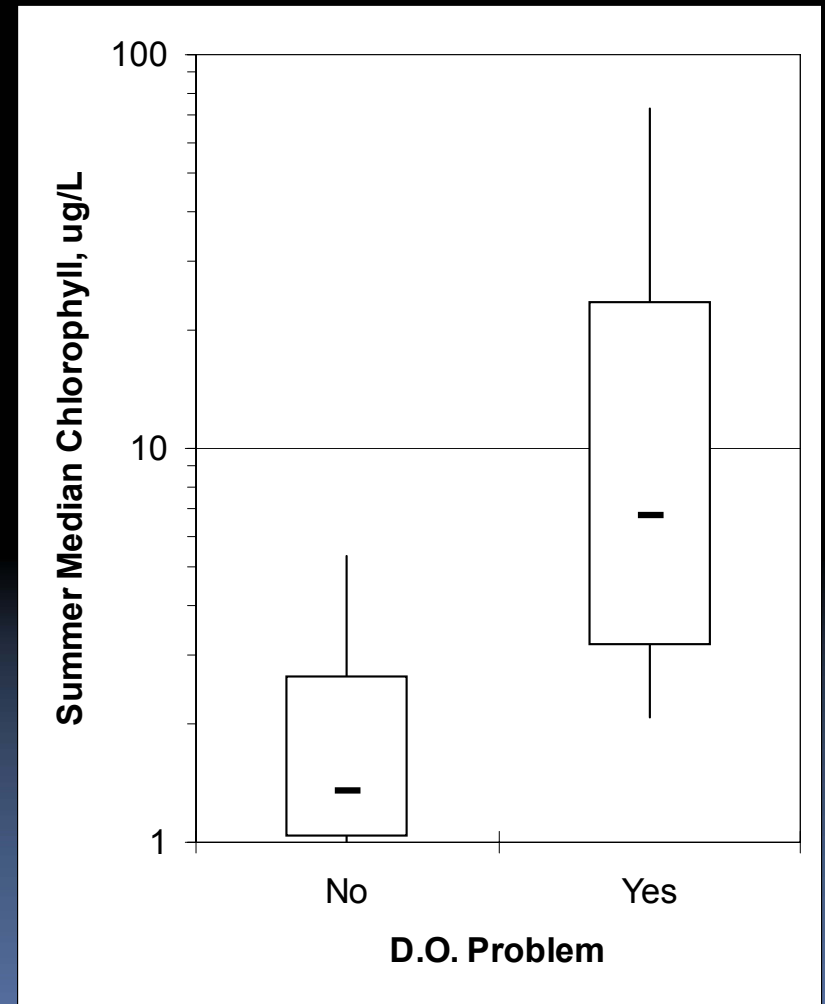
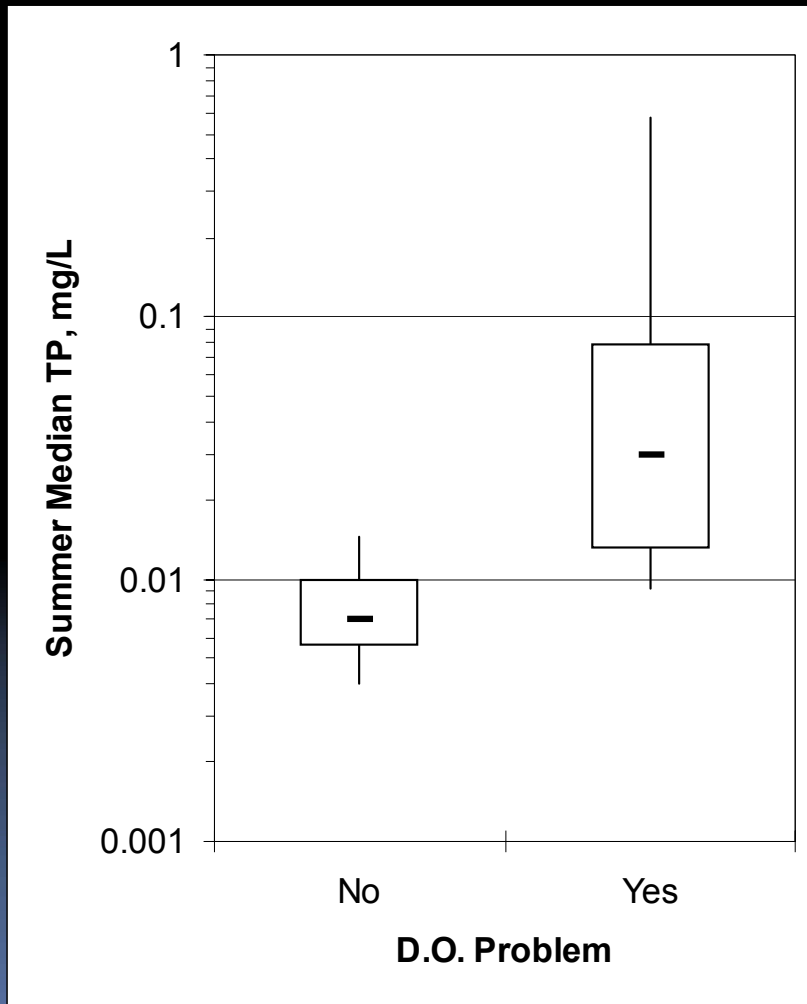
Chlorophyll and DO

