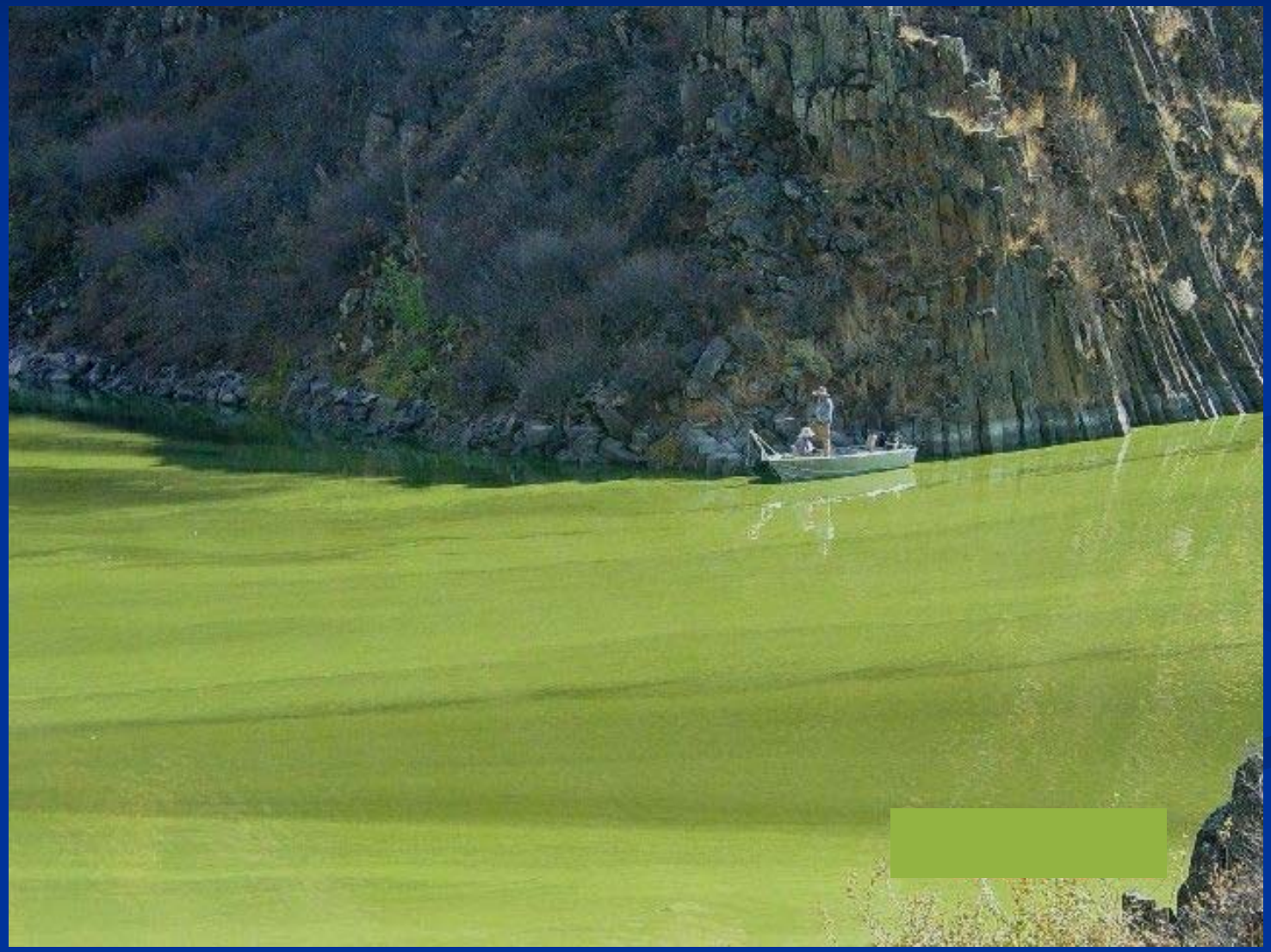
Water Quality Criteria:
Nitrogen & Phosphorus Pollution



Presentation Outline

- I. Key “Take Home” Messages
- II. History of the Nutrient Criteria Program
- III. Approaches for Nutrient Criteria Development
- IV. CA Nutrient Numeric Endpoint Framework
- V. CA NNE Regulatory Status
- VI. Klamath River NNE Case Study
- VII. Stream and Wetlands Policy – Protecting Physical Integrity

Key Take Home Messages

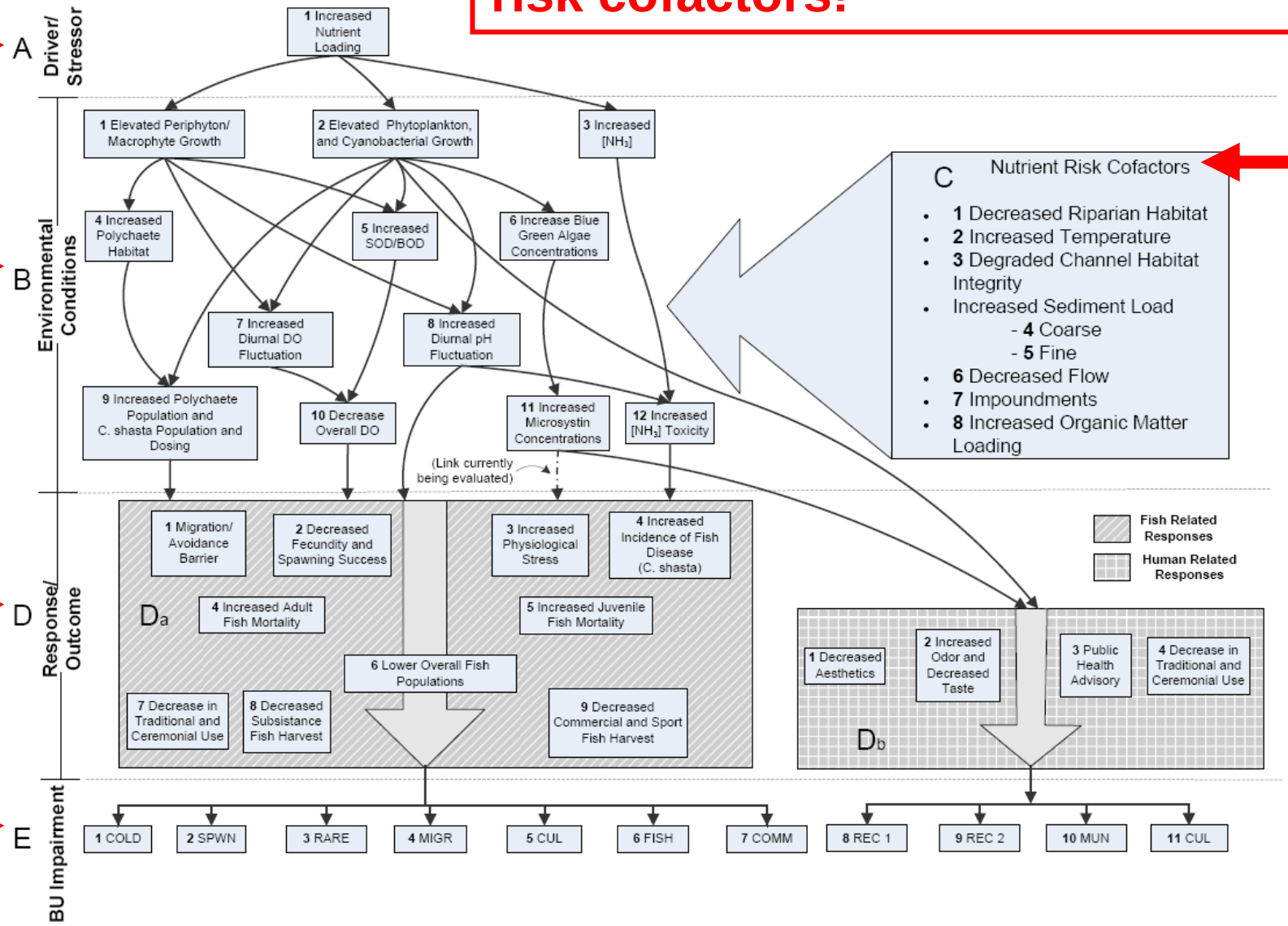
- Nutrient related impairments are pervasive;
- Numeric Nutrient Criteria provide quantifiable targets for incorporation into NPDES Permits and TMDLs;
- Nutrients are not inherently toxic, therefore are “unique” as pollutants, and require a unique approach;

Key Messages

- Nutrients, which are necessary for aquatic life, generally don't cause impairment, it's the secondary impacts (e.g., low DO) that cause concern.
- "Excess" concentrations of nutrients vary by waterbody type, climate, geologic areas, and other local risk cofactors (e.g., degraded riparian).
- Therefore, Nutrient Criteria cannot be developed as a single number for the Nation due to variability in background conditions and the role of other risk co-factors which affect nutrient processing within ecosystems.

Key Messages

Nutrients have a complex and nonlinear relationship to Beneficial Uses that is influenced by other risk cofactors!



Key Messages

- **Nutrient related impacts are many and varied:**
  - Algal blooms (scum);
  - Low dissolved oxygen;
  - Extreme pH conditions;
  - Fish disease & fish kills;
  - “Weeds” affecting boating and swimming;
  - Taste/odor; and
  - Additional relationships include: pathogens (e.g. microcystin), methyl mercury, arsenate, and trihalomethanes.

History of Nutrient Criteria

- Nutrients (Nitrogen and Phosphorus) were consistently one of the top pollutants on the CWA Section 303(D) Lists to Congress Reports beginning in the early 1990's.
- The "Nutrient Criteria Program" was initiated in 1995.
- 1998 – The "National Strategy for the Development of Nutrient Criteria" identified need for numeric targets to measure effectiveness of watershed management programs

Initial EPA Nutrient Mission

- Principal Goal: Develop Nutrient Criteria across the nation in 3 years.
- Criteria needed to address nutrient pollution, not natural enrichment.
- Primary Parameters: Total P, Total N, Chlorophyll-a and some measure of water clarity (e.g., Secchi disk depth, turbidity)
- Types: Numeric criteria, or narrative with numeric translator

