Nutrient Criteria and Resources to Support Development

Rochelle Labiosa, R10 Nutrients Coordinator and HABs Lead for Ambient Waters

Outline

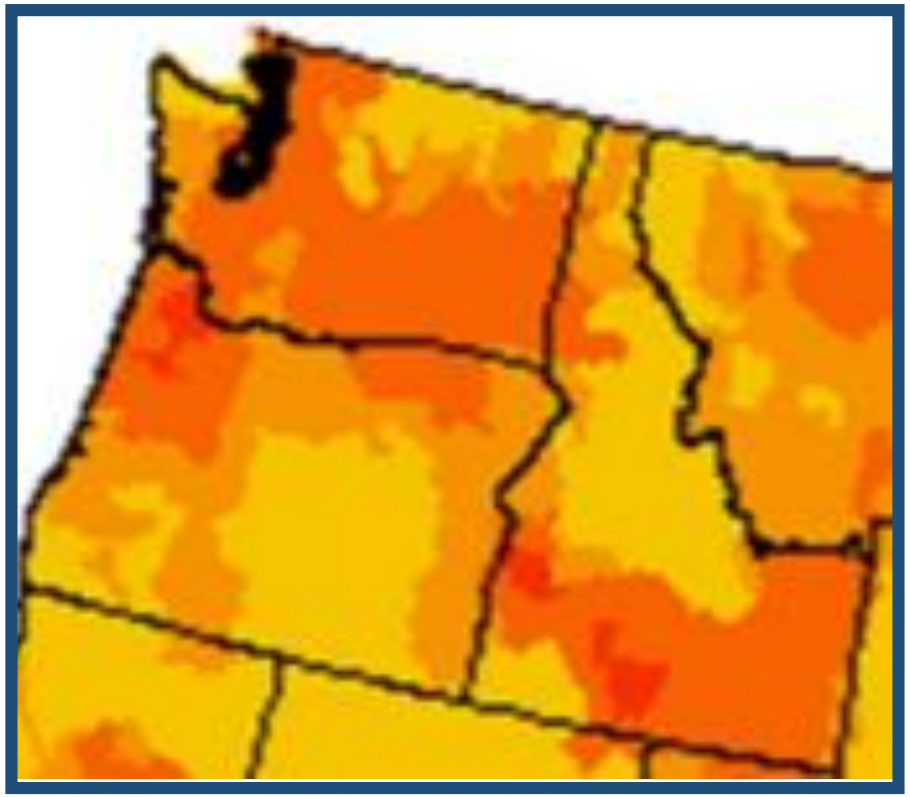
- Nutrient Impacts in Region 10
- National and Regional Nutrient Criteria Status
- Available Tools and Resources
- NSTEPS Support for Nutrient Criteria Development
- Published 304(a) Recommendations and Draft 304(a) for Lakes (under development)
- Interim Approaches and Potential Resources to Support Nutrient Work

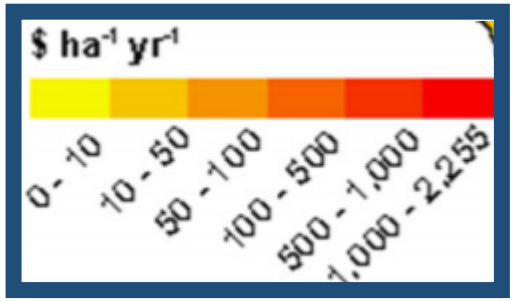
The views expressed here are those of the speaker and are not necessarily those of US EPA

The Goal of NNC

To reduce the anthropogenic component of nutrient overenrichment to levels that restore beneficial uses (i.e. described as designated uses by the CWA), or to prevent nutrient pollution in the first place.

Impacts of excess nutrients – example costs





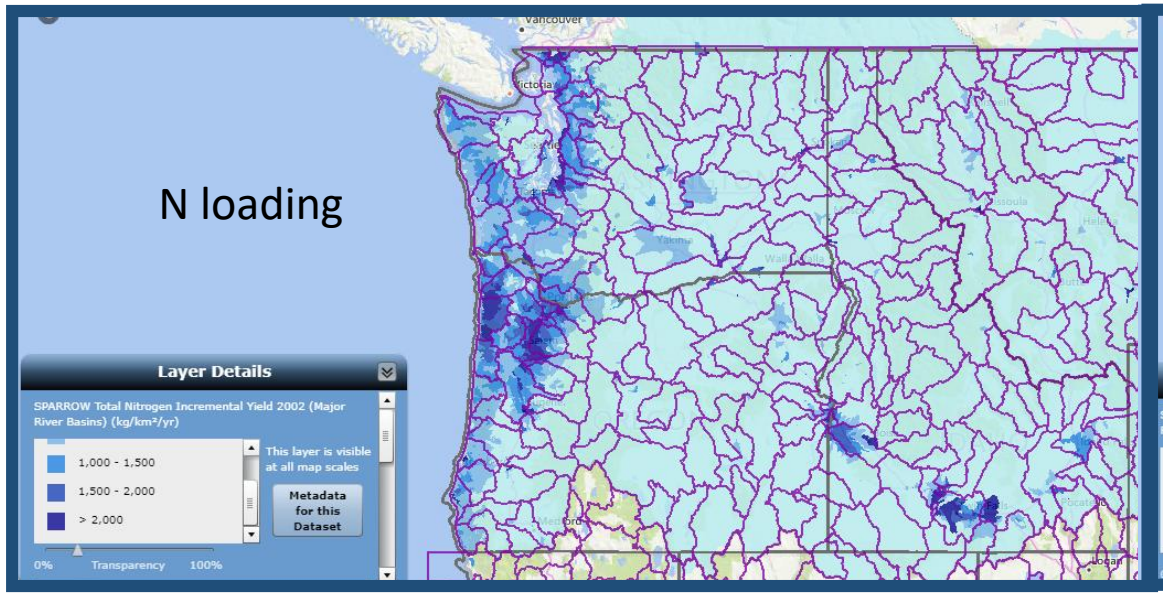
Sobota et al. 2015*

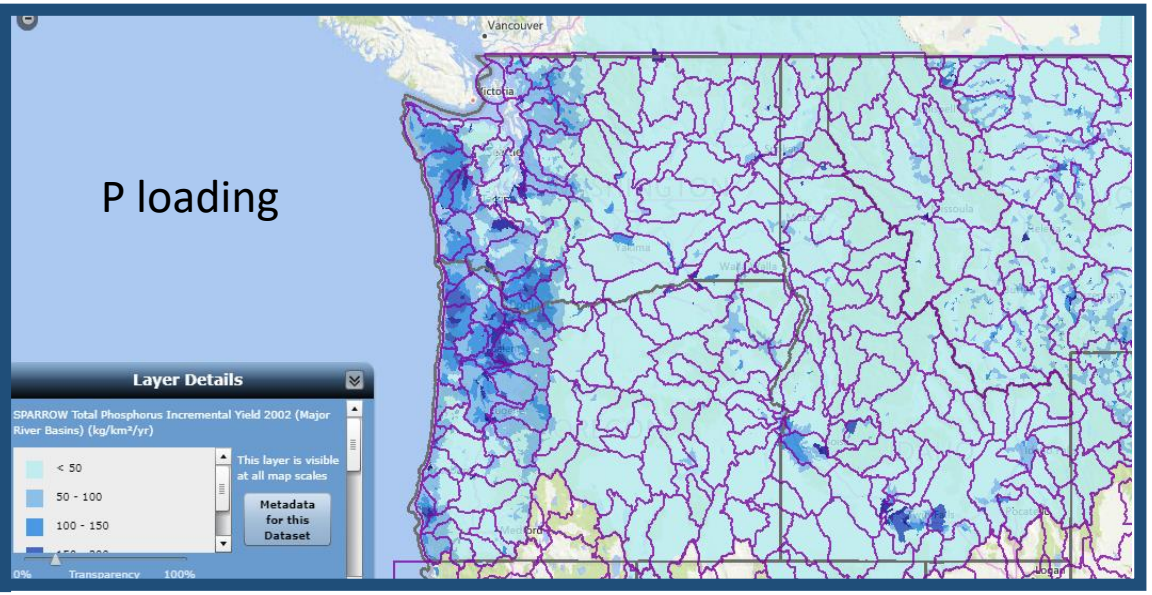
Figure 5. Distribution of total potential damage costs caused by anthropogenic N leaked to the environment by HUC8 watersheds of the conterminous United States in the early 2000s. Potential damage costs were calculated by multiplying specific new and recycled anthropogenic N inputs by source with the central damage cost estimate of US dollars (2008 or as reported) per kg of N leaked to the environment.

https://iopscience.iop.org/article/10.1088/1748-9326/10/2/025006

*Based on 2000 estimates and does not include certain costs, including harmful algal bloom costs

N and P loading: USGS SPARROW 2002





https://gispub2.epa.gov/npdat/

HABs Issues –Oregon examples

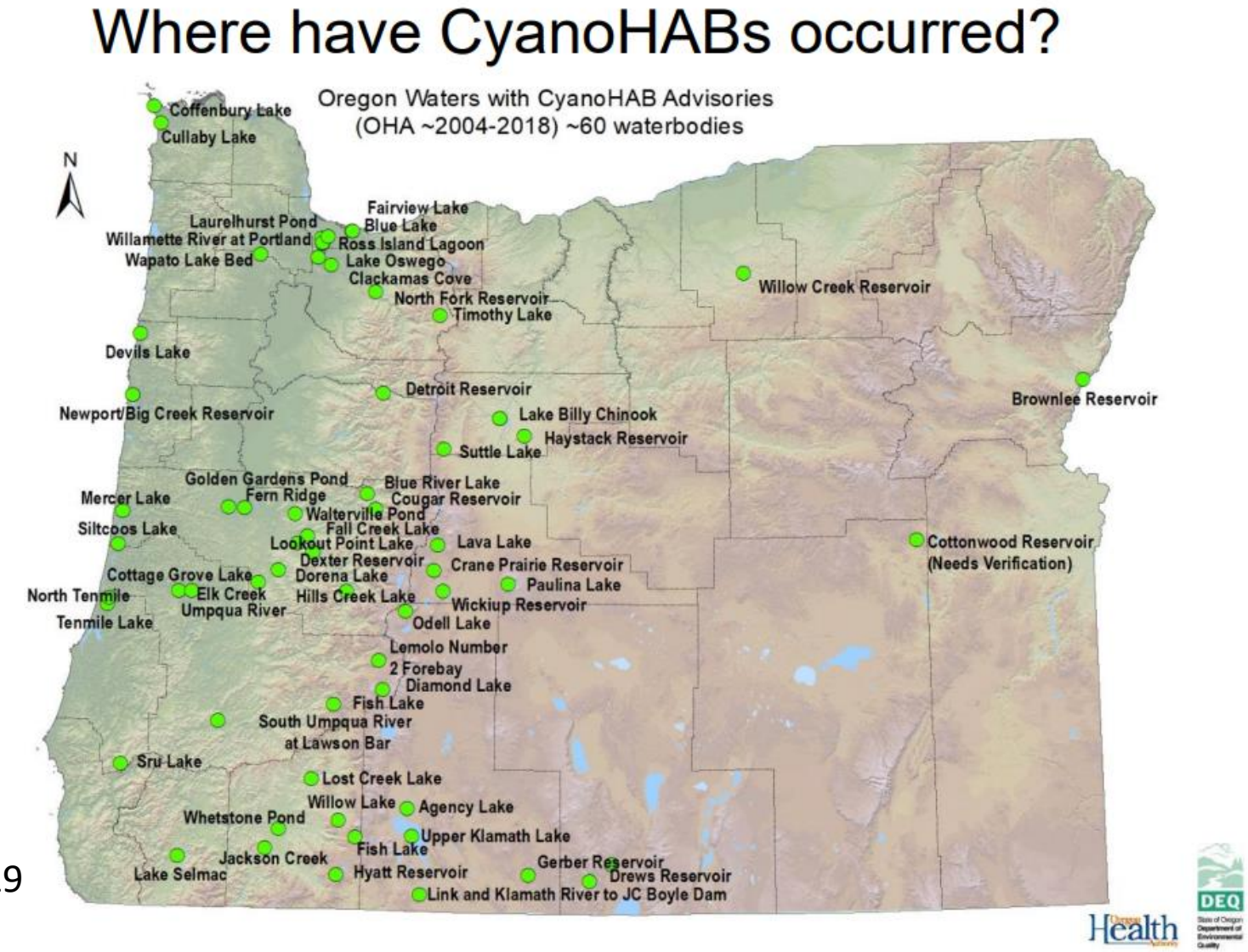
Upper Klamath Lake, OR
Sentinel satellite image