- Higher chlorophyll – higher oxygen demand in hypolimnion of *stratified* lakes
- Review data from Colorado lakes
- Identify DO profiles where min DO < 2 mg/L
 - Not an aquatic life criterion!!
 - Threshold for redox
 - Precursor to major chemical changes (internal release of TP, metals)

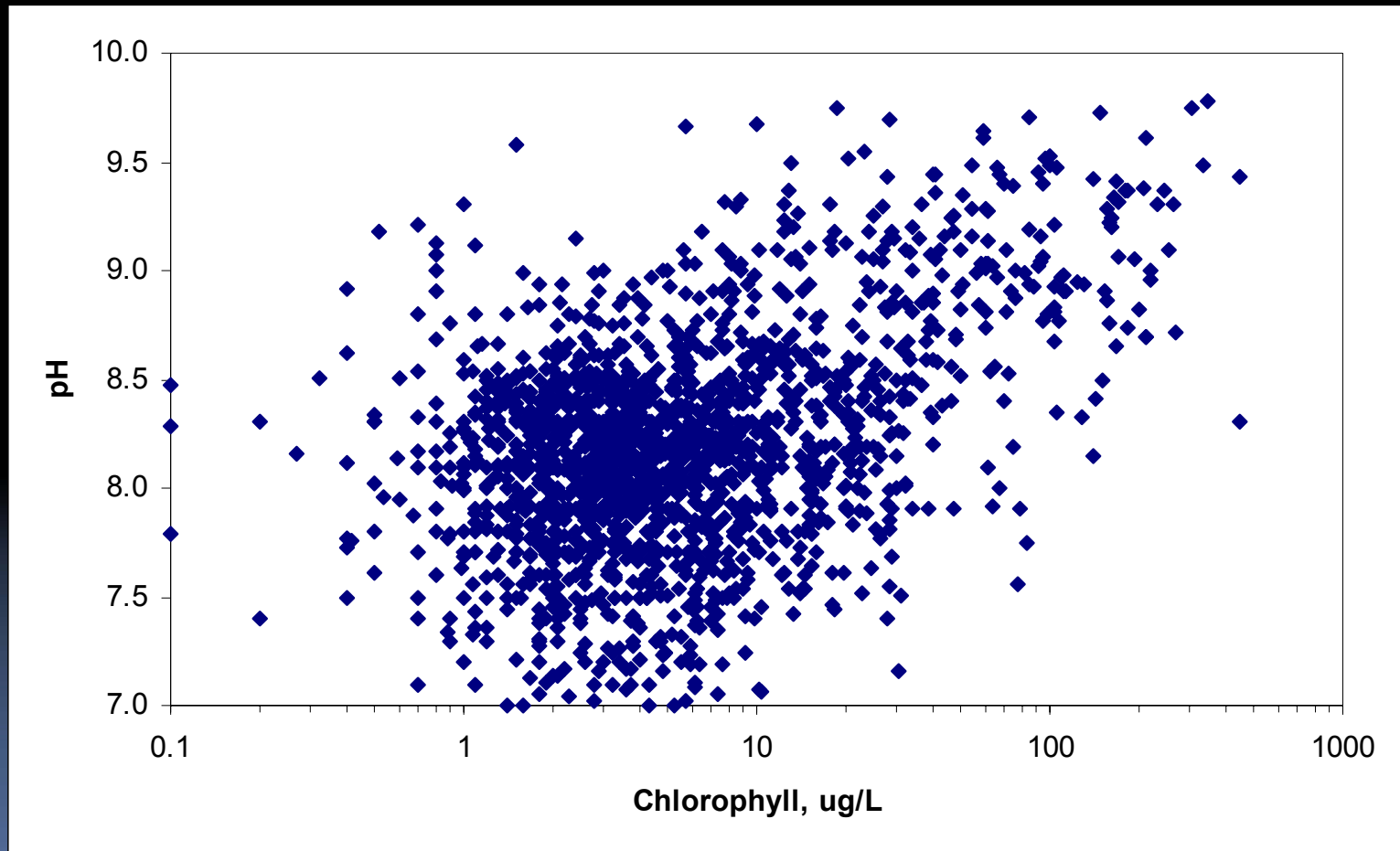
DO Problem likely if TP > 0.015 or chl > 6