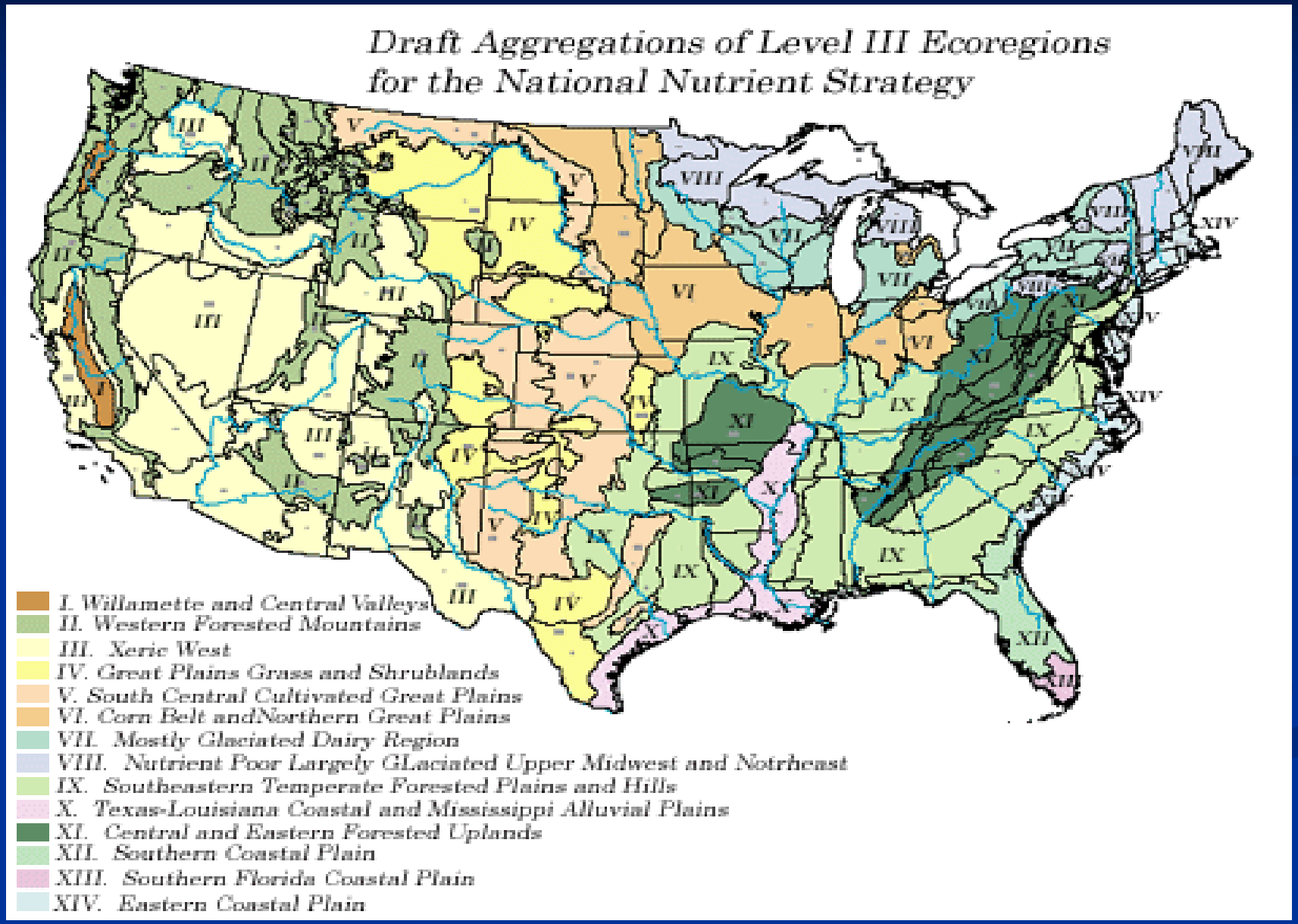
Primary Concepts

- Tailor criteria by nutrient ecoregion and waterbody type
- Identify minimally impacted conditions (reference)
- Address causal and response variables
- Utilize local expertise, as in Regional Technical Advisory Groups (RTAGs), or other locally available experts

Initial Approach

- EPA drew upon the experience of the already successful Biocriteria Program, and used their ecoregional, frequency distribution approach – which was evaluated as “scientifically defensible” by EPA’s Science Advisory Board
- EPA calculated “estimated reference conditions” using a frequency distribution of ecoregional data – and recommended they be used as starting points for states to develop their own criteria, using this, or other scientifically defensible methods.

Ecoregional Classification



CA Level IV Ecoregions

01 Coast Range

04 Cascades

05 Sierra Nevada

06 Southern & Central CA Chaparral & Oak Woodlands

07 Central CA Valley

08 So. CA Mountains

09 Eastern Cascades Slopes & Foothills

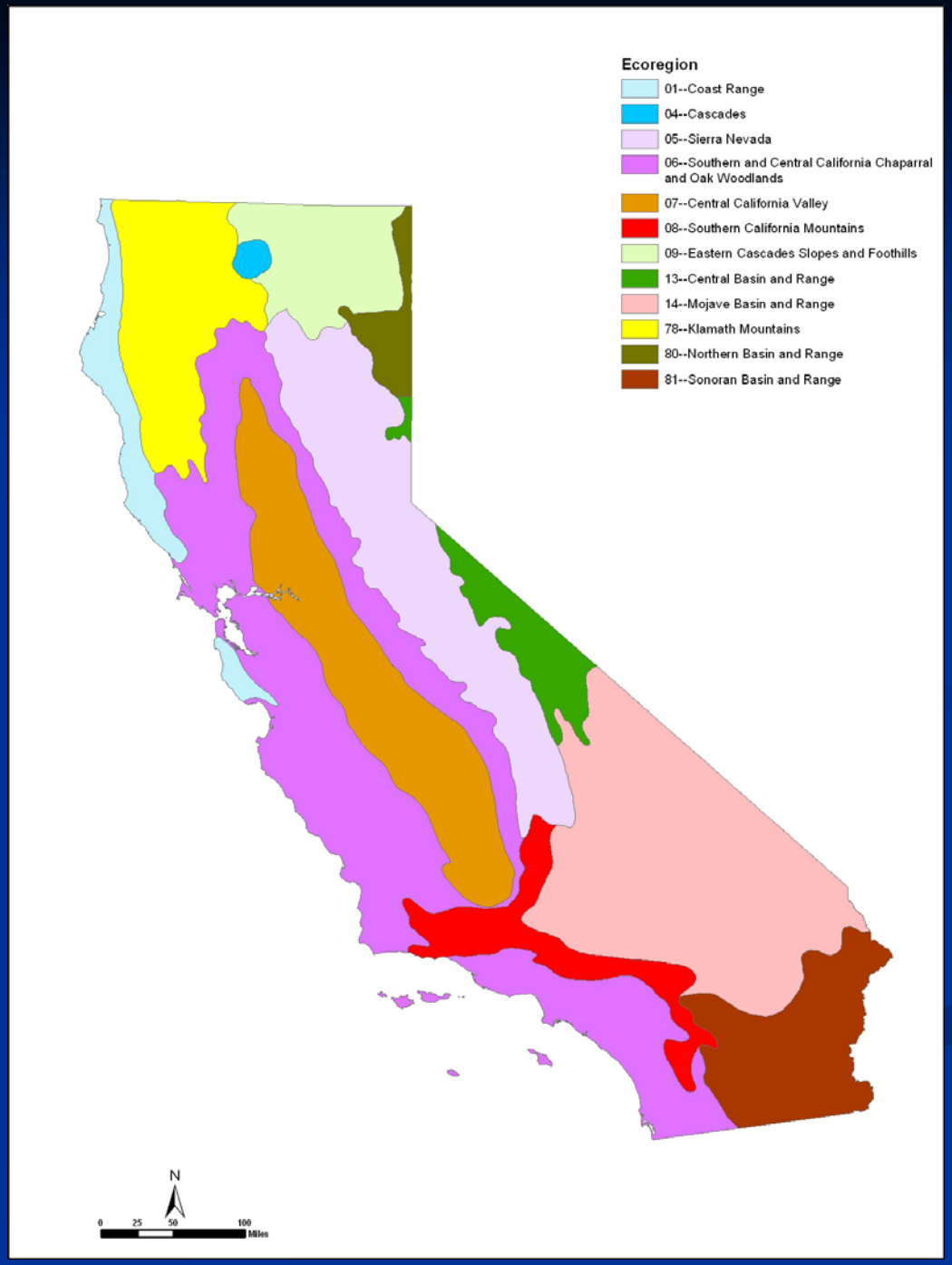
13 Central Basin & Range

14 Mojave Basin & Range

78 Klamath Mountains

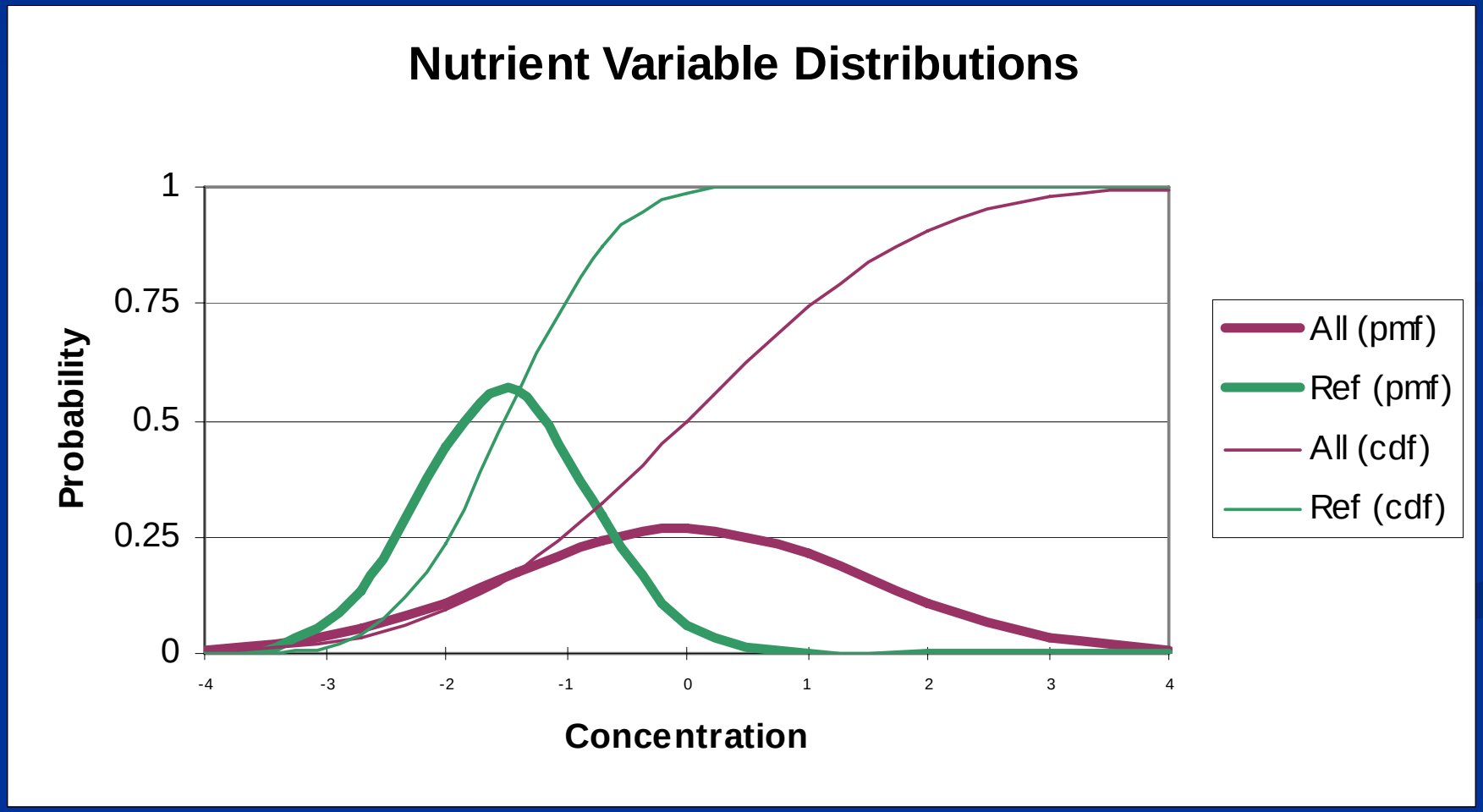
80 Northern Basin & Range

81 Sonoran Basin & Range



Distributional Approach

The 25th or 75th percentiles were an estimate of reference conditions – protective of all uses.



Distribution Approach Critique

- This approach automatically delineates 75% of your waterbodies as impaired;
- Many also argued that it was not directly linked to the protection of designated uses, and was therefore potentially over-protective;
- Some argued that this approach would generate criteria that harm designated uses, such as recreational or commercial fishing.