Odell Lake – August 2019, courtesy Dan Sobota, ODEQ

Ross Island Lagoon, Willamette River, OR
kptv

- Salem, OR Drinking Water Emergency

HABs in Oregon



Source: ODEQ 2019

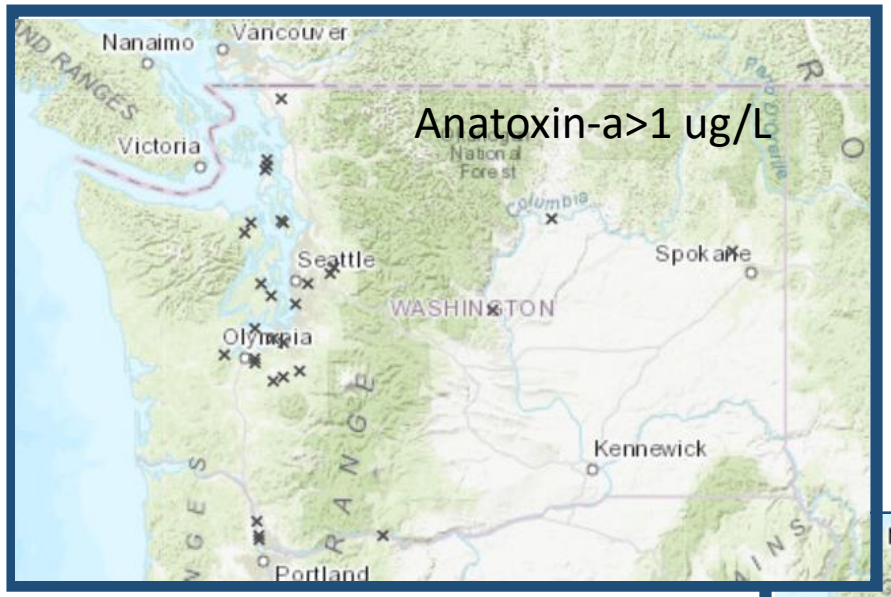
HABs Issues – WA Examples

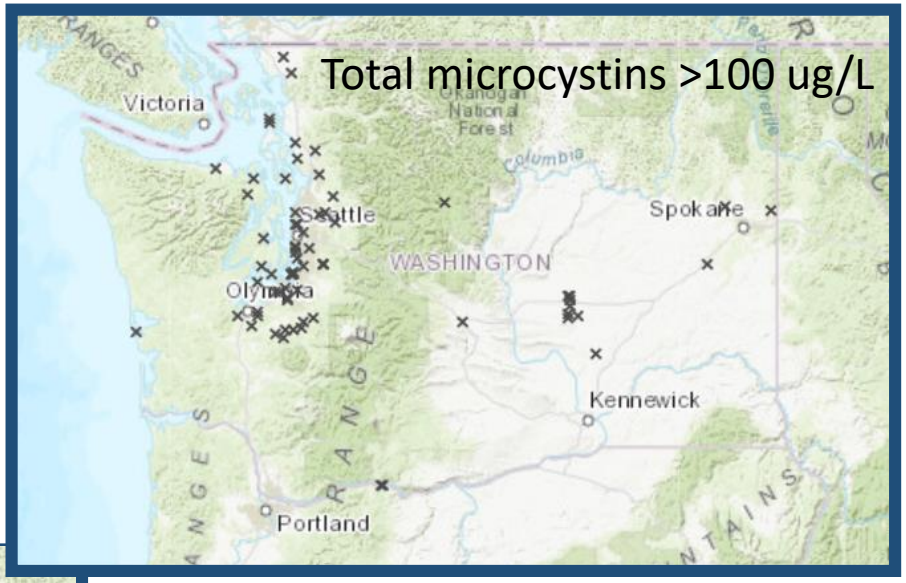
Hicklin Lake, WA

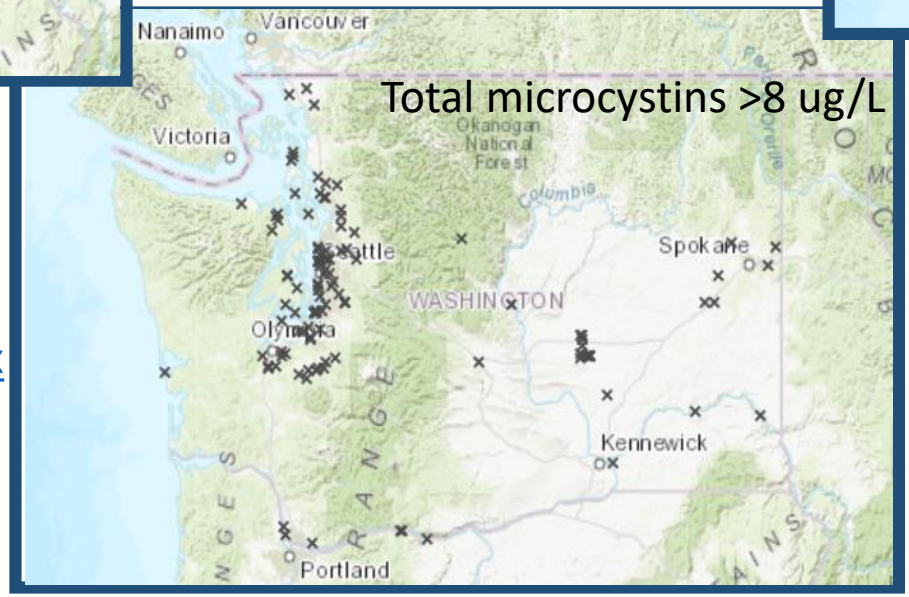
Green Lake, Seattle, WA

Moses Lake, WA (courtesy, WALPA)

HABs in Washington 2007-2019



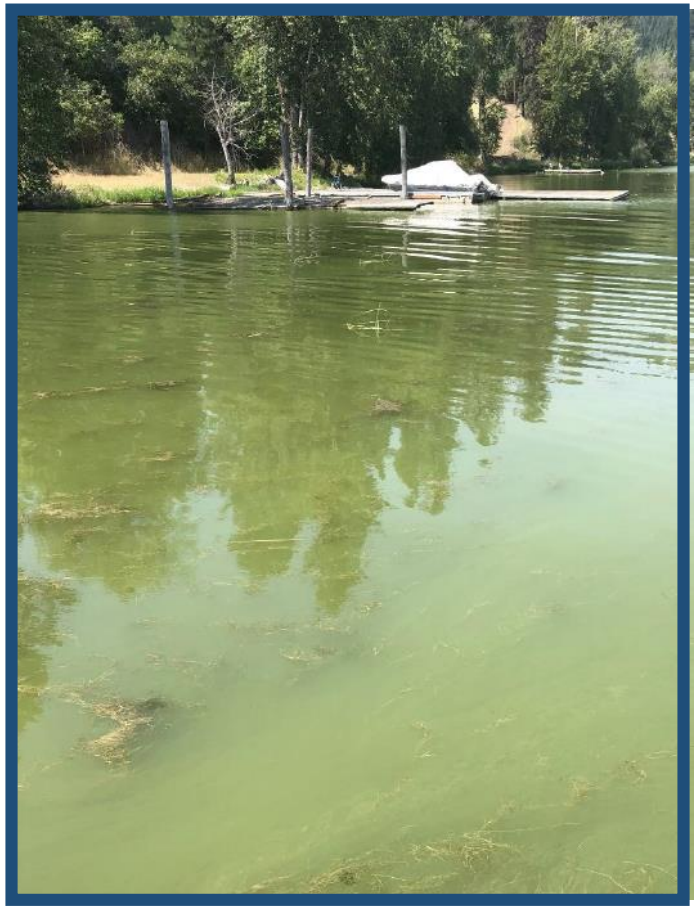




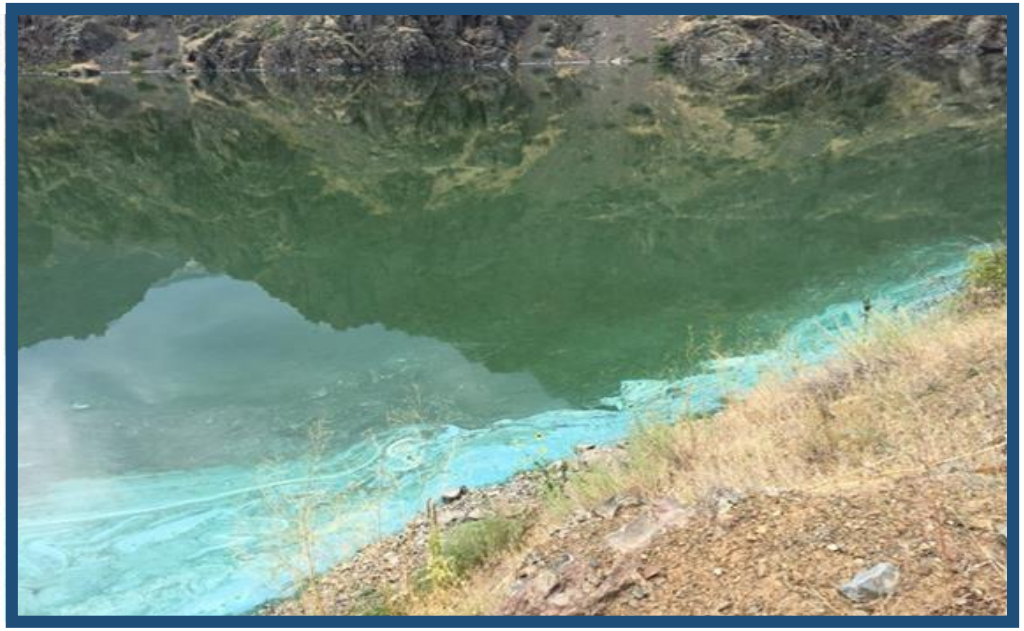
Source – WA Ecology and King County
https://www.nwtoxicalgae.org/Data.aspx