D.O. Problem from another view

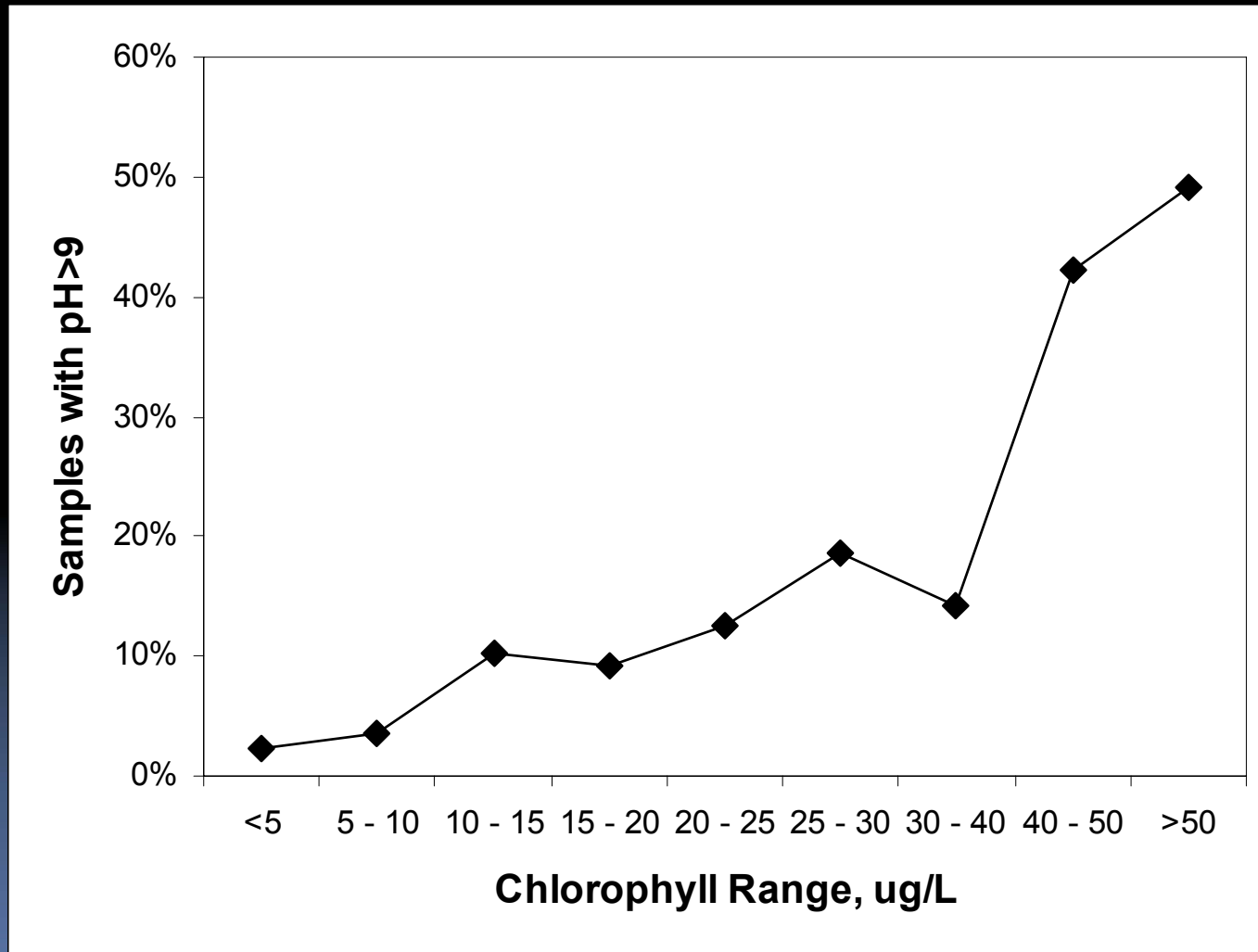


Linking pH and Chlorophyll



Grab samples, all lakes, all dates; N=2300

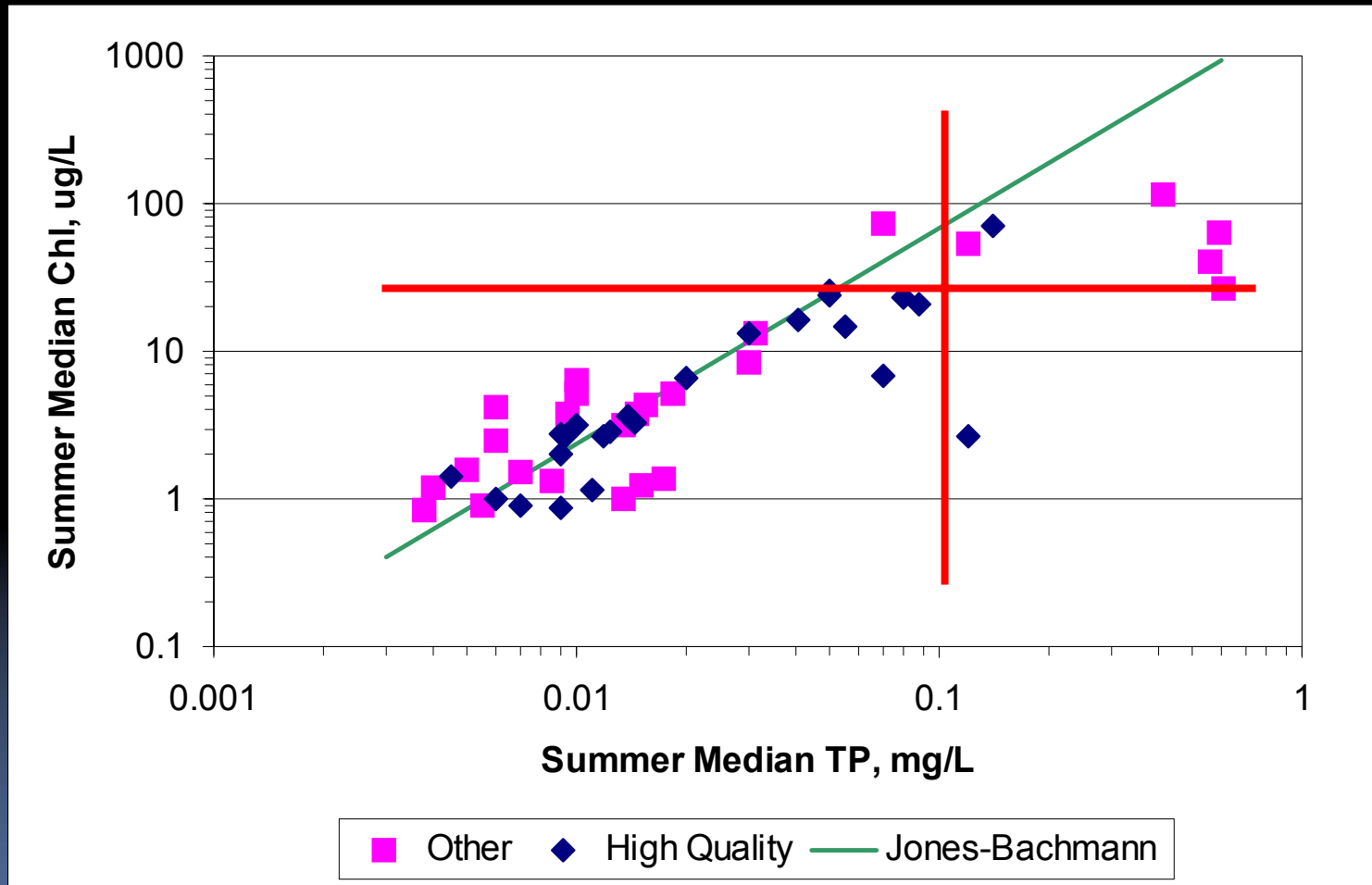
pH and Chlorophyll, simplified



Fishery Quality as Surrogate for Aquatic Life Protection

- Appealing idea to link to nutrients
 - VA has done this in their nutrient criteria
- Subjective fishery quality rating from CDOW
- Useful for detecting upper bound on TP and chl (would apply mainly to warmwater lakes)
- How does this compare to information from DO and pH evaluations?