Shift in Policy

- EPA Responded in 2001 with a policy of "flexibility", encouraging states to use different approaches.
- Many states adopted a "stressor-response" approach, where they began extensive field studies to identify the algal (diatom and periphyton) responses to N and P. Some states also began looking for responses in macroinvertebrates (or stream insects).
- EPA has established a technical support center (N-STEPS) to assist states with the extensive technical challenges involved in these stressor-response approaches.

Range of Technical Approaches

- **Stressor Response Approach:**
  - **Biomonitoring: algae, macroinvertebrates, and fish;**
  - **Statistical analysis, indices, regression analysis, etc.;**
  - **Dynamic Models;**
  - **Scientific Literature; and**
  - **Multiple Lines of Evidence – Weight of Evidence**

CA Nutrient Numeric Endpoints

- Regional Technical Advisory Group initiated in 1999 to collaboratively develop nutrient criteria – all Regional Boards participated
- Studies undertaken to evaluate alternative options
- Existing approach adopted by Regional Boards and other participating agencies -- still under development but basic framework is in place.

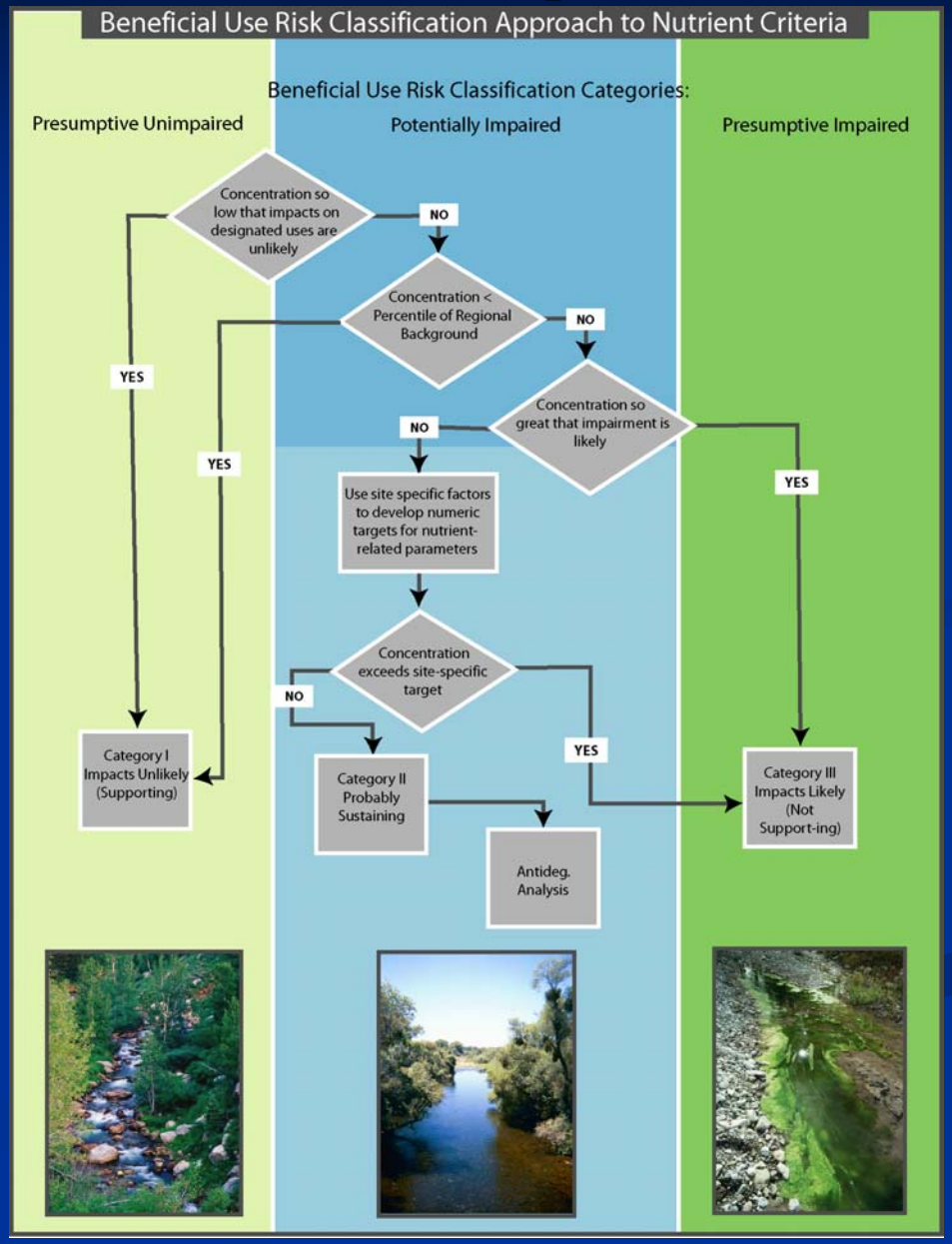
CA Nutrient Numeric Endpoints

Decision framework includes:

- Risk Based Approach: targets for response variables / secondary indicators – benthic algal biomass, DO, pH
- Beneficial Use Risk Categories: **(BURCs)** BURC 1 – Presumptive Unimpaired; BURC 2 – Potentially Impaired; BURC 3 – Presumptive Impaired
- Spreadsheet tools: convert response variable limits (secondary indicator targets) to initial site-specific nutrient concentration goals.

CA Nutrient Numeric Endpoints

- Category I: Presumptively Unimpaired
- Category II: Potentially Impaired
- Category III: Presumptively Impaired



Example 303(d) Screening BURC Boundaries

RESPONSE VARIABLE	BURC BOUNDARY	BENEFICIAL USE						
		COLD	WARM	REC-1	REC-2	MUN	SPWN	MIGR
Benthic Algal Biomass in streams (mg chl-*a*/m^2) Maximum	I / II	100	150	C	C	100	100	B
	II / III	150	200	C	C	150	150	B
Planktonic Algal Biomass in Lakes and Reservoirs (as µg/L Chl-*a*) summer mean	I / II	5	10	10	10	5	A	B
	II / III	10	25	20	25	10	A	B

A = No direct linkage

B= More research needed to quantify linkage

C= Addressed by existing Aquatic Life Criteria

CA Nutrient Numeric Endpoints
Regulatory Status

- **Estuarine Framework in Development**
- **Possible adoption options:**
  - **Narrative Nutrient Objectives with Nutrient Numeric Endpoint Framework adopted as implementation option.**
  - **Narrative Nutrient Objectives with default Beneficial Use Risk Category Boundaries and NNE Framework as implementation option.**
  - **Other?**

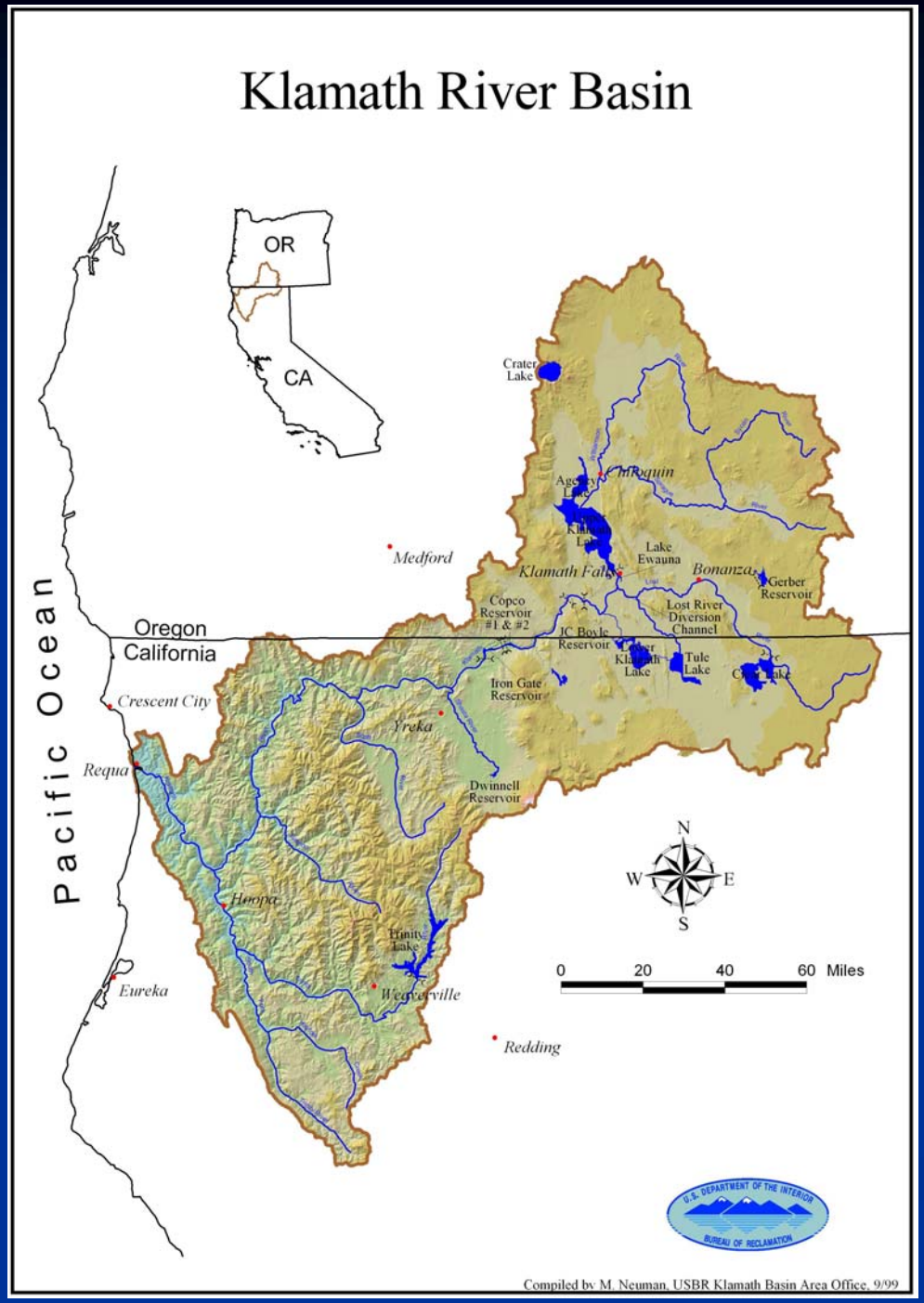
CA Nutrient Numeric Endpoints
Next Steps

- Peer Review of five case studies
- Several TMDLs are being developed using the CA NNE
- Biomonitoring capabilities are being developed to expand lines of evidence
- Develop regional ranges for Beneficial Use Risk Categories
- Get EPA to check the Yes column!