HABs Issues- Idaho examples

Fernan Lake

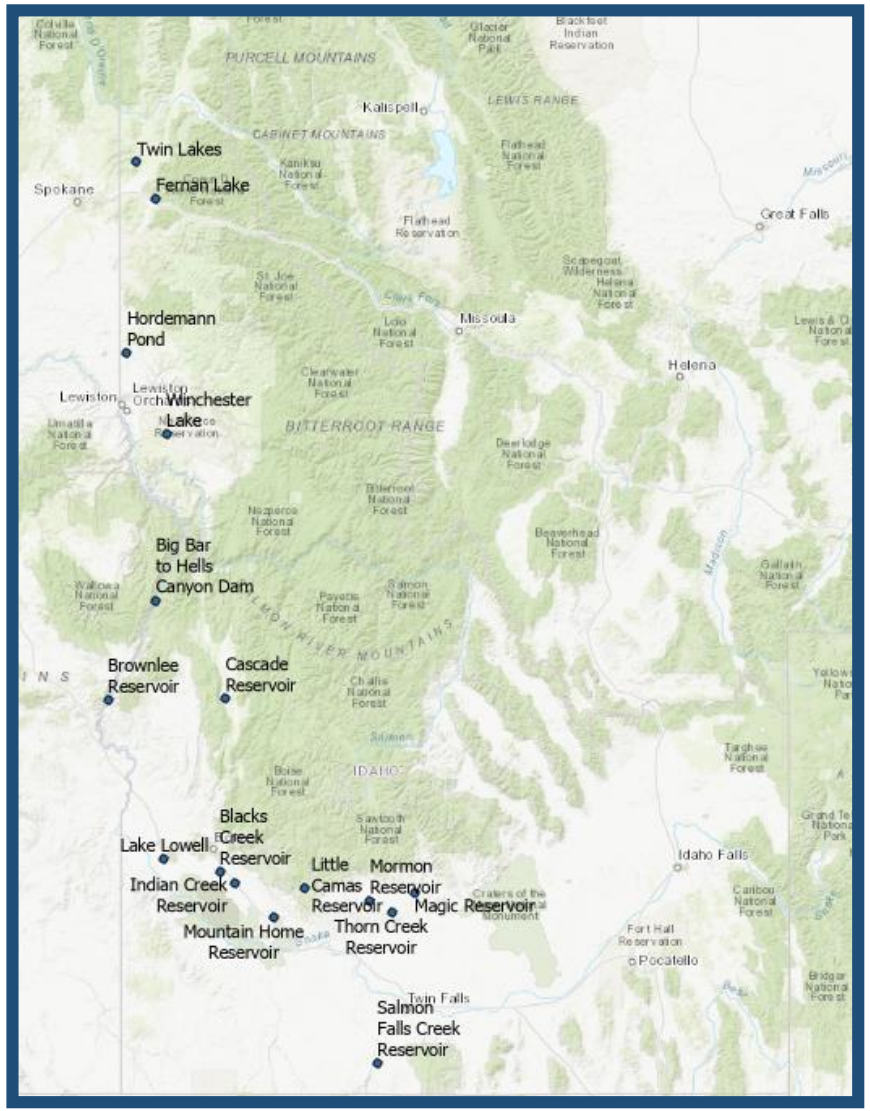


Round Lake, courtesy B. Scofield



Brownlee Reservoir

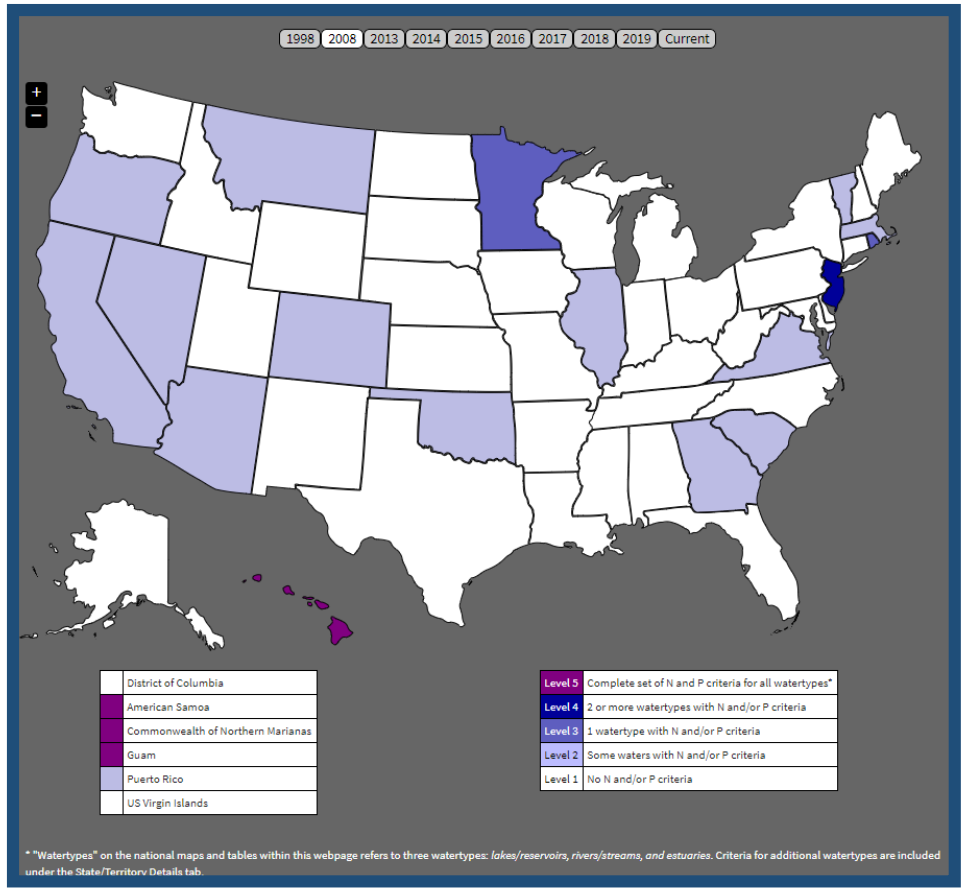
HABS in Idaho 2019-2020



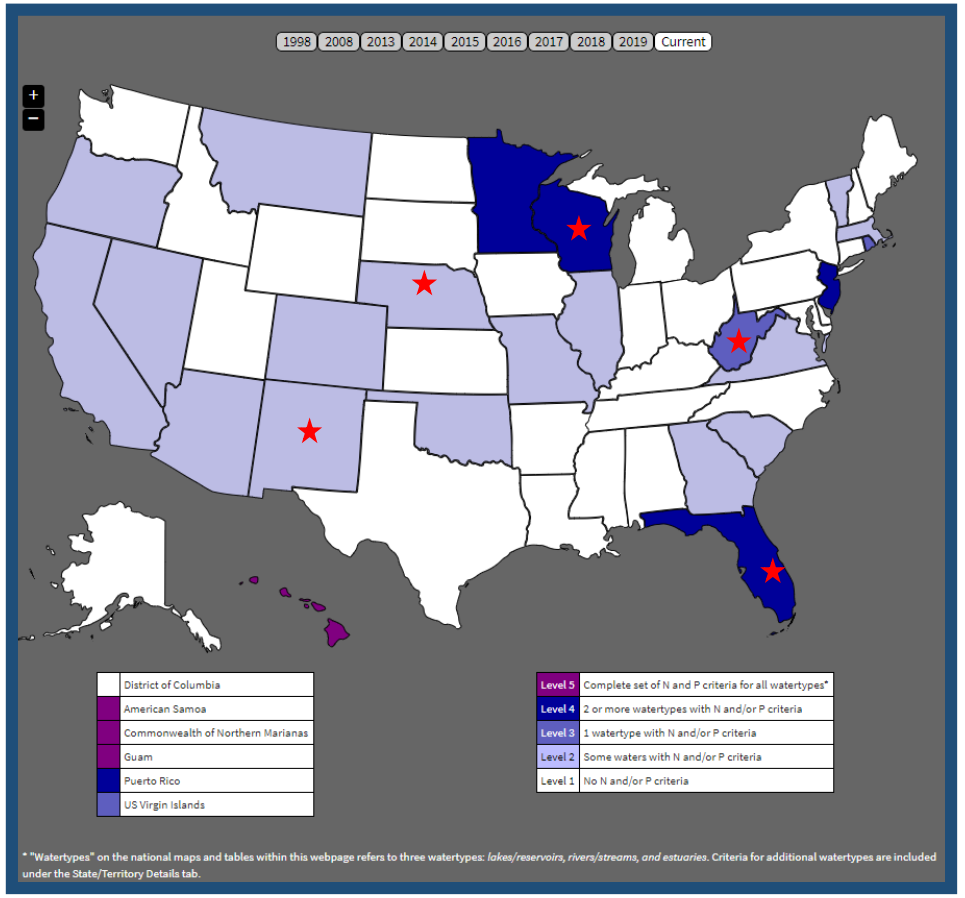
Source: IDEQ

NNC National Status

2008

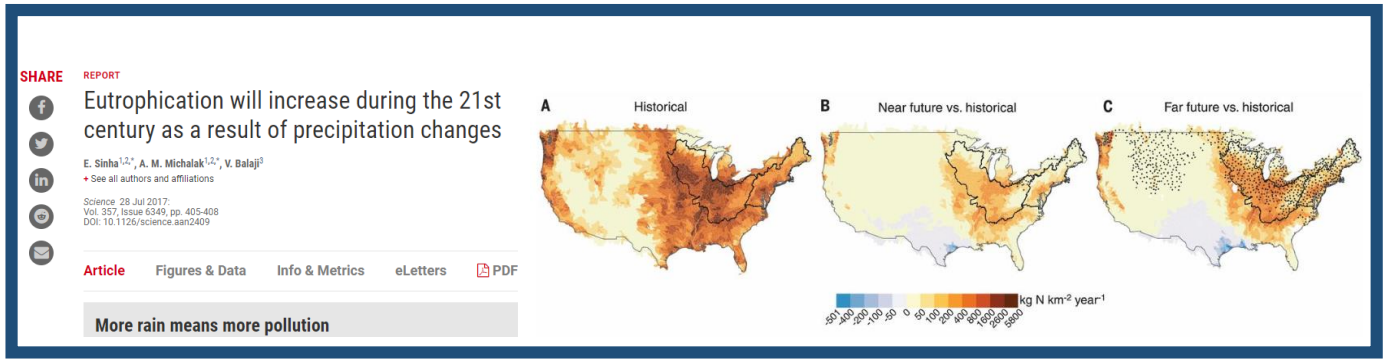


2020

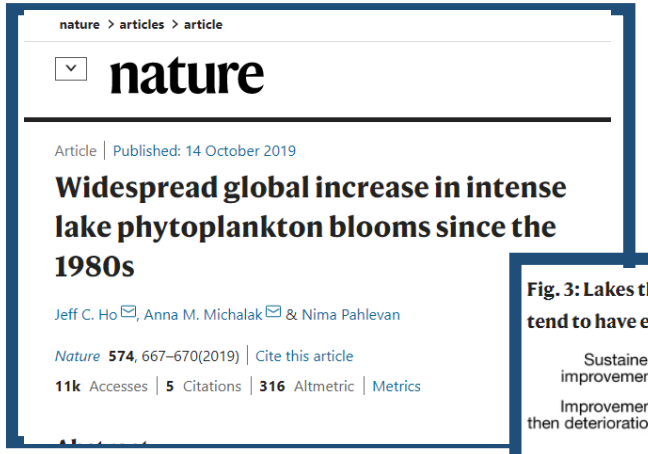


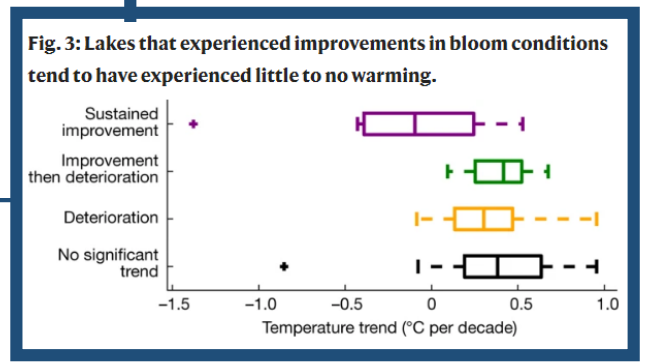
Status of Numeric Nutrient Criteria (NNC) Development

- Technical support is available for identifying suitable endpoints
- Nationally, progress is being made
  - Regionally, incremental progress toward narrative translation; some projects on NNC
- R10 highly recommends prioritization of NNC adoption for waterbodies vulnerable to or impacted by eutrophication and to prevent further eutrophication



https://science.sciencemag.org/content/357/6349/405





*and recommends identifying targets for pristine waterbodies to ensure further degradation does not occur

Resources for Establishing NNC or Translating Narrative Criteria

Tools to assist states and tribes:

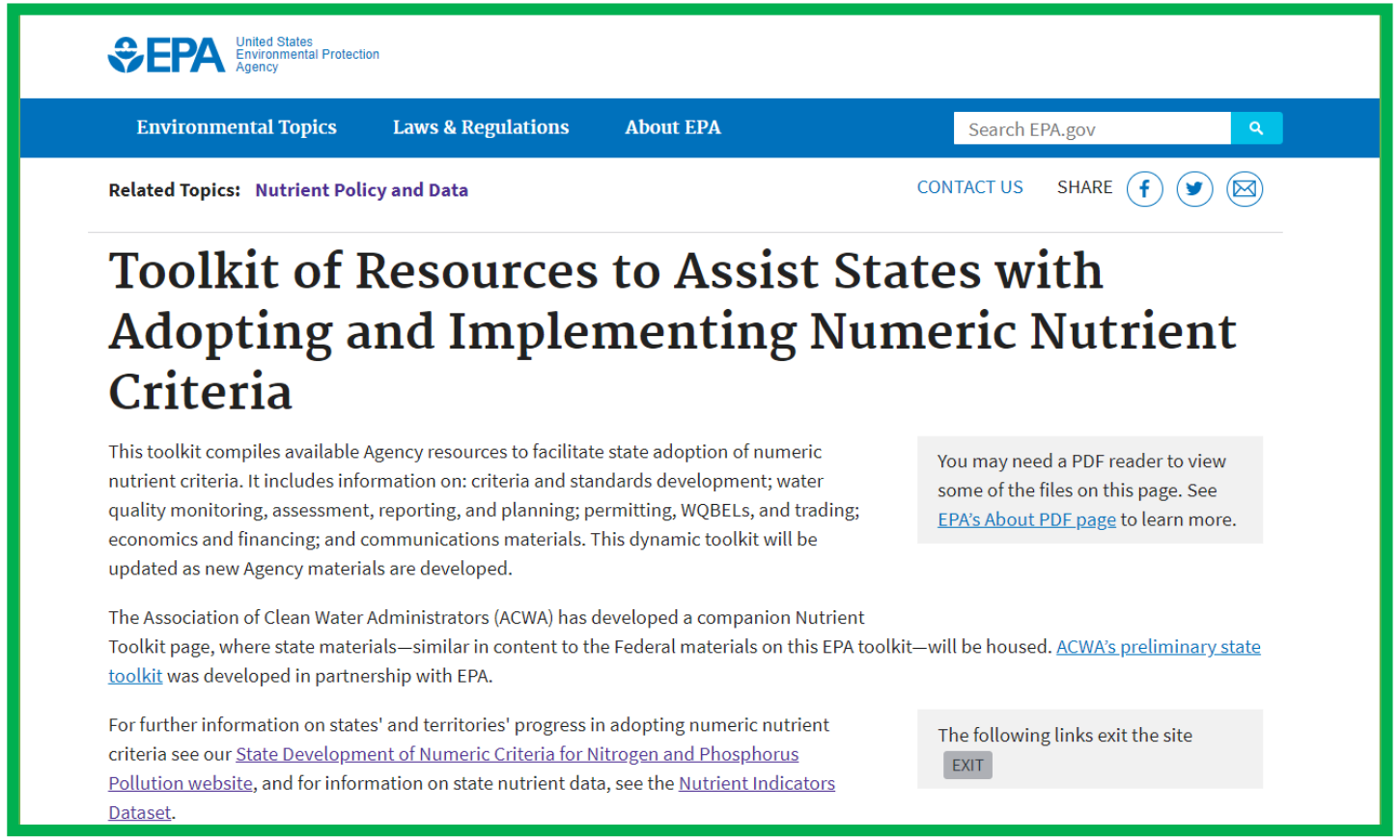
https://www.epa.gov/nutrient-policy-data/tools-assist-states-and-tribes-reduce-nutrient-pollution

The Toolkit

https://www.epa.gov/nutrient-policy-data/toolkit-resources-assist-states-adopting-and-implementing-numeric-nutrient

Includes:

- Criteria Documents
- Implementation documents
- Economics/Financing
- Communications materials



Toolkit, ctd.

Nutrient Indicators Dataset

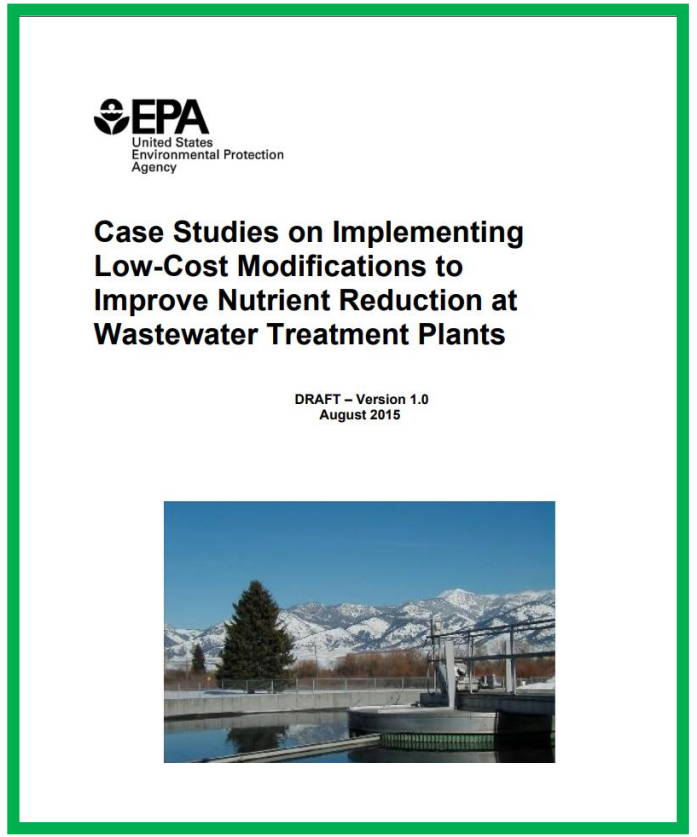
Specific Indicators		
Documented Nutrient Pollution Nutrient loads and yields Fertilizer Manure	**Documented Impacts** Hypoxia Harmful algal toxins Groundwater nitrate Assessed and impaired waters	**State Actions Underway** Limiting loads (Status of Nutrient Requirements for NPDES-Permitted Facilities) Adoption of standards

Introduction

Water pollution from excess nitrogen and phosphorus (nutrients) is harming the environmental and economic viability of our nation's waters. Human activities have led to a significant increase in nitrogen and phosphorus in the biosphere, altering biological communities in aquatic ecosystems, impairing drinking water, and threatening the growth of businesses and economic sectors that rely on high-quality and sustainable sources of water such as tourism, farming, fishing, manufacturing, and transportation. Recent estimates suggest that nitrogen

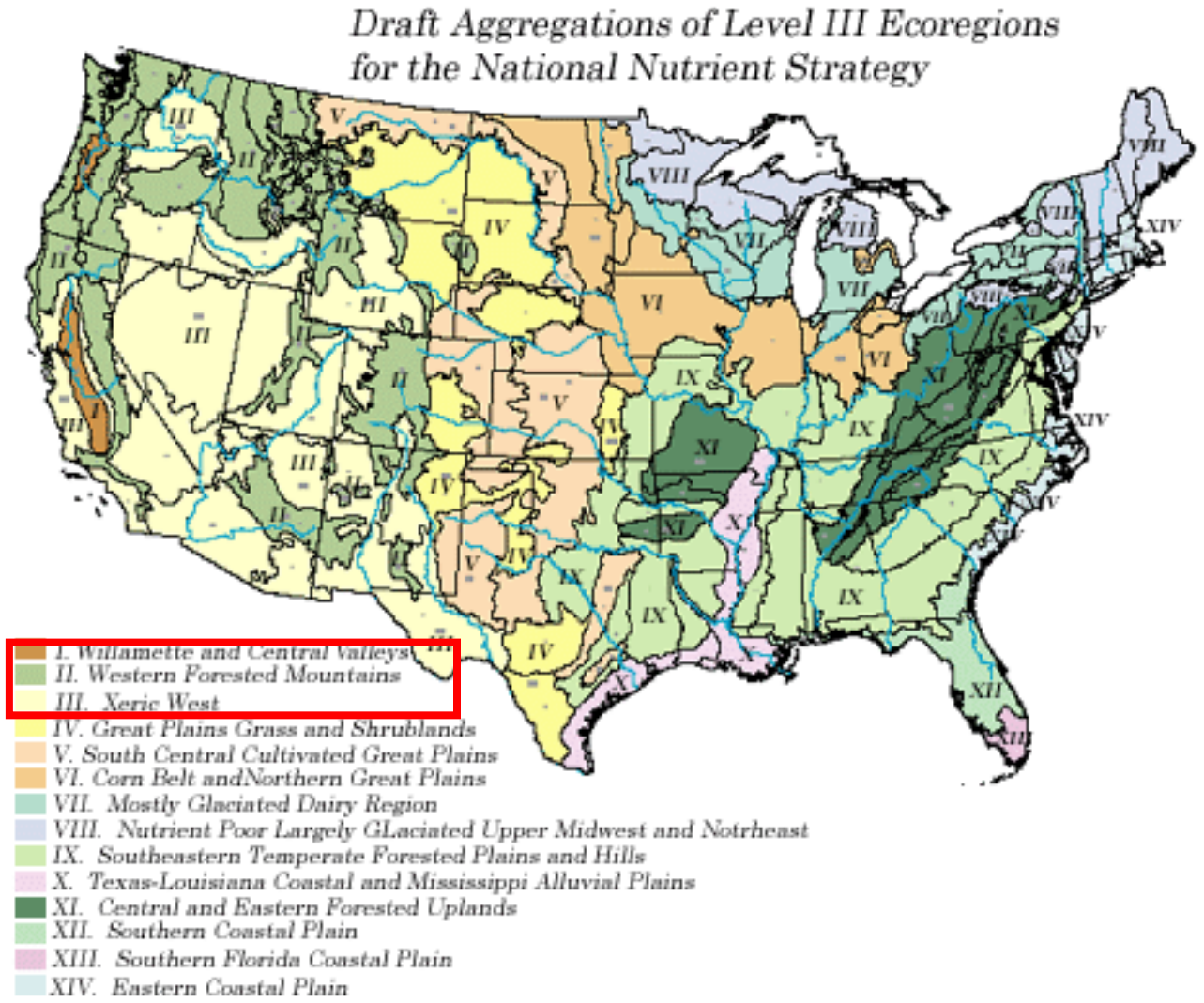
Expert Workshop: Nutrient Enrichment Indicators in Streams

For the past 15 years, EPA has encouraged states and tribes to adopt numeric criteria into water quality standards to protect waters from the widespread and growing problem of nutrient pollution. Excess nutrients (nitrogen and phosphorus) cause algal growth that degrades aquatic communities and cause fish kills, degrades beaches and shorelines with nuisance algae, and adversely affect human health from algal toxins and trihalomethane formation in drinking water. State progress toward adopting numeric nutrient criteria has been limited in flowing waters in part because of the technical challenge of developing numeric nutrient criteria when multiple factors (e.g., light, flow) can influence responses (e.g., algal biomass) and confound nutrient response models. Such conditions can make it difficult to predict nitrogen and phosphorus concentrations that adversely affect aquatic life. One approach to overcome such challenges and to reduce uncertainty



https://www.epa.gov/sites/production/files/2015-08/documents/case_studies_on_implementing_low-cost_modification_to_improve_potw_nutrient_reduction-combined_508_-_august.pdf

Ecoregional Criteria



https://www.epa.gov/nutrient-policy-data/ecoregional-criteria

Ecoregional Criteria Recommendations and Guidance for Developing NNC- Lakes and reservoirs

Note – no Agg Ecoregion I (Willamette Valley)

Aggregate Ecoregions Lakes and Reservoirs

Parameter	Agg Ecor II	Agg Ecor III	Agg Ecor V	Agg Ecor V	Agg Ecor VI	Agg Ecor VII	Agg Ecor VIII	Agg Ecor IX	Agg Ecor XI	Agg Ecor XII	Agg Ecor XIII	Agg Ecor XIV
TP µg/L	8.75	17.00	20.00	33.00	37.5	14.75	8.00	20.00	8.00	10.00	17.50	8.00
TN mg/L	0.10	0.40	0.44	0.56	0.78	0.66	0.24	0.36	0.46	0.52	1.27	0.32
Chl *a* µg/L	1.90	3.40	2.00 S	2.30 S	8.59 S	2.63	2.43	4.93	2.79 S	2.60	12.35 T	2.90
Secchi (m)	4.50	2.70	2.00	1.30	1.36	3.33	4.93	1.53	2.86	2.10	0.79	4.50