Fishery Quality and Nutrient Criteria



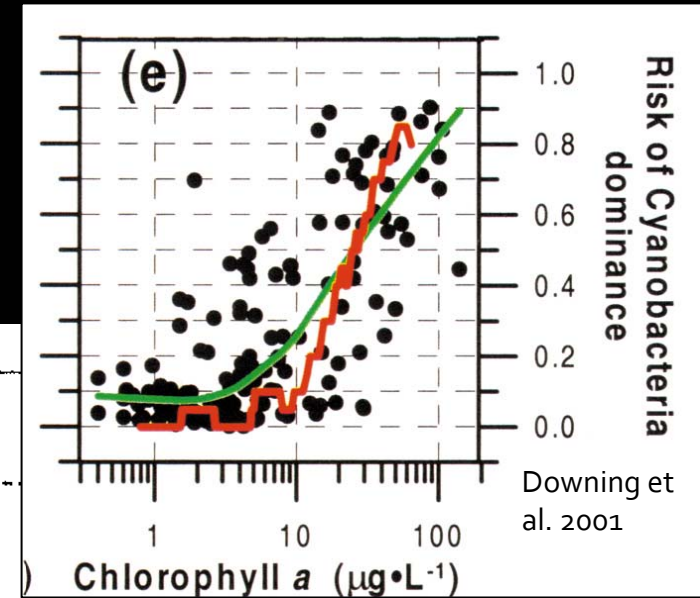
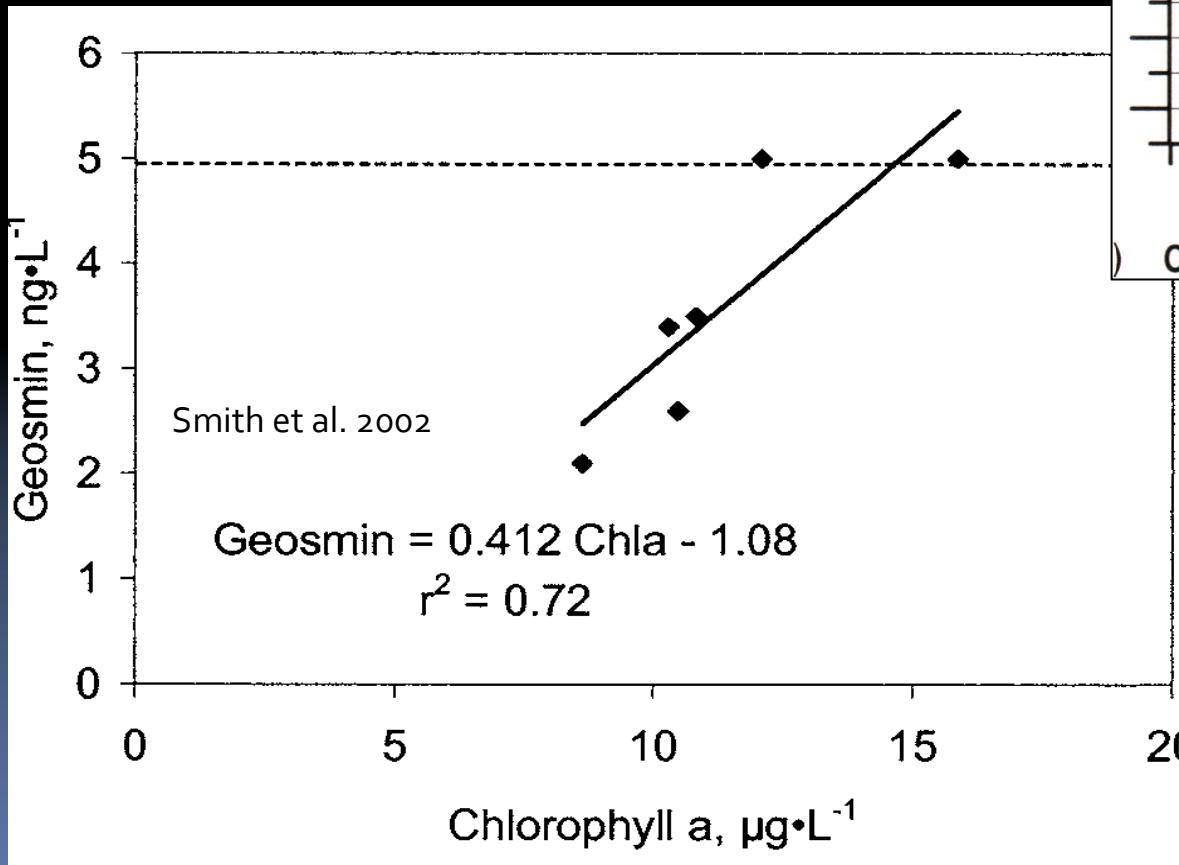
- High quality rare when $TP > 0.1$ or $chl > 25$

Water Supply Use Protection

- Excessive algal abundance associated with
 - TOC
 - DBP formation potential
 - Taste & odor
 - Cyanotoxins
 - Turbidity
 - DO demand