Klamath River NNE Case Study

Upper Klamath Lake
Hanks Marsh

Klamath River
Entering Pacific Ocean



Klamath CA NNE Case Study

- Basin: 12,680 sqr. Miles
- River ~250 miles
- Five dams
- Population 114,000
- 2/3 Federal land ownership
- Several Federally recognized Tribes
- TMDL listed tributaries

Klamath River Impairments

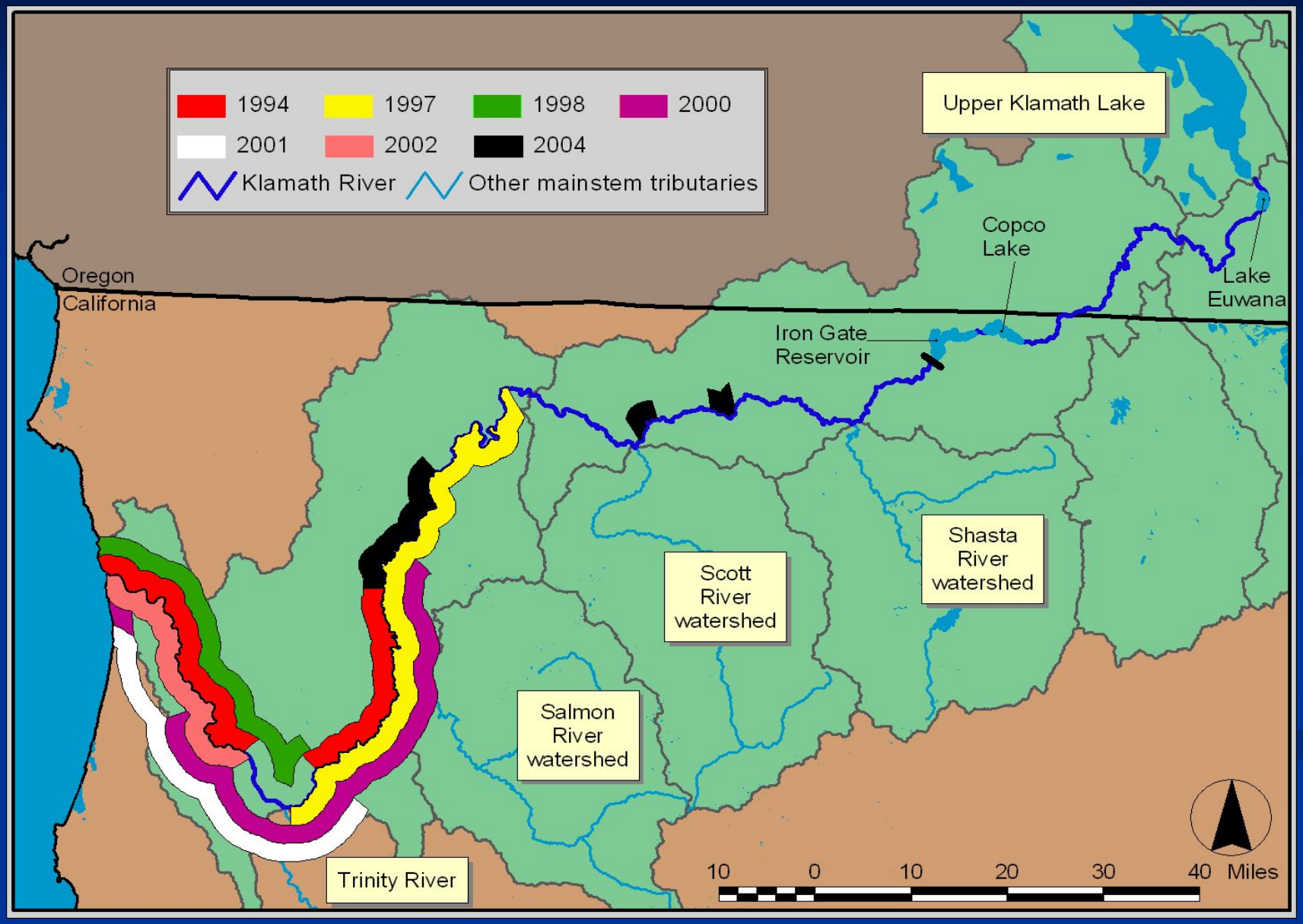
California

- DO
- Temperature
- Nutrients
- Sediment *