Summary Table for Aggregate Ecoregions

Guidance:
https://www.epa.gov/sites/production/files/2018-10/documents/nutrient-criteria-manual-lakes-reservoirs.pdf

Criteria Documents:
https://www.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-lakes-and-reservoirs

Ecoregional Criteria Recommendations and Guidance for Developing NNC- Rivers and Streams

- Nitrogen fixing (red) Alder can be a challenge along the coast
- Diversity of streams

EPA Guidance:
https://www.epa.gov/sites/production/files/2018-10/documents/nutrient-criteria-manual-rivers-streams.pdf

304(a) Criteria Documents:
https://www.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-rivers-and-streams

Aggregate Ecoregions for Rivers and Streams

Parameter	Agg Ecor I	Agg Ecor II	Agg Ecor III	Agg Ecor V	Agg Ecor V	Agg Ecor VI	Agg Ecor VII	Agg Ecor VIII	Agg Ecor IX	Agg Ecor X	Agg Ecor XI	Agg Ecor XII	Agg Ecor XIV
TP µg/L	47.00	10.00	21.88	23.00	67.00	76.25	33.00	10.00	36.56	128 *	10.00	40.00	31.25
TN mg/L	0.31	0.12	0.38	.56	0.88	2.18	0.54	0.38	0.69	0.76	0.31	0.90	0.71
Chl *a* µg/L	1.80	1.08	1.78	2.40	3.00	2.70	1.50	0.63	0.93 S	2.10 S	1.61 S	0.40 S	3.75 S
Turb FTU/ NTU	4.25	1.30 N	2.34	4.21	7.83	6.36	1.70 N	1.30	5.70	17.50	2.30 N	1.90 N	3.04

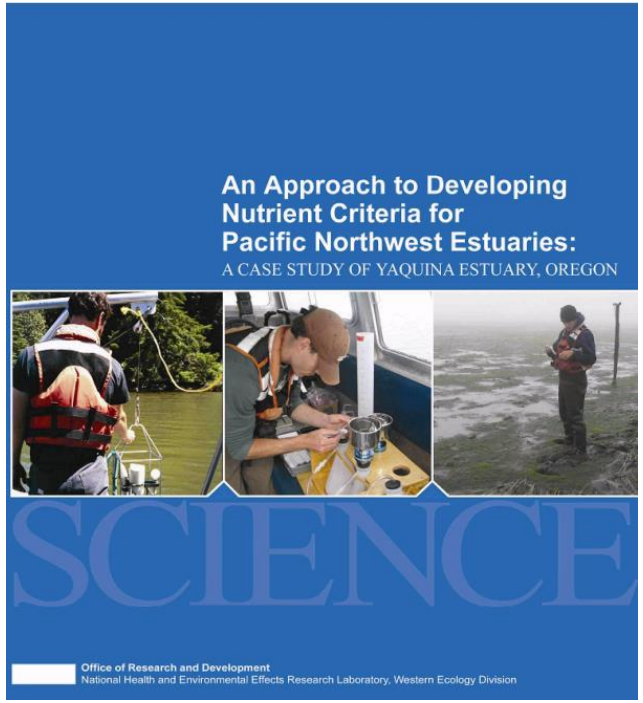
*This value appears inordinately high and may either be a statistical anomaly or reflects a unique condition. In any case, further regional investigation is indicated to determine the sources, i.e., measurement error, notational error, statistical anomaly, natural enriched conditions, or cultural impacts.
Turb - Turbidity
Chl *a* - Chlorophyll *a* measured by Fluorometric method, unless specified. S is for Spectrophotometric and T is for Trichromatic method.
N for NTU. Unit of measurement for Turbidity.

Summary Table for Aggregate Ecoregions

Criteria Recommendations and Guidance for Developing NNC- Marine Waters

- Upwelling complicates west coast development of NNC
- Can be evaluated with reference-based (mixing models or statistical analyses) or numerical modeling approaches

Potential dry season criteria for the Yaquina Estuary based on median values for all parameters except for DO.		
Parameter (units)	Zone 1	Zone 2
DIN (µM)	14	14
Phosphate (µM)	1.3	0.6
Chlorophyll *a* (µg l^{-1})	3	5
Water Clarity (m^{-1})	0.8	1.5
Dissolved Oxygen (mg l^{-1})	6.5	



https://www.epa.gov/sites/production/files/2019-02/documents/an-approach-pacific-nw-estuaries-oregon.pdf

EPA Guidance: https://www.epa.gov/sites/production/files/2018-10/documents/nutrient-criteria-manual-estuarine-coastal.pdf

Dry season medians in Zone 1 (lower estuary) and Zone 2 (upper estuary) based on EPA recommendations for high quality estuaries; note DO instantaneous min

2019 Recreational Water Quality Criteria or Swimming Advisories for Two Cyanotoxins

- Swimming advisories –one day duration; magnitudes are never to be exceeded
- Note for recreational water quality criteria, the 10-day periods **are not** rolling

From the draft implementation materials - duration and frequency interpretation:

- If toxin concentrations are higher than the criterion magnitude in a sample collected during a ten-day assessment period, then that period should be considered an excursion from the recreational criteria.
- Do not transform (e.g., average) sampling data.
- The recommended frequency *within a single recreational season* is no more than three excursions. The number of years that a pattern of more than three excursions can *occur across* recreational seasons is to be identified by a state or authorized tribe in its WQS.

Table 6-1. Recreational Criteria or Swimming Advisory Recommendations for Microcystins and Cylindrospermopsin[a]

Application of Recommended Values	Microcystins			Cylindrospermopsin		
	Magnitude (µg/L)	Duration	Frequency	Magnitude (µg/L)	Duration	Frequency
Recreational Water Quality Criteria	8	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]	15	1 in 10-day assessment period across a recreational season	More than 3 excursions in a recreational season, not to be exceeded in more than one year[b]
Swimming Advisory		One day	Not to be exceeded		One day	Not to be exceeded

[a] These recommendations can apply independently within an advisory program or in WQS. States can choose to apply either or both toxin recommendations when evaluating excursions within and across recreational seasons.

[b] An excursion is defined as a 10-day assessment period with any toxin concentration higher than the criteria magnitude. When more than three excursions occur within a recreational season and that pattern reoccurs in more than one year, it is a indication the water quality has been or is becoming degraded and is not supporting its recreational use. **As a risk-management decision, states should include in their WQS an upper-bound frequency stating the number of years that pattern can reoccur and still support its recreational use.**

New Draft 304(a) for Lakes (to be released soon for public comment)

- Uses National Lakes Assessment Data (2007 and 2012)
- Comprises a series of models – first to identify chlorophyll *a* targets, and then ultimately derive TN and TP numeric values.
- Models are Bayesian (probabilistic)
- No Alaska

Contact: Lester Yuan,
yuan.lester@epa.gov

New Draft 304(a) for Lakes: Demo 1 – Identifying Human Health Targets Associated with Chlorophyll *a* Targets

- Total microcystins
  - 304(a) magnitudes
  - Drinking water advisory magnitudes

Image removed

All slides on draft 304(a) are examples subject to change

New Draft 304(a) for Lakes: Demo 2 – Identifying Ecological Chlorophyll *a* Targets (Example)

- Hypoxia model
- Zooplankton

Image removed

New draft 304(a) – after deriving Chlorophyll *a* targets, deriving TN and TP targets

- Separate models for TN and TP

Image removed

Note examples only

Image removed

Image removed

Image removed

Lakes and Reservoirs – Applying draft lake nutrient models with additional state data

- Bayesian model allows us to specify elements of state data and national data that are similar and different.

Image removed

See:

https://www.sciencedirect.com/science/article/pii/S1569883193002653?via%3Dihub

Rivers and Streams- resources used in other states

Periphyton indicators – sensitive response to eutrophication; Algal indicators in streams compilation- an overview

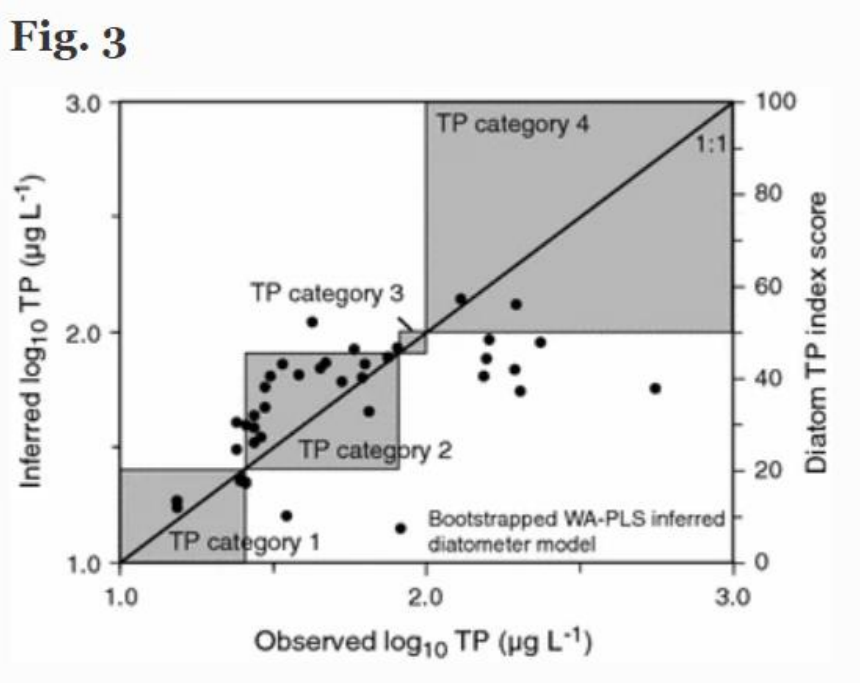
https://www.epa.gov/sites/production/files/2017-06/documents/algal-indicators-whitepaper.pdf

- New Jersey- based on Ponader et al. 2008

https://link.springer.com/article/10.1007/s10750-008-9429-6

- Macroinvertebrates- Vermont (also for lakes):

https://www.tandfonline.com/doi/full/10.1080/10402381.2016.1149257?src=recsys Smeltzer et al. 2016



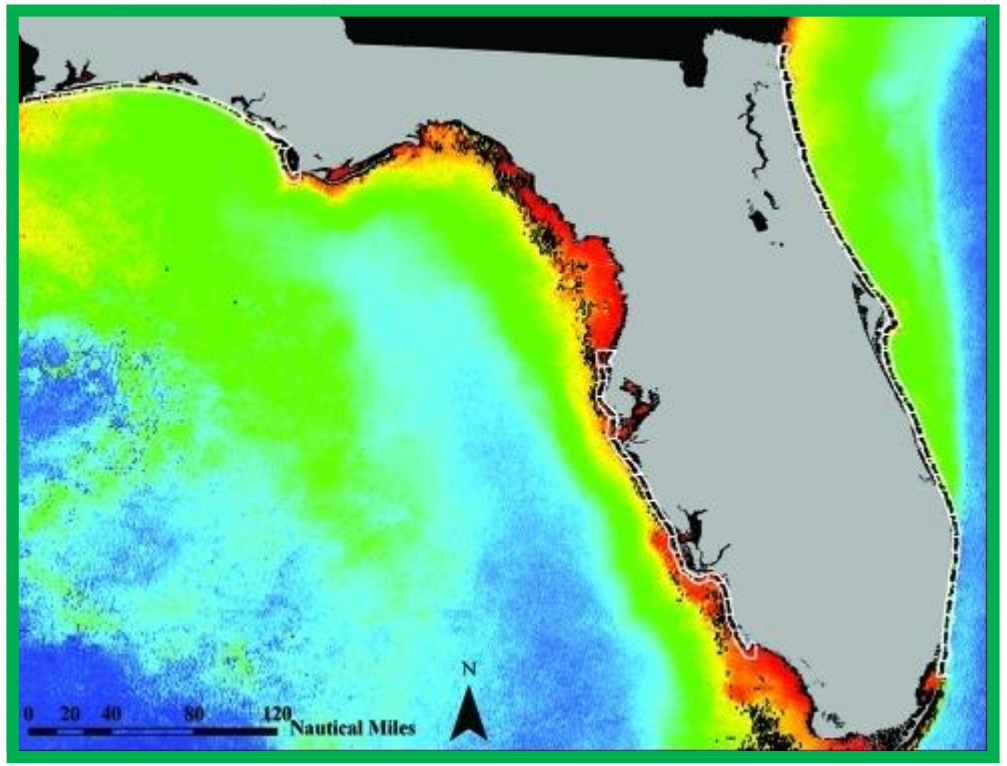
Marine waters

Case studies: Nutrients in Estuaries, EPA 2010

https://www.epa.gov/sites/production/files/documents/nutrients-in-estuaries-november-2010.pdf