Oklahoma Sensitive Water Supply

- 10 µg/L
- Taste & odor
- Risk of blue-green dominance



Water Supply Protection

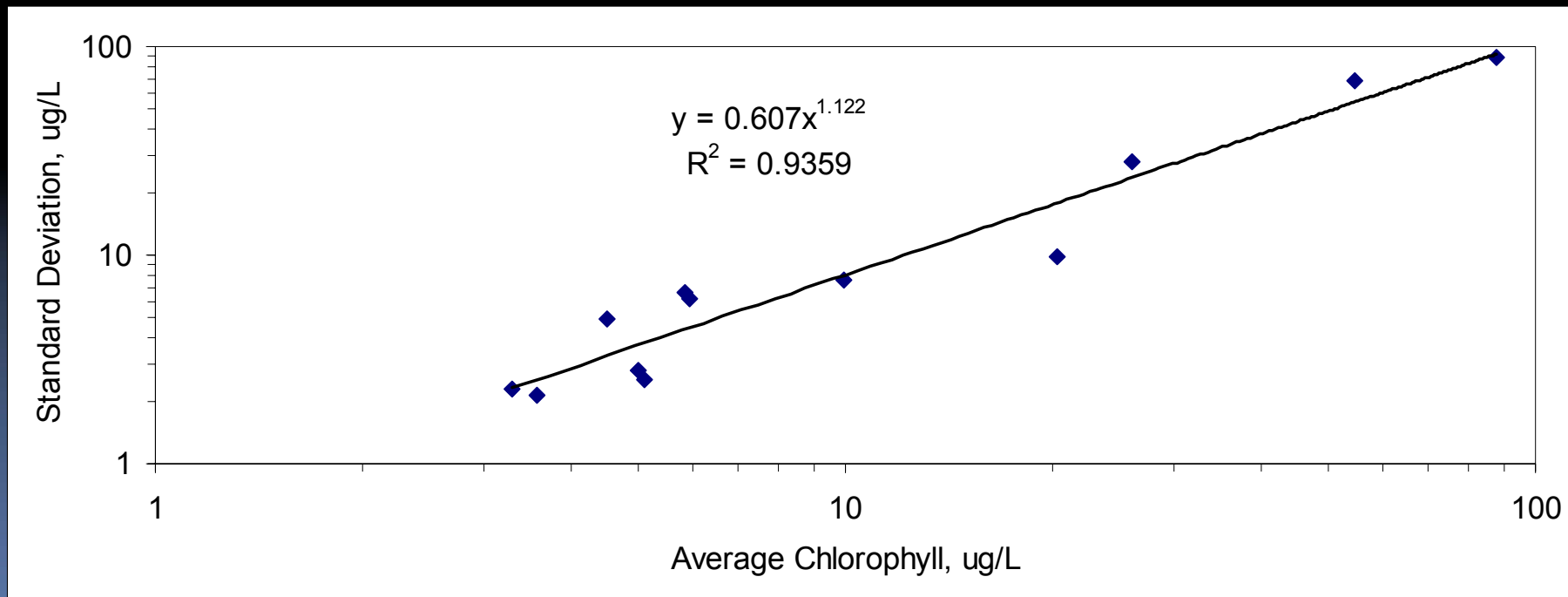
- Active stakeholders – water providers
- Pressing for site-specific protection
- Relying on NY studies by Dr. Callinan
- Aiming for:
 - Chl : ~5 ug/L
 - TP: 12-15
 - Secchi: 4-5m

Recreation Protection

- Threats – health risk from cyanotoxins; diminished recreational experience
- User perceptions don't help much
- Bloom thresholds
 - MN “nuisance” – 20 ug/L
 - MN “severe nuisance” – 30 ug/L
 - FL – 40 ug/L
 - TX – 27 ug/L based on user surveys
- NE beach closures – 40 ug/L (WHO cyanotoxin exposure risk)

Blooms and Averages

- Empirical relationship between growing season average and std deviation (lognormal distribution)...Walker's approach
- Distribution yields exceedance frequencies



Chlorophyll and Uses Overview

- <5 ug/L – direct use water supply
- <6 ug/L – preserve hypolimnetic DO
- 12-13 ug/L – Chatfield site-specific
- 20 ug/L – bloom threshold
- 25 ug/L – Cherry Creek site-specific
- <25 ug/L – high quality fisheries
- <30-40 ug/L – pH within bounds
- <50 ug/L – cyanotoxin risk

Existing Site-Specific Criteria

- 4 lakes have site-specific nutrient criteria developed during Clean Lakes studies in 1980s
 - 1 has narrative based on (improving) trophic state
 - 3 had phosphorus standards and chlorophyll goals
 - 1 now has chl standard and P goal
- Solid data base from these lakes is big help for statewide development
- 3 are under review

Learning from Reviews...

- General acceptance of chlorophyll as primary basis for nutrient criteria
- Natural variability in chlorophyll-phosphorus relationship makes P control a hard sell; considerable resistance from dischargers
- Commission concerned about attainment determination for non-toxic constituent
 - Summer chl is quite variable; uncertainty in avg
 - How can we guard against false exceedance?



Plans

- Goal is adoption of criteria in June 2010
- A few more stakeholder meetings
- Expansion of lake data base
- Refinement of linkages between criteria and use protection (includes cooperative effort with fisheries group at CDOW)
- Preparation of proposal by December 2009