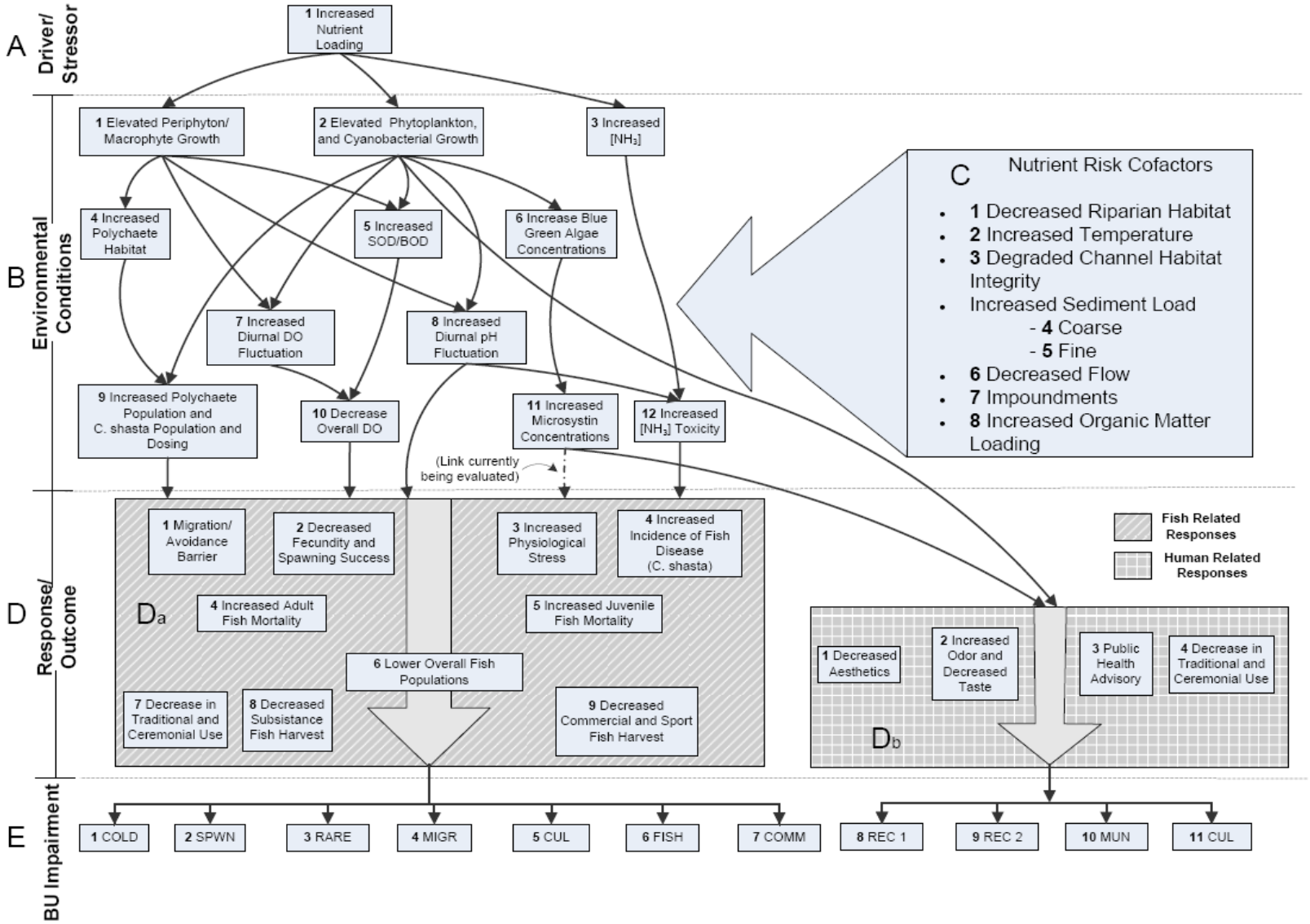
Oregon

- DO
- Chlorophyll a
- Temperature
- pH
- Ammonia

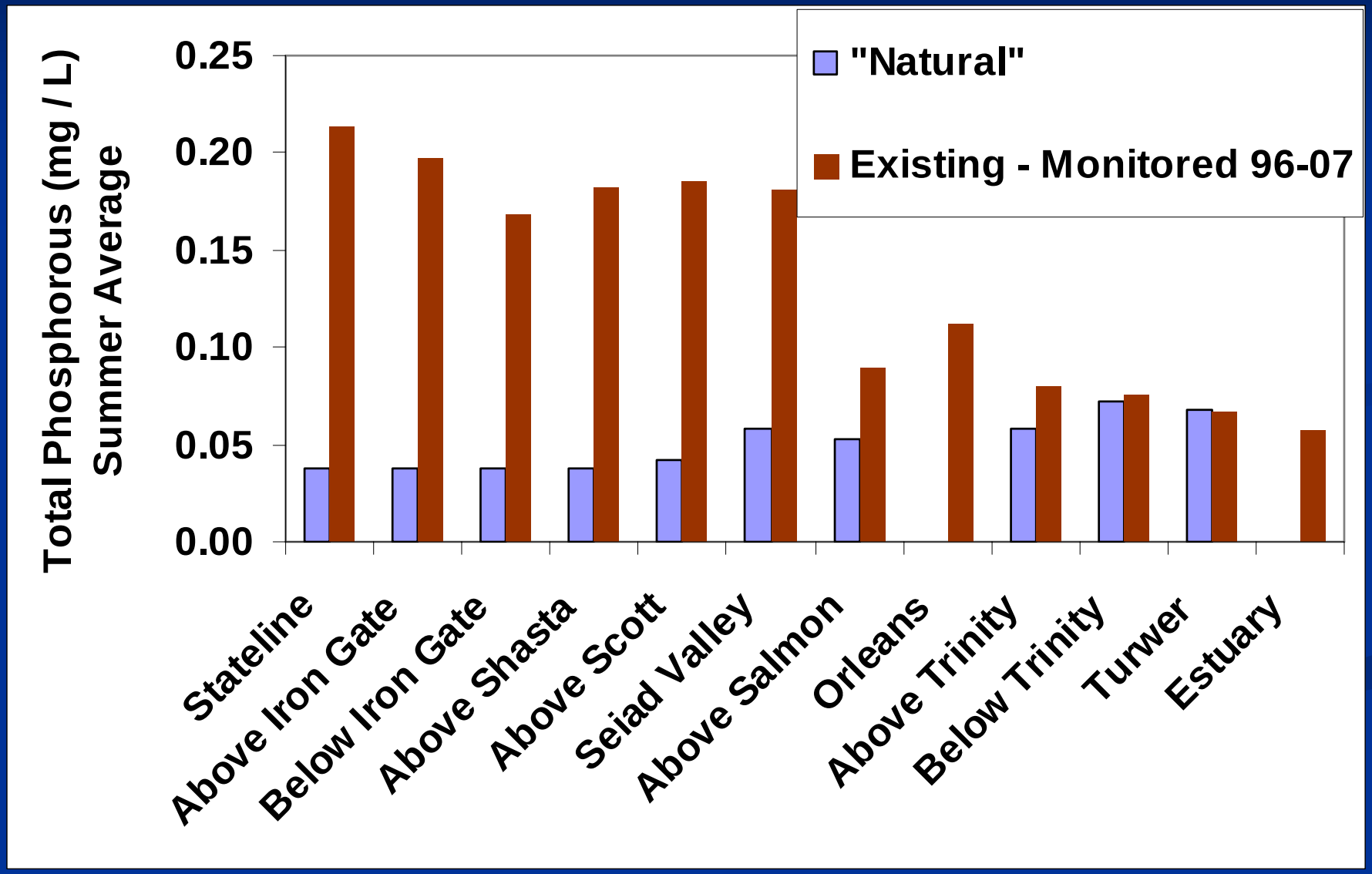
Klamath River Fish Kills



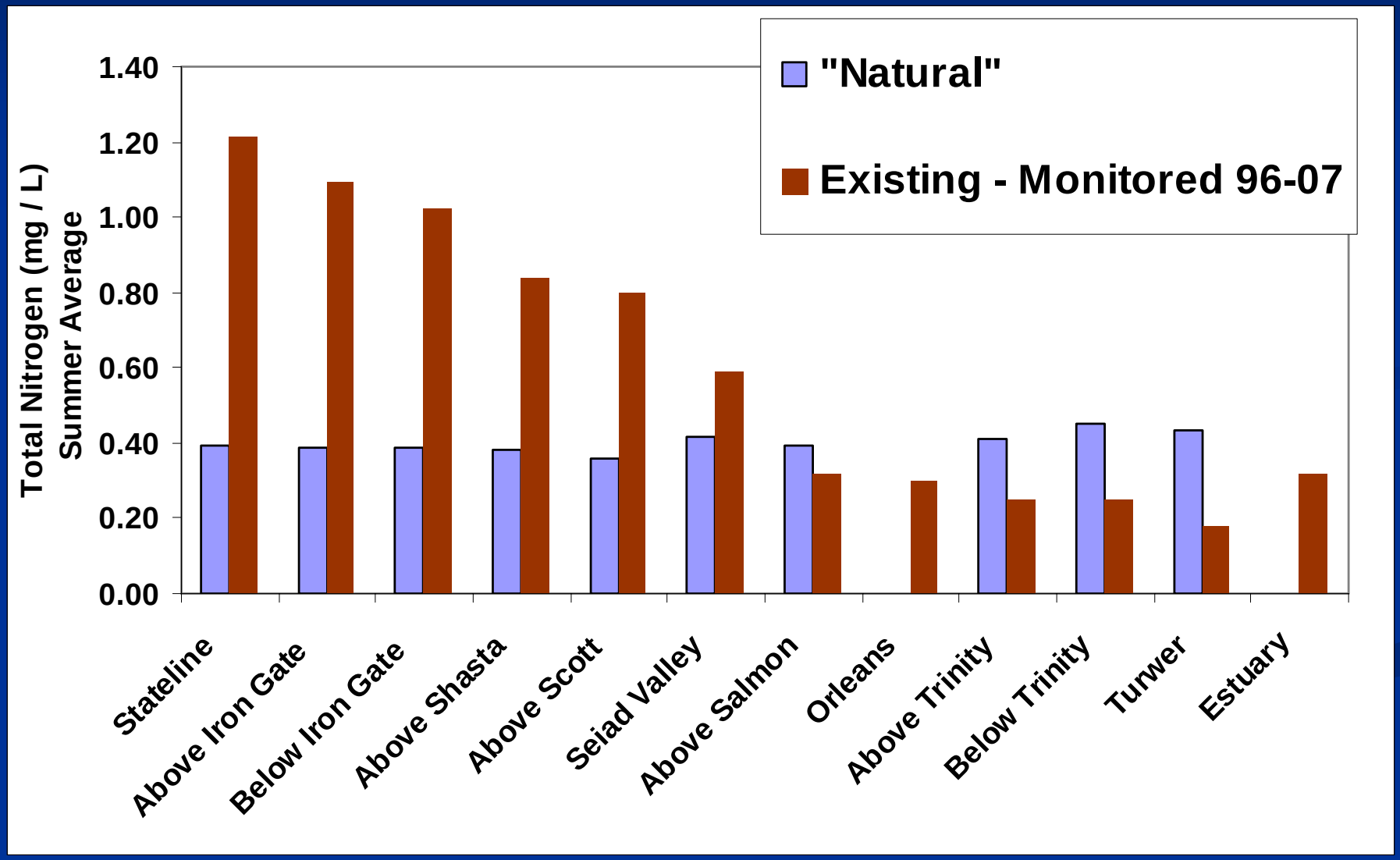
Klamath River – NNE Conceptual Model



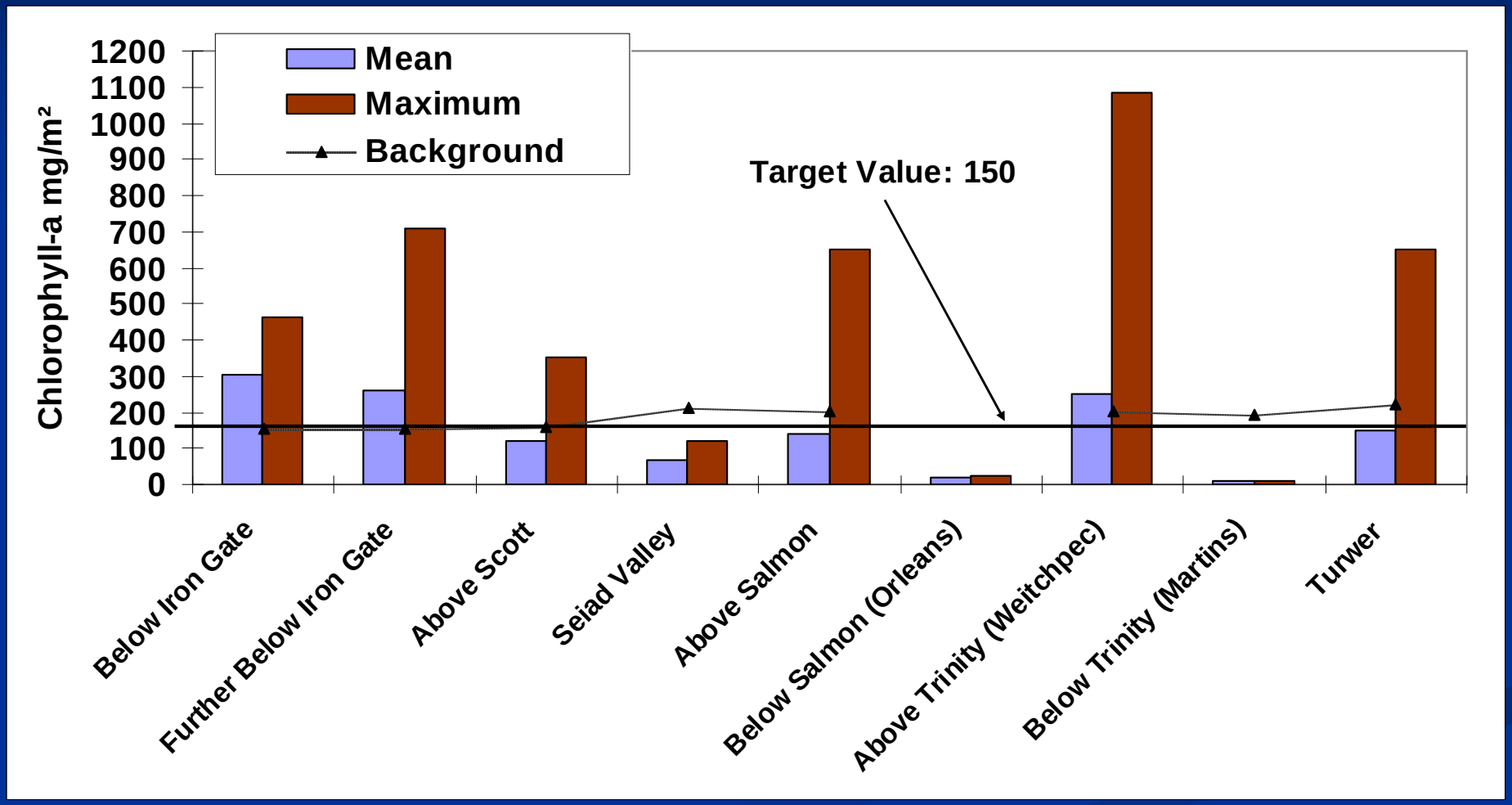
Klamath River – Nutrients



Klamath River - Nutrients

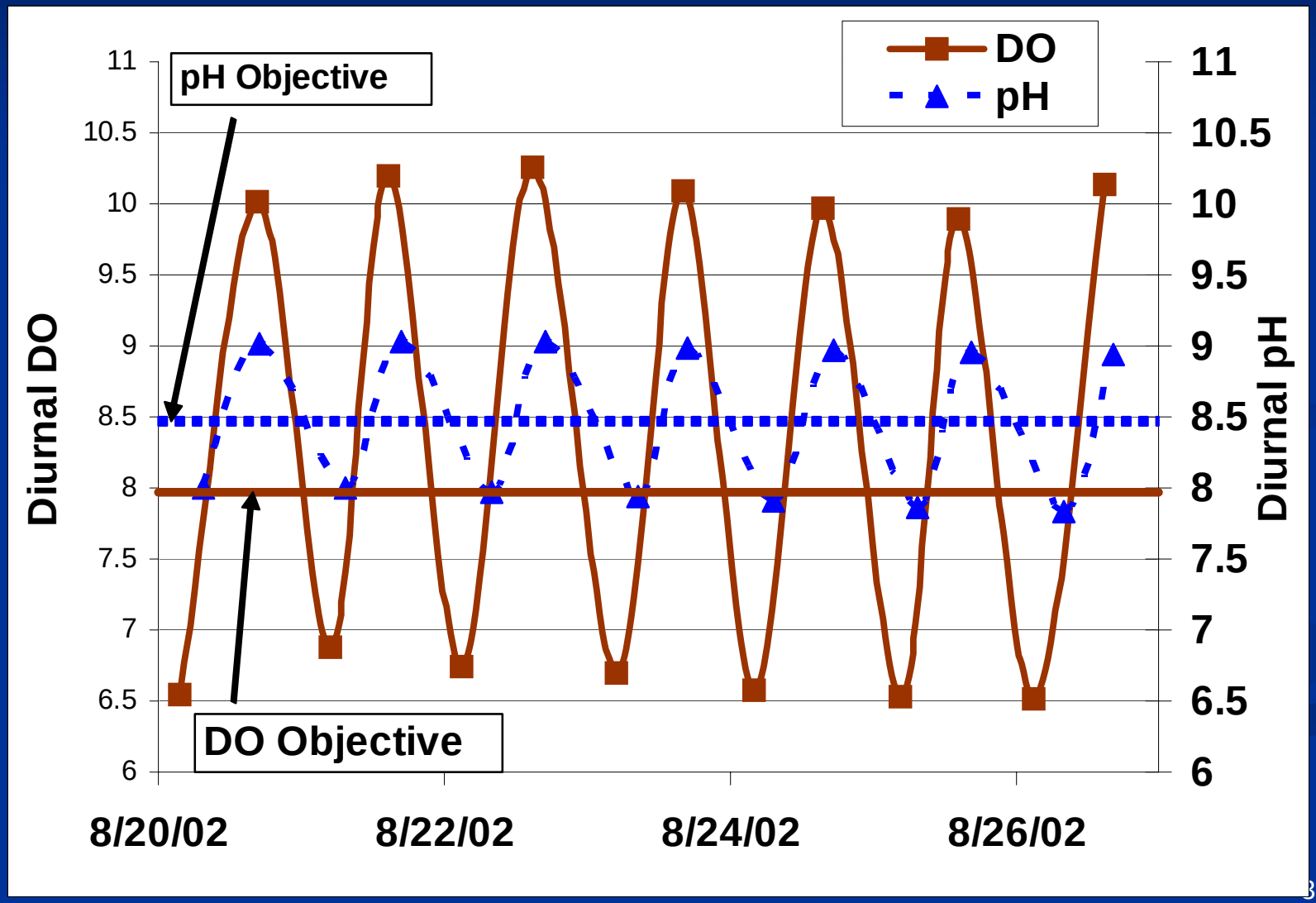


Klamath River - Periphyton