- Florida approach – using remotely sensed data to generate a baseline - Schaeffer et al. 2012

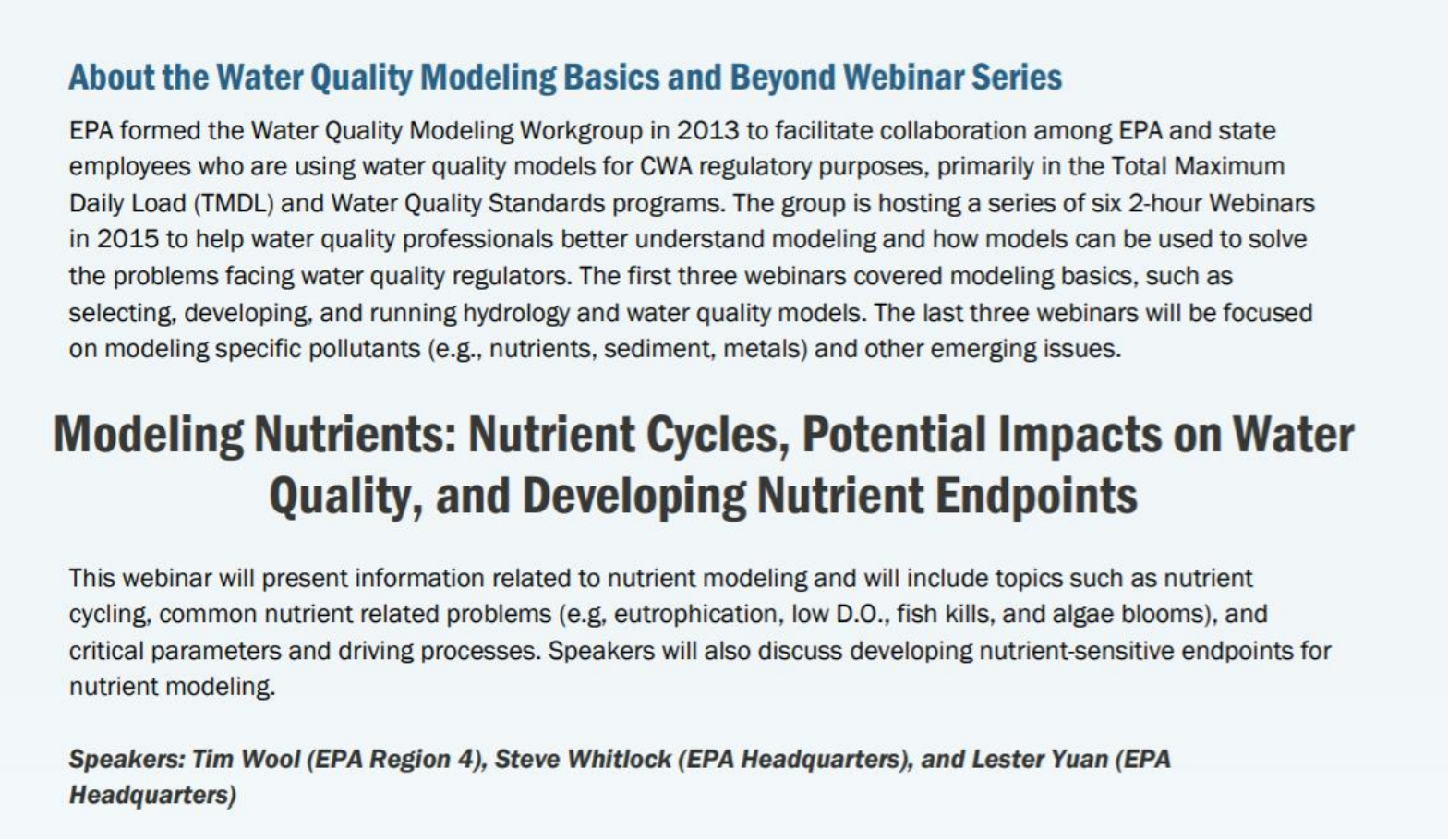
https://europepmc.org/articles/pmc3287117/bin/es2014105_si_003.pdf



Nutrient Model Derivation

https://www.epa.gov/tmdl/tmdl-modeling

See e.g.,



About the Water Quality Modeling Basics and Beyond Webinar Series

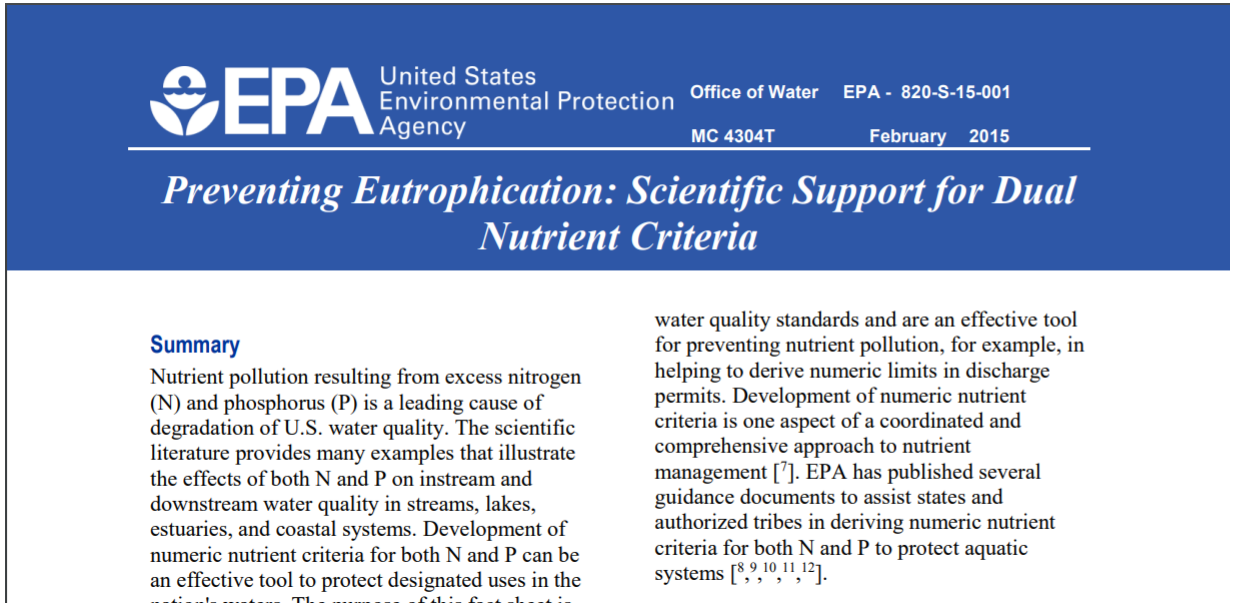
EPA formed the Water Quality Modeling Workgroup in 2013 to facilitate collaboration among EPA and state employees who are using water quality models for CWA regulatory purposes, primarily in the Total Maximum Daily Load (TMDL) and Water Quality Standards programs. The group is hosting a series of six 2-hour Webinars in 2015 to help water quality professionals better understand modeling and how models can be used to solve the problems facing water quality regulators. The first three webinars covered modeling basics, such as selecting, developing, and running hydrology and water quality models. The last three webinars will be focused on modeling specific pollutants (e.g., nutrients, sediment, metals) and other emerging issues.

Modeling Nutrients: Nutrient Cycles, Potential Impacts on Water Quality, and Developing Nutrient Endpoints

This webinar will present information related to nutrient modeling and will include topics such as nutrient cycling, common nutrient related problems (e.g, eutrophication, low D.O., fish kills, and algae blooms), and critical parameters and driving processes. Speakers will also discuss developing nutrient-sensitive endpoints for nutrient modeling.

Speakers: Tim Wool (EPA Region 4), Steve Whitlock (EPA Headquarters), and Lester Yuan (EPA Headquarters)

A Note About the Need for Dual Control of N and P



EPA United States Environmental Protection Agency | Office of Water | EPA - 820-S-15-001 | MC 4304T | February 2015

Preventing Eutrophication: Scientific Support for Dual Nutrient Criteria

Summary

Nutrient pollution resulting from excess nitrogen (N) and phosphorus (P) is a leading cause of degradation of U.S. water quality. The scientific literature provides many examples that illustrate the effects of both N and P on instream and downstream water quality in streams, lakes, estuaries, and coastal systems. Development of numeric nutrient criteria for both N and P can be an effective tool to protect designated uses in the

water quality standards and are an effective tool for preventing nutrient pollution, for example, in helping to derive numeric limits in discharge permits. Development of numeric nutrient criteria is one aspect of a coordinated and comprehensive approach to nutrient management [7]. EPA has published several guidance documents to assist states and authorized tribes in deriving numeric nutrient criteria for both N and P to protect aquatic systems [8,9,10,11,12].

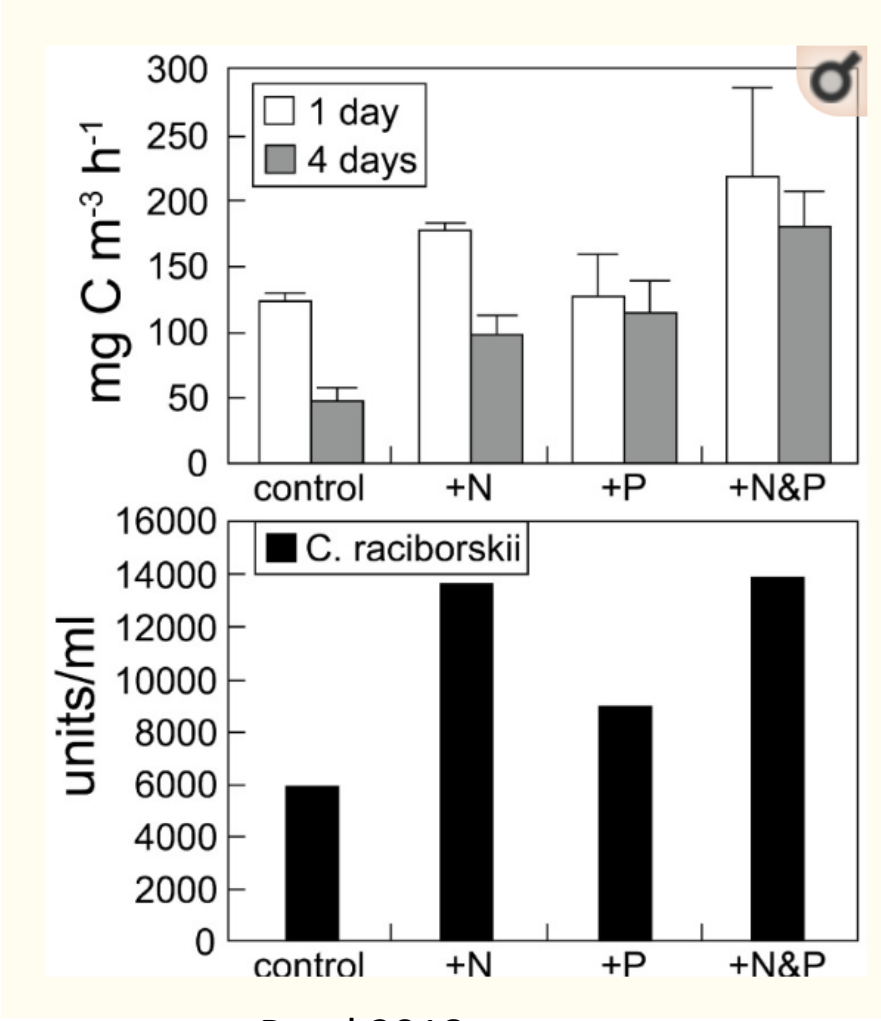
https://www.epa.gov/sites/production/files/documents/nandpfactsheet.pdf