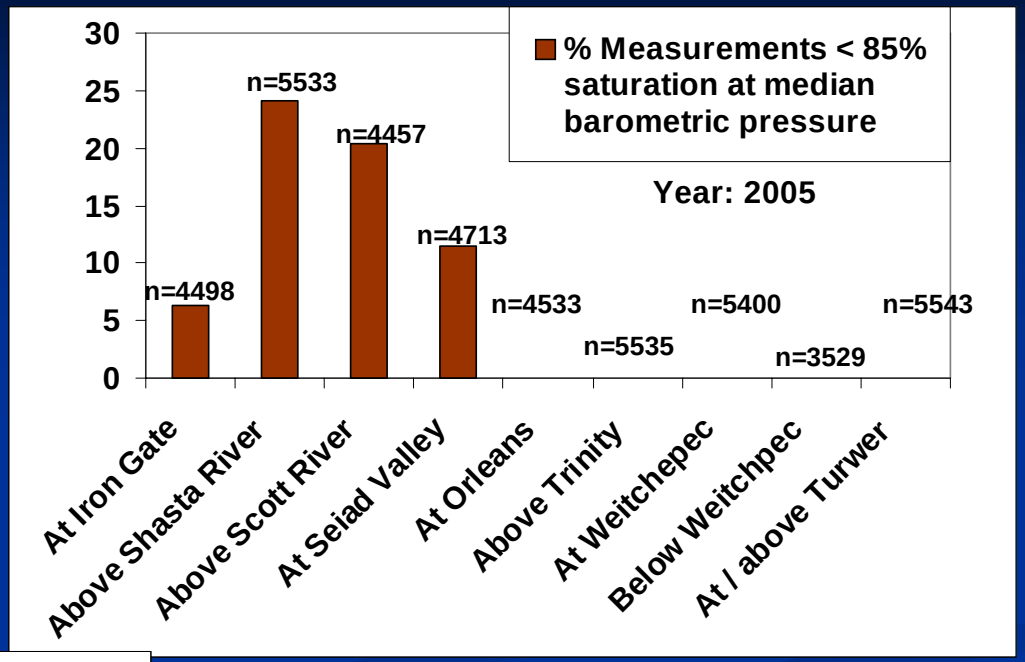
Klamath River – Diurnal DO & pH

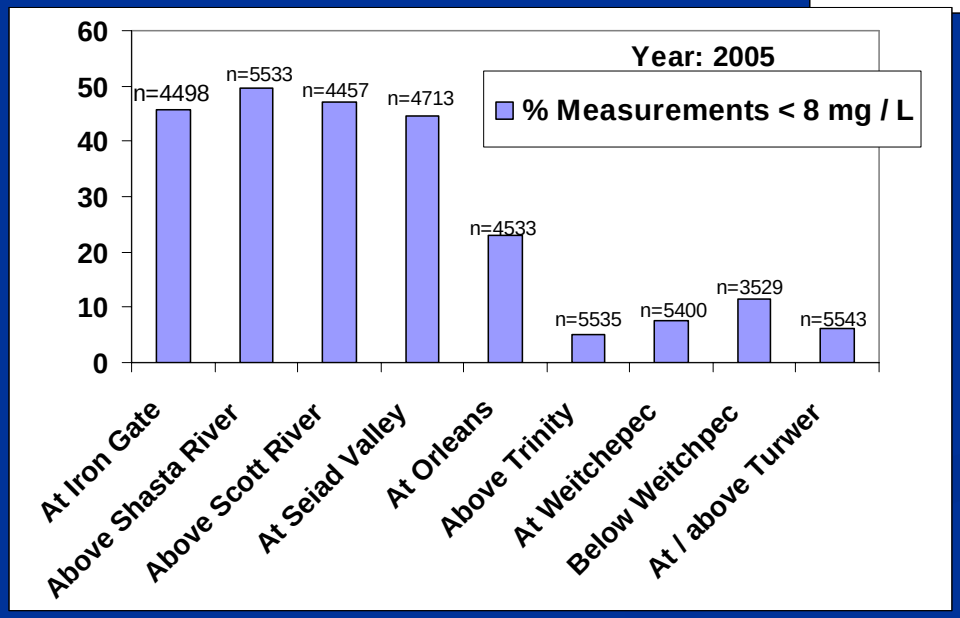
Seiad Valley – Typical Summer Diurnal Pattern



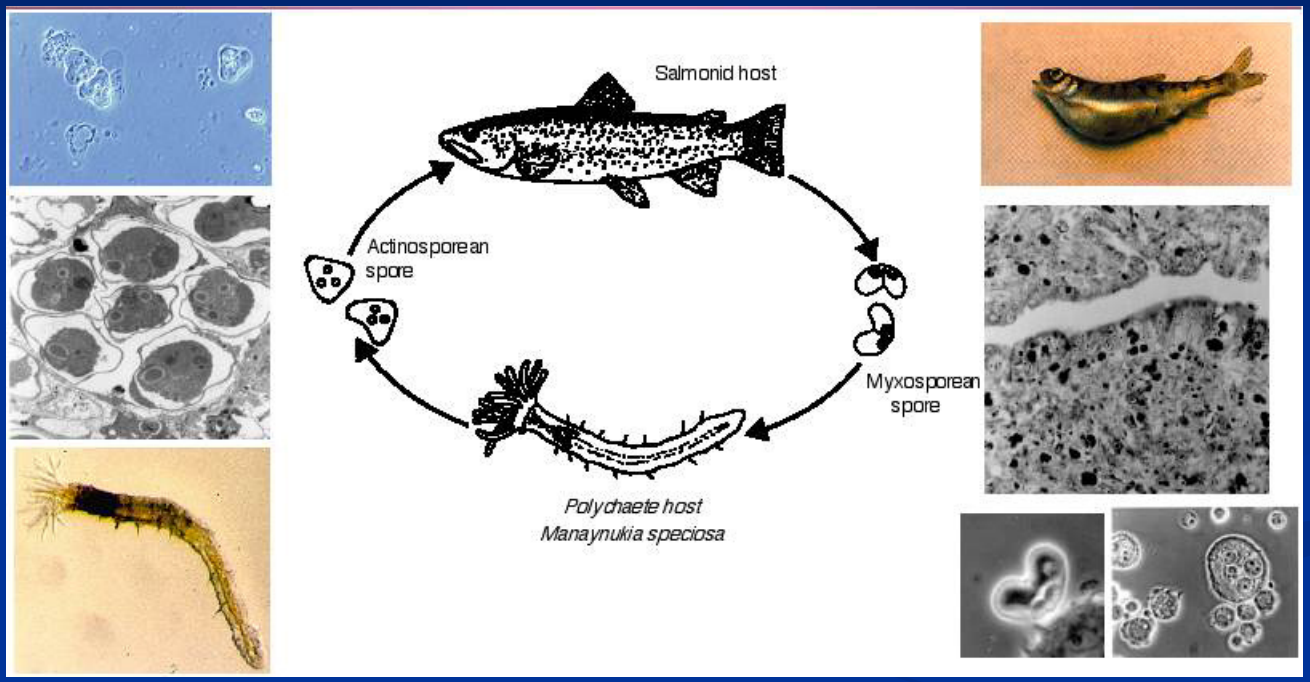
Klamath River - DO

Frequent violation of both existing and proposed DO Water Quality Objectives during summer months.





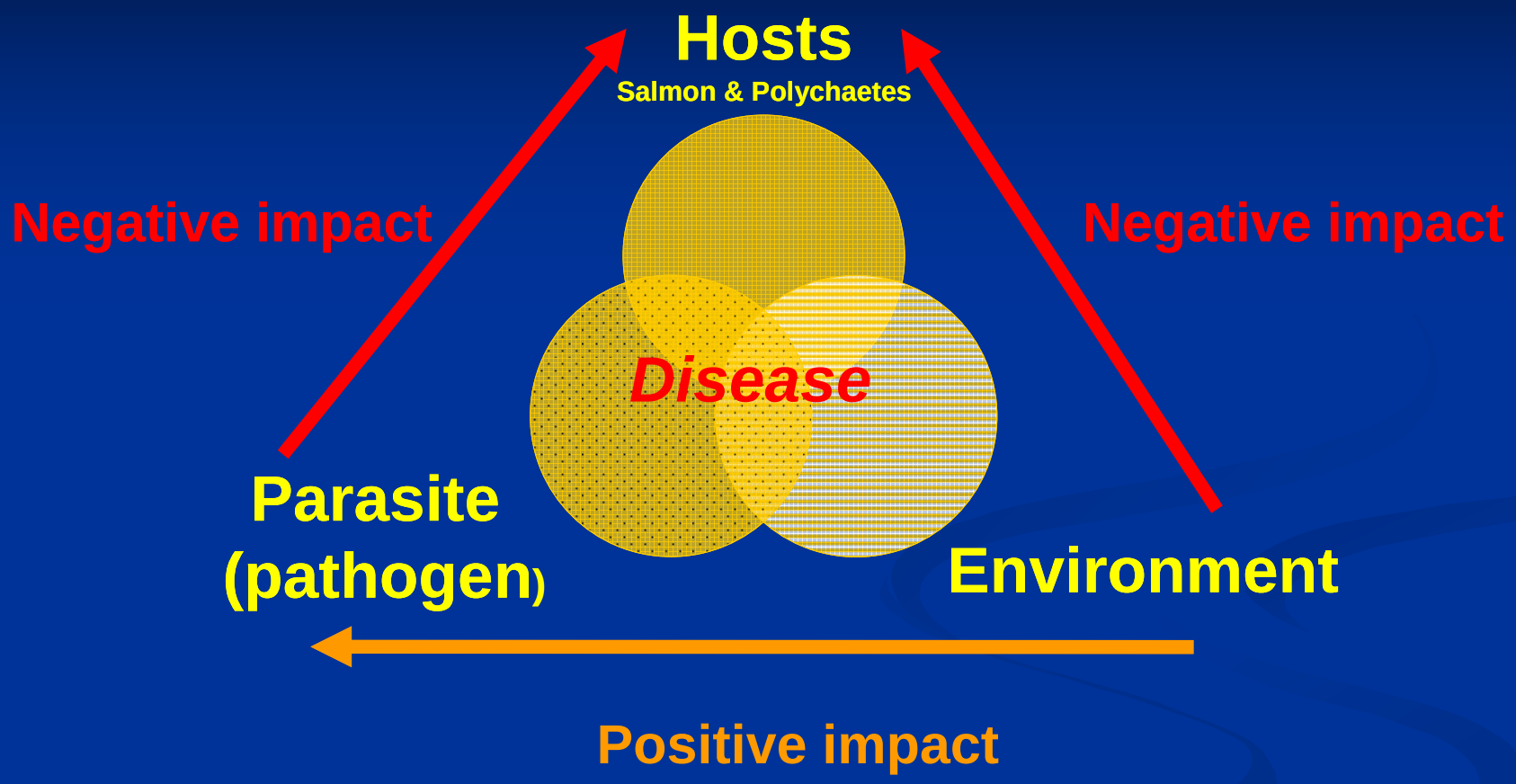
Klamath River – Fish disease



Life cycle of the parasite Ceratomyxa shasta:

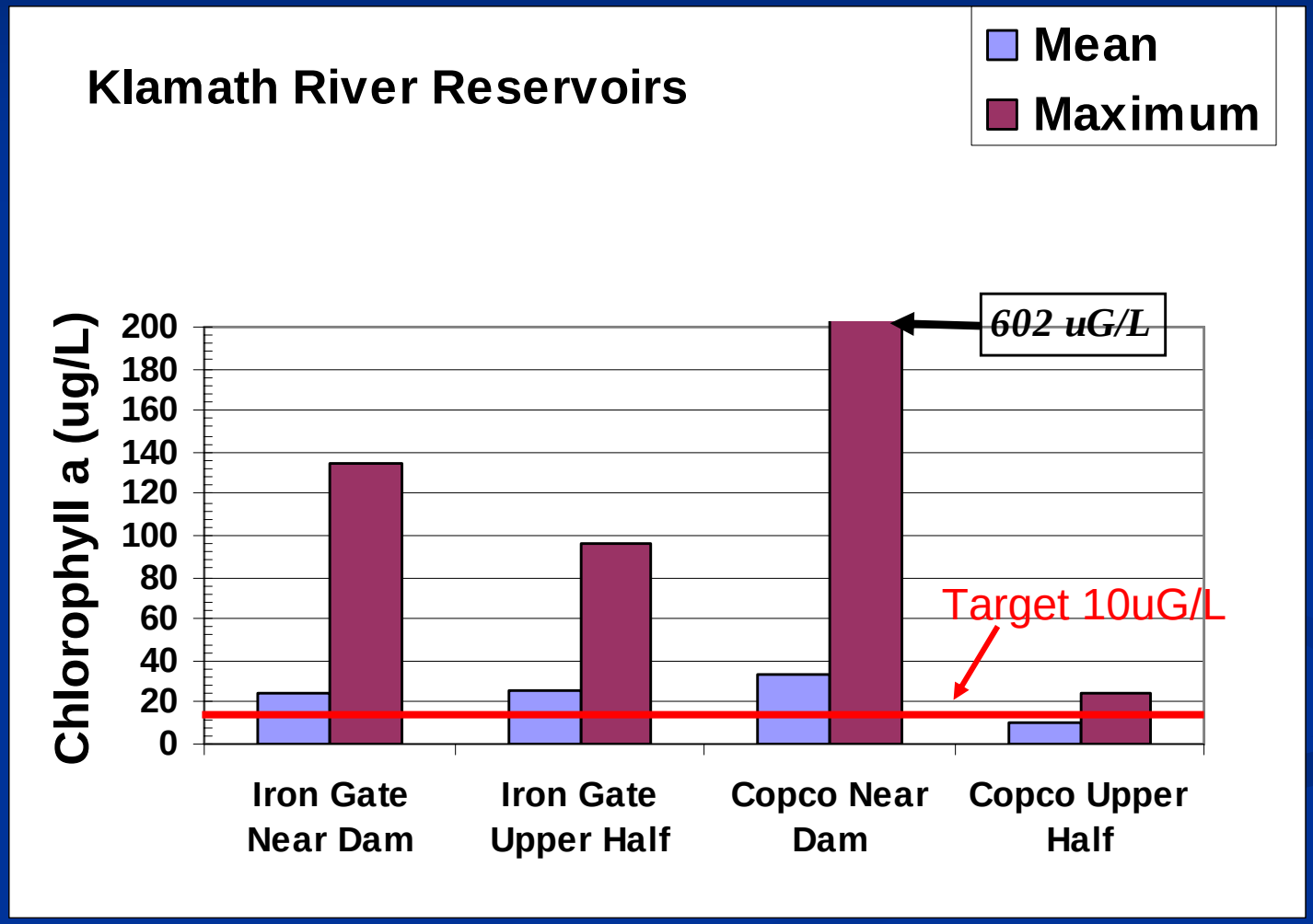
- **The parasite is the primary fish health issue in the Klamath River according to USFWS**

Klamath River – Fish disease

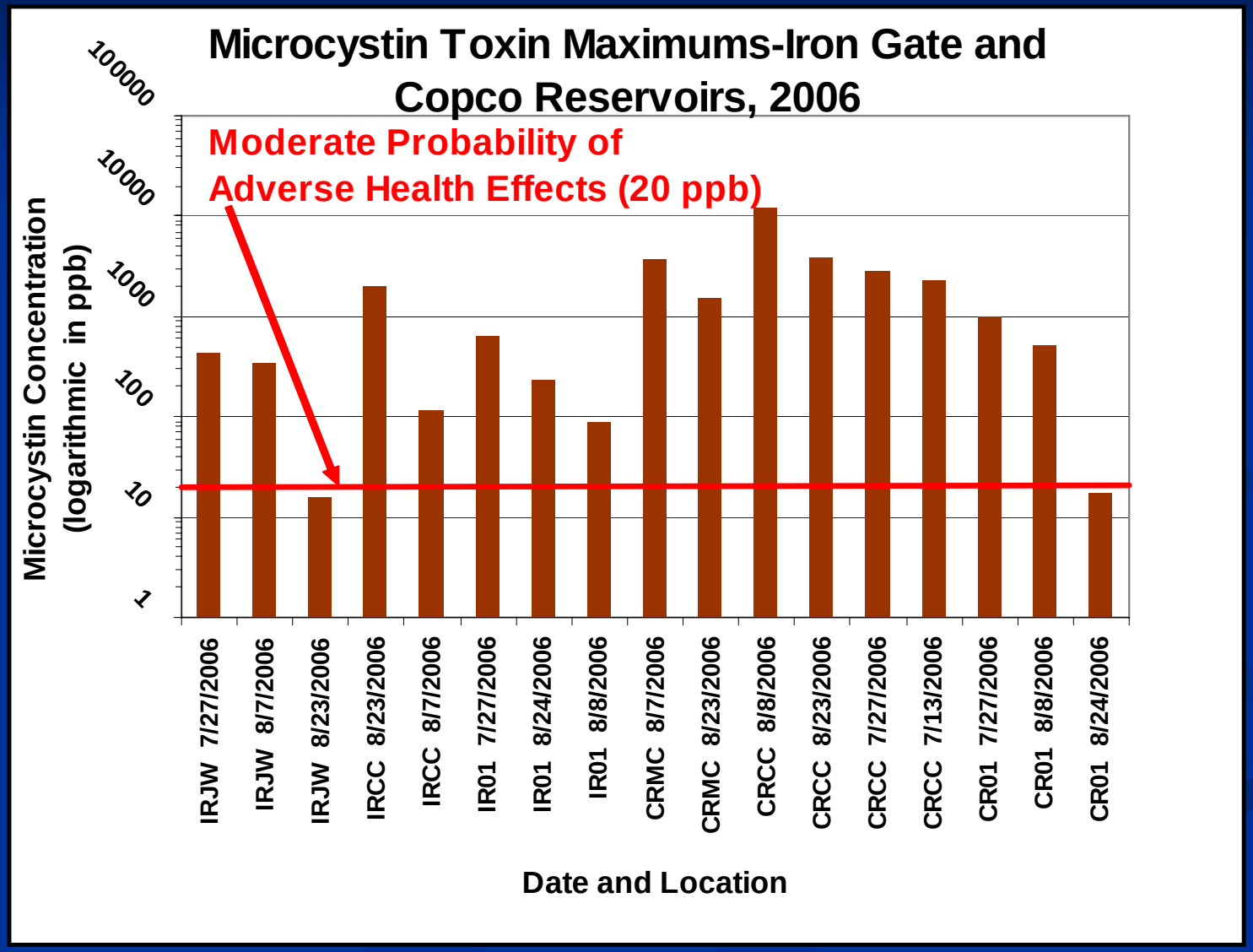


Severity of *Ceratomyxosis* in Klamath River suggests a shift in the host: parasite balance towards *C. shasta*

Klamath River (reservoirs) Chlorophyll a



Klamath River – Blue-green algae



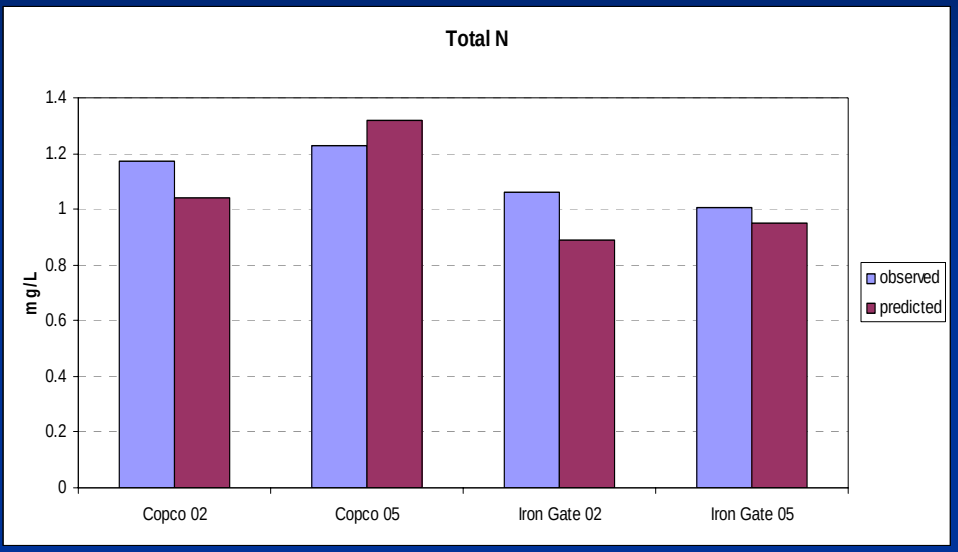
CA NNE Targets for Reservoirs

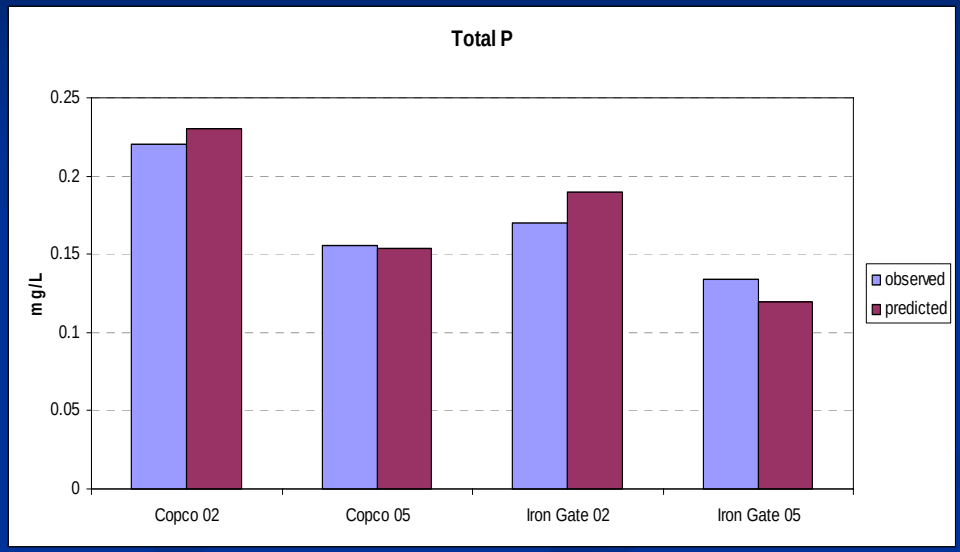
- **Proposed BURC II/III Boundary:**

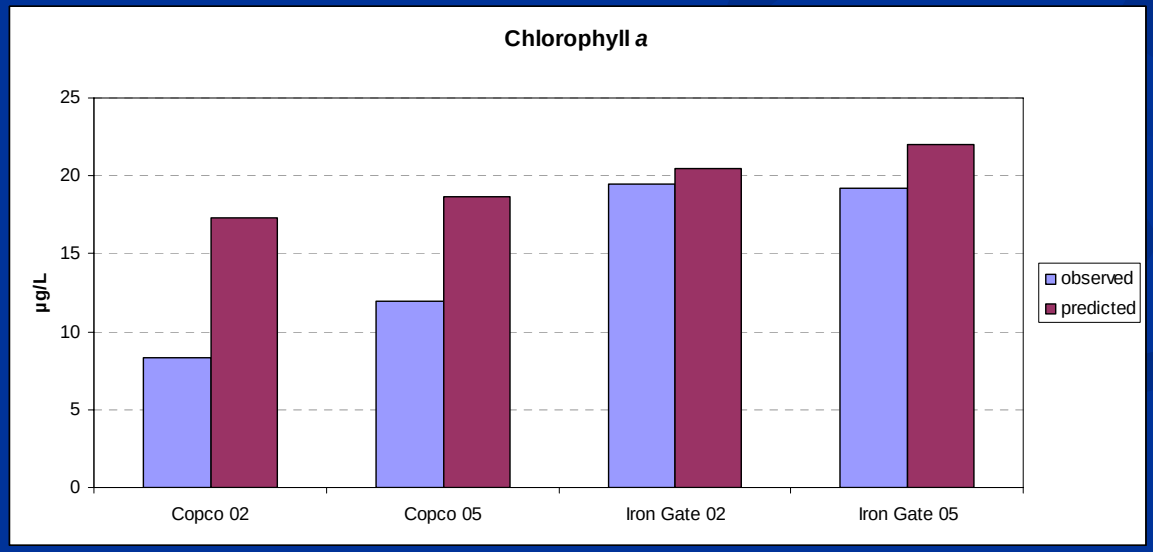
10 µg/L summer average chlorophyll *a*

- **Potential additional target: Reduced predicted cyanobacterial fraction of biomass to < 50% using regression equations relating BGI "blue green index" to TN and TP (see Downing et al., 2001)**