Main points

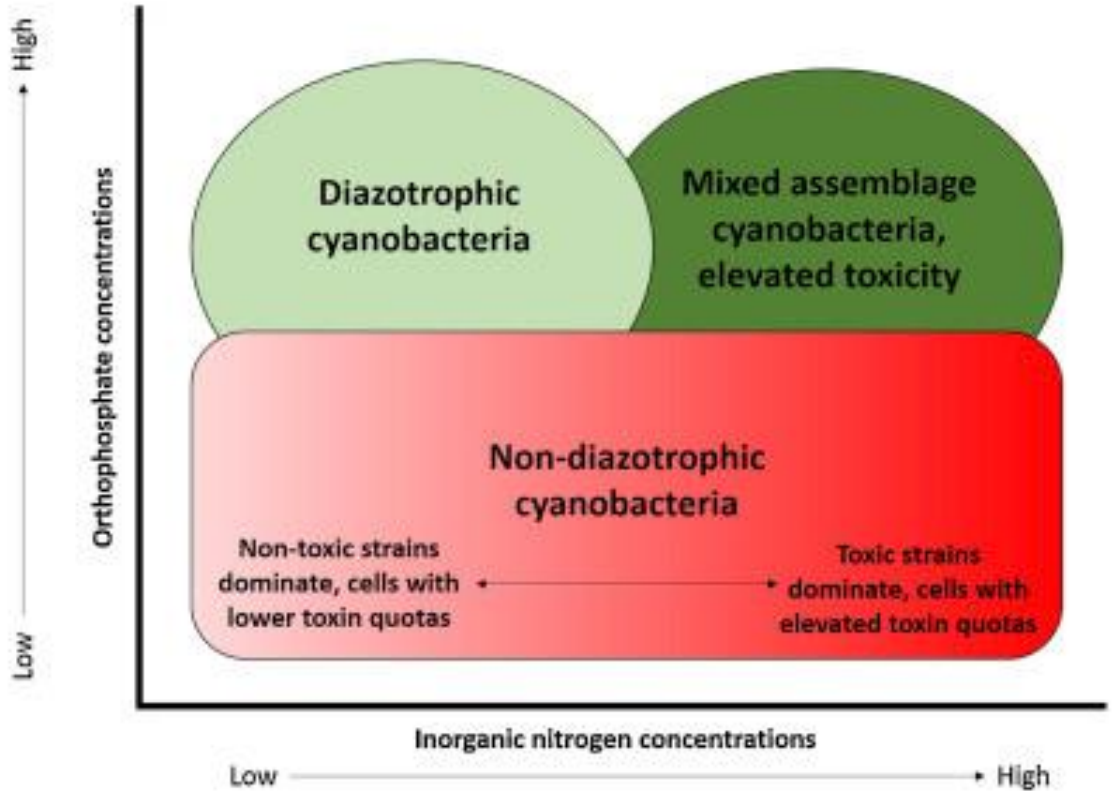
- Trophic status can vary in space and time
- N and P in excess typically result in the highest rates of primary production
- Cyanobacteria dominance can be supported by N and/or P in excess
- DS protection typically requires control of both N and P

Dual N and P Control

- cyanobacteria (as well as algae/ net primary production) thrive with abundant excess reactive N and P together



Paerl 2018



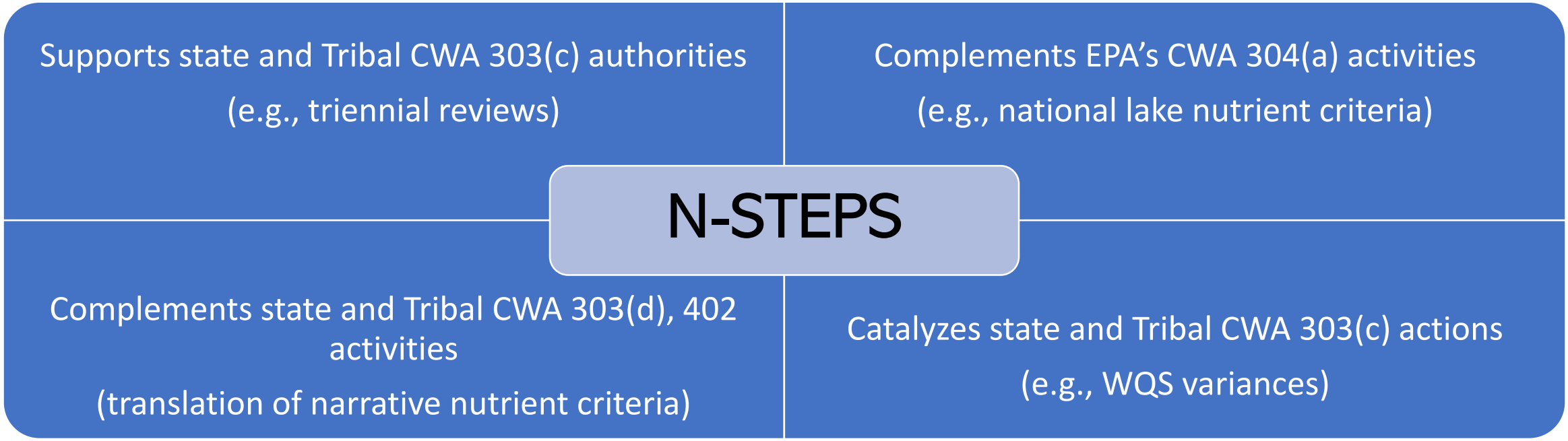
Gobler et al. 2016

Download : Download high-res image (292KB)

Download : Download full-size image

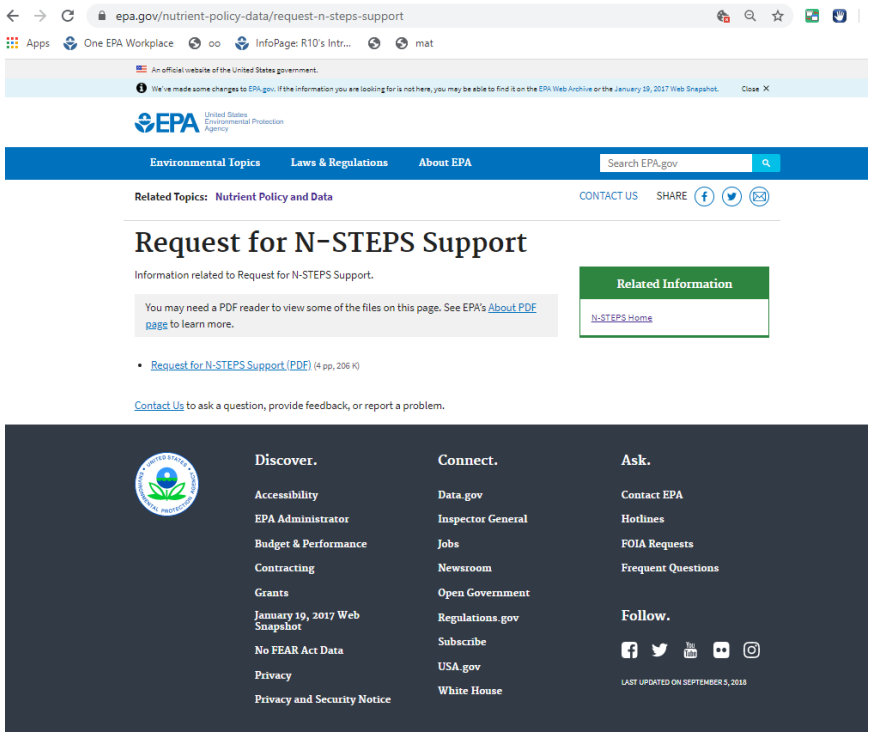
N-STEPS[1] (b. 2005): Scope and Role

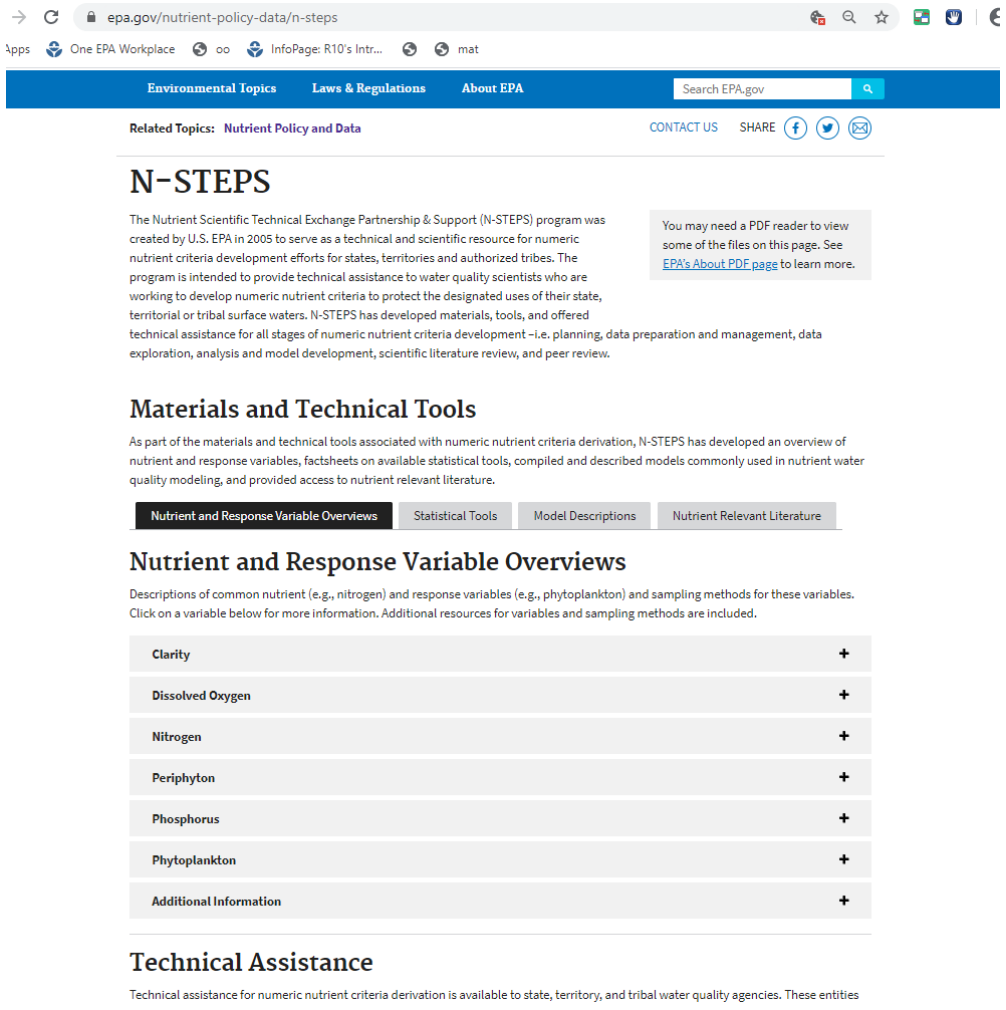
- Broad geographic scope – all surface water types, state-wide, site-specific
- Broad technical scope – data acquisition, analysis, model development, technical writing
- Collaborative partnerships – EPA Regions, state and Tribal agencies, other federal partners