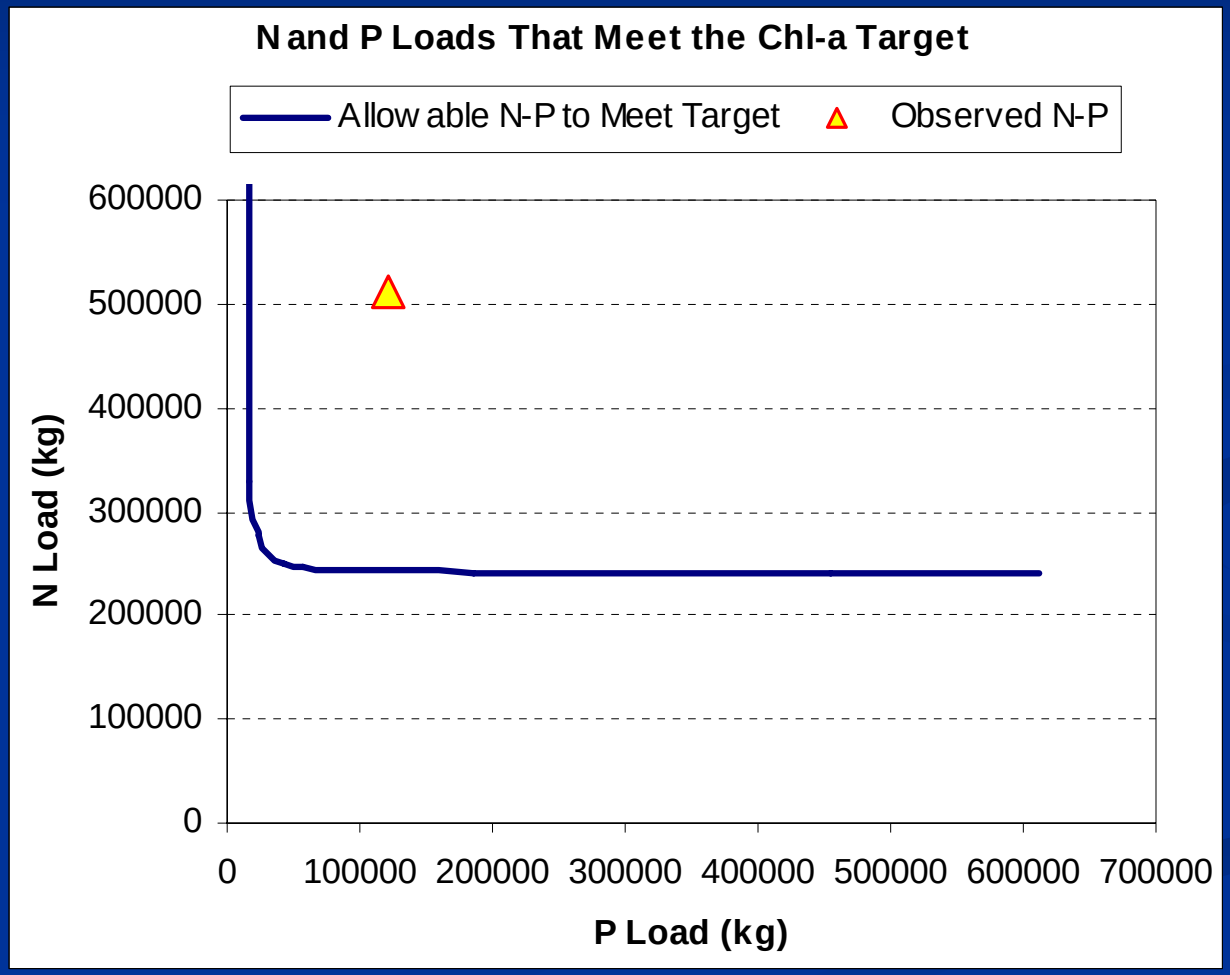
BATHTUB Scoping Tool Predicts Observed TN, TP, Chlorophyll *a*







Tool Predicts TN and TP Loads that Achieve Target

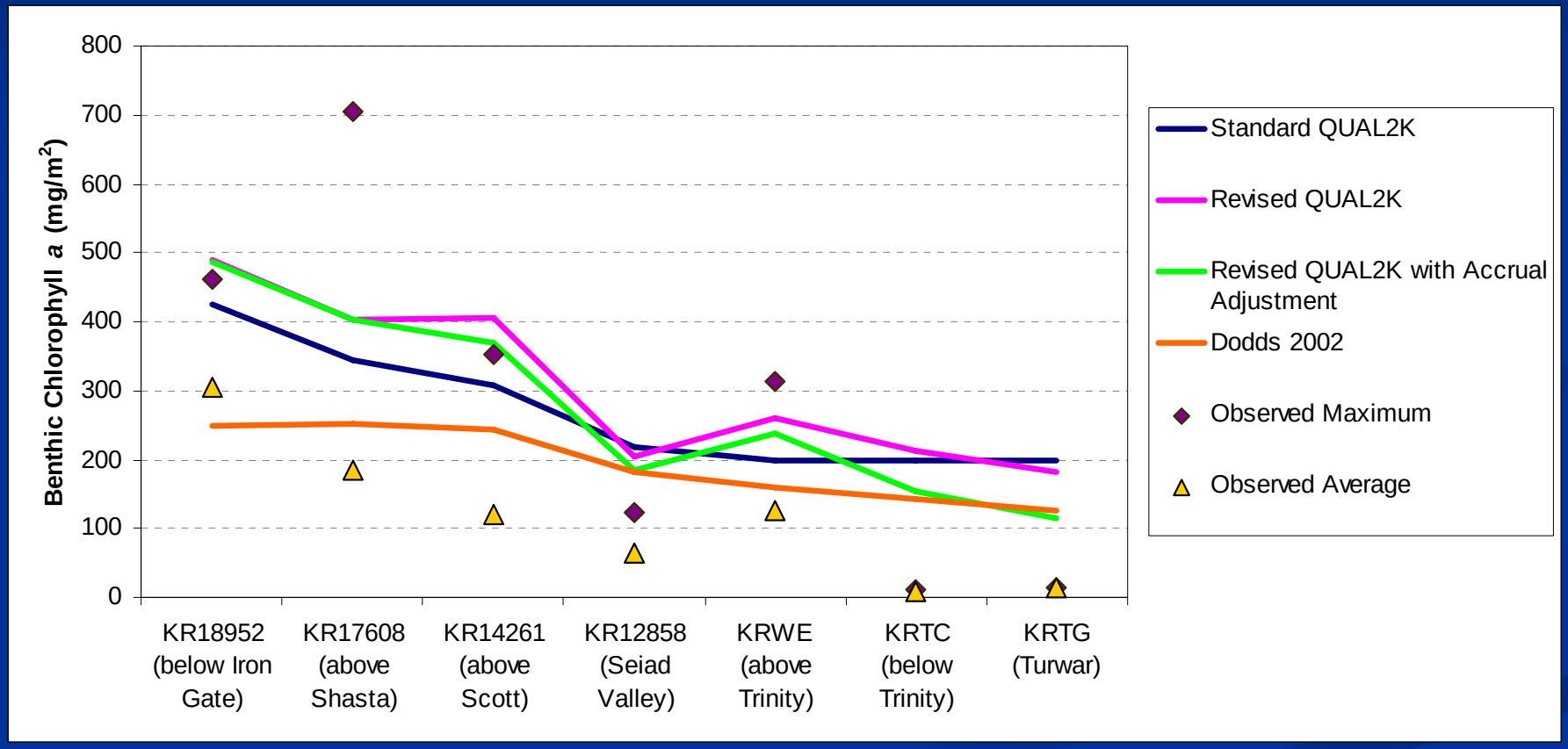


Reductions to Meet Chl-a Target in Reservoirs

- **Reduce TP by 80 to 92%; *or* Reduce TN by by 53 to 67%.**
- **Reductions very similar to reductions needed to achieve DO targets using CE-QUAL-W2 model**
- **Average cyanobacterial fraction of algal biomass predicted to be reduced to about 50%**

Klamath NNE Periphyton Biomass Target Analysis below Iron Gate

Predicted and Observed Maximum Chlorophyll *a* (mg /m2)



Note: Predicted maxima are spatial averages for reach. Observed data are point measurements. Data for 2004 sampling is shown.

Preliminary NNE Nutrient Goals

TN and TP Goals (mg/L) for Target of 150 mg/m2 Maximum Benthic Chlorophyll *a*

Station	Revised QUAL2K	Revised QUAL2K with Accrual Adjustment	Dodds 2002
Below Iron Gate	0.18 / 0.025	0.18 / 0.025	0.34 / 0.047
Above Shasta River	0.23 / 0.032	0.23 / 0.032	0.30 / 0.042
Above Scott River	0.23 / 0.032	0.28 / 0.039	0.33 / 0.046
@ Seiad Valley	0.38 / 0.053	0.44 / 0.061	0.38 / 0.053
Above Trinity River	0.24 / 0.033	0.28 / 0.039	0.50 / 0.069
Below Trinity River	0.24 / 0.033	0.41 / 0.057	0.49 / 0.068
@ Turwar	0.24 / 0.033	0.51 / 0.071	0.53 / 0.074

Estimated Reductions from 2005-2007 Levels to achieve 150 mg/m^2

Station	Percent Reduction	TN / TP Current	TN / TP Goal
Below Iron Gate	83% (N)	1.08 / 0.14	0.18 / 0.025
Above Shasta River	78% (N)	1.05 / 0.14	0.23 / 0.032
Above Scott River	70% (N)	0.94 / 0.16	0.28 / 0.039
@ Seiad Valley	21% (N)	0.56 / 0.091	0.44 / 0.061
Above Trinity River	30% (P)	0.24 / 0.056	0.28 / 0.039
Below Trinity River	-	0.21 / 0.050	0.41 / 0.057
@ Turwar	-	0.23 / 0.041	0.51 / 0.071

Klamath River NNE Conclusions

The following nutrient risk co-factors impact Water Quality / Beneficial Use Support and will need to be addressed in any recovery plan:

- Reduced wetland area and function in upper basin
- River hydrologic regime
- Impoundments
- Temperature
- Riparian shading
- Excess Sediment
- Stream channel degradation

For Further Information

- **http://http://rd.tetratech.com/epa/**
- **http://n-steps.tetratech-ffx.com/**
  - Archived Webcasts
  - Elements of a criteria plan
  - Repository of nutrient information materials
  - 9000+ Article Bibliography
  - News from EPA and States