N-STEPS

https://www.epa.gov/nutrient-policy-data/n-steps





Previous N-STEPS work

WA NSTEPS for Streams – Example Results

periphyton diatom assemblage sensitive indicator to nutrient pollution

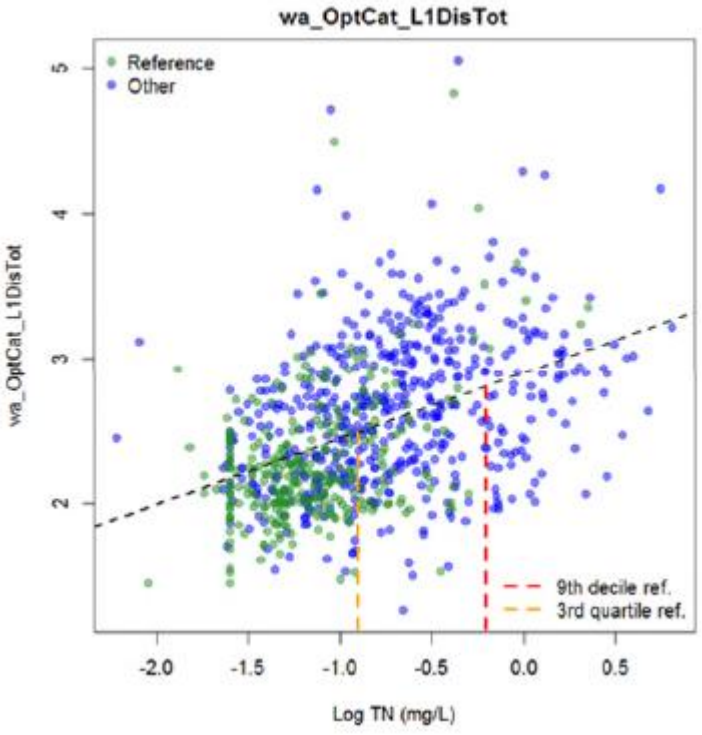


Table 3 - TN endpoints interpolated from periphyton metric regression models as responses to TN for all reference sites. All linear regressions presented were statistically significant ($p < 0.001$) in the proper response direction (ecologically sound). Rho = spearman's correlation coefficient, b = regression intercept, m = regression slope, r^2 = variance explained by regression, q = percentile of deciles (90th) and quartiles (75th), TN90 and TN75 are the interpolated log-base TN values (first value) and back-transformed values (second value) associated with the reference percentile of each metric. Metrics and metric sources are explained in the Methods and in Appendix 3. Results for other metrics are shown in Appendix 5.

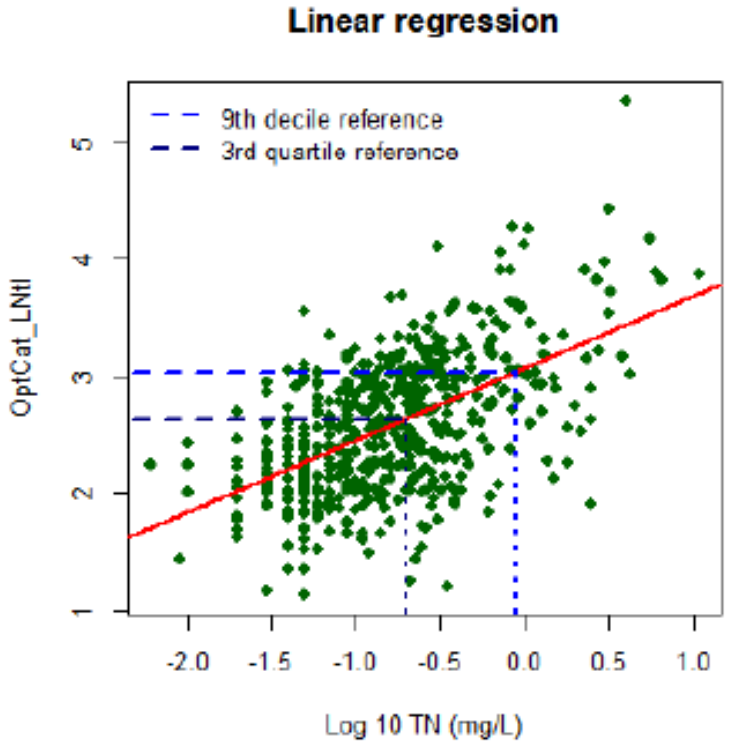
Metric	Abbreviation	rho	intercept	slope	r2	q90	TN90		q75	TN75	
TN Optima Index	wa_OptCat_LNtl	0.46	2.73	0.45	0.21	2.68	-0.11	**0.78**	2.28	-1.01	**0.10**
% Disturbed Land Index	wa_OptCat_L1DisTot	0.45	2.90	0.45	0.19	2.81	-0.21	**0.62**	2.49	-0.91	**0.12**
Multivariate Disturbed Land Index	wa_OptCat_DisTotMMI	0.38	2.52	0.48	0.14	2.57	0.10	**1.26**	2.15	-0.77	**0.17**
TN and TP Index	wa_OptCat_NutMMI	0.37	2.49	0.46	0.14	2.56	0.16	**1.45**	2.16	-0.71	**0.19**
Embeddedness Index	wa_OptCat_XEMBED	0.36	2.24	0.42	0.15	2.15	-0.22	**0.60**	1.84	-0.94	**0.11**

Table 4 – TP endpoints interpolated from periphyton metric regression models as responses to TP. All other details as in Table 3.

Metric	Abbreviation	rho	intercept	slope	r2	q90	TP90		q75	TP75	
TP Optima Index	wa_OptCat_L1Ptl	0.67	3.31	0.72	0.41	2.52	-1.10	**0.080**	2.07	-1.72	**0.019**
TN and TP Index	wa_OptCat_NutMMI	0.65	3.36	0.71	0.38	2.57	-1.11	**0.078**	2.18	-1.66	**0.022**
Multivariate Disturbed Land Index	wa_OptCat_DisTotMMI	0.63	3.34	0.69	0.34	2.61	-1.05	**0.089**	2.16	-1.71	**0.020**
Embeddedness Index	wa_OptCat_XEMBED	0.58	2.86	0.56	0.30	2.15	-1.28	**0.052**	1.85	-1.81	**0.015**
Conductivity Index	wa_OptCat_LCond	0.57	3.18	0.61	0.27	2.58	-0.98	**0.106**	2.11	-1.74	**0.018**

OR NSTEPS for Streams – Example Results

- Large variety of endpoints provided over the wide range of possible MMI identified
- Focus on most significant MMI, and threshold of median reference response



ID NSTEPS for Streams- Example Results; includes aesthetic ratings

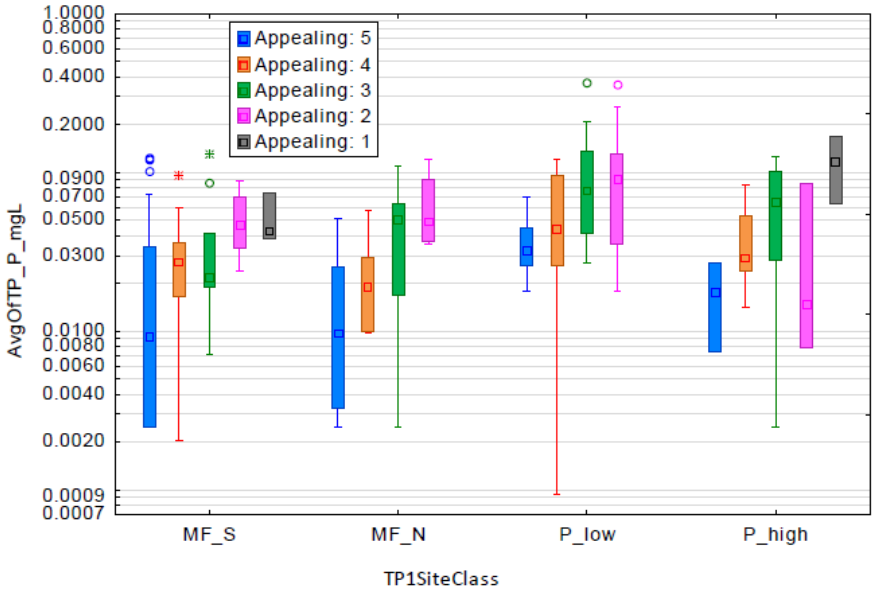
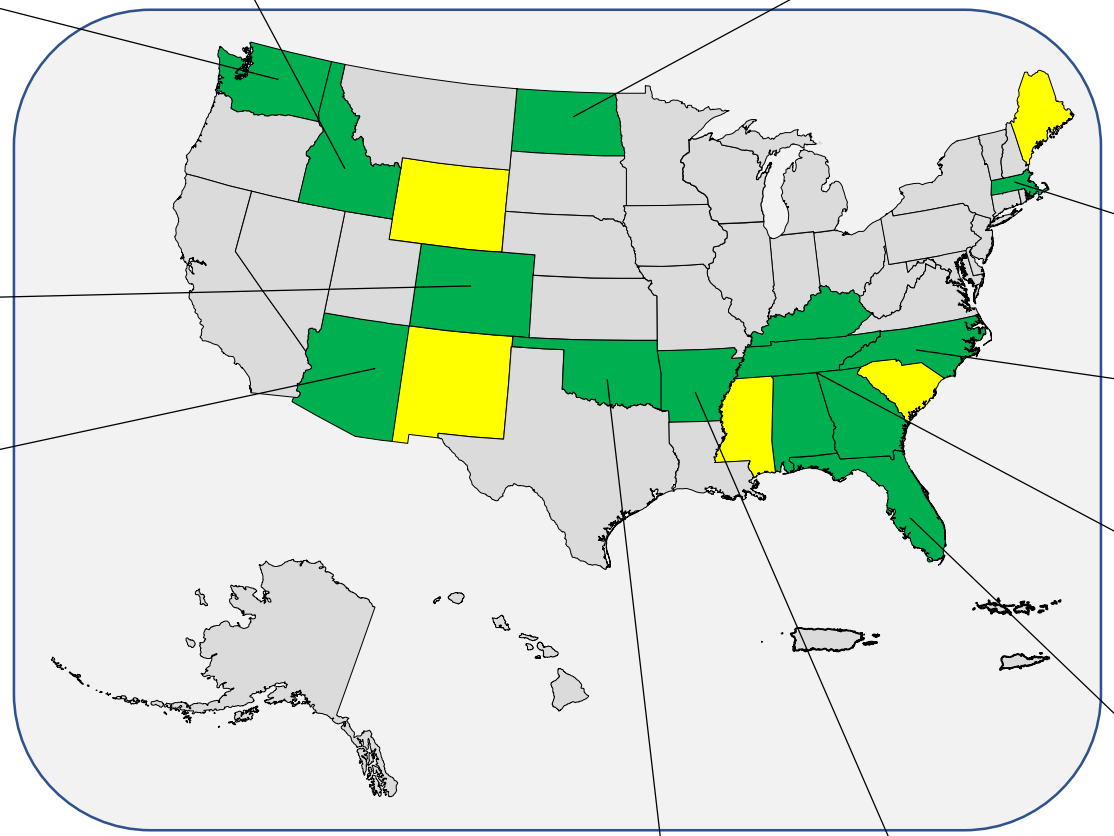


Figure 16. TP concentrations in aesthetic rating categories, by site class.

Table ES-1. Nutrient threshold values (mg/L) based on reference distributions, modeled reference, and stressor-response analysis for TP and TN in nutrient site classes.

TP	MF_N	MF_S	P_high	P_low
Reference Distribution 75th	**0.011**	**0.019**	**0.025**	**0.046**
Reference Distribution 90th	0.015	0.035	0.033	0.082
Median CPA	**0.013**	**0.017**	0.043	**0.049**
Median Reference Regr. Interp.	0.004	**0.018**	0.017	0.131
Median non-reference Regr. Interp.	0.017	0.028	0.061	0.076
Potential Threshold Range	0.011-0.013	0.017-0.019	0.025	0.046-0.049
TN	**North**	**S_hi_E**	**S_hi_W**	**S_low**
Reference Distribution 75th	**0.15**	**0.38**	**0.22**	0.58
Reference Distribution 90th	0.26	0.45	**0.24**	0.81
Median CPA	0.76	**0.31**	**0.13**	1.29
Median Reference Regr. Interp.	**0.14**	**0.30**	**0.14**	na
Median non-reference Regr. Interp.	1.04	1.55	0.44	na
Potential Threshold Range	0.14 - 0.15	0.30 – 0.38	0.13 - 0.24	0.58 - 0.81

Current N-STEPS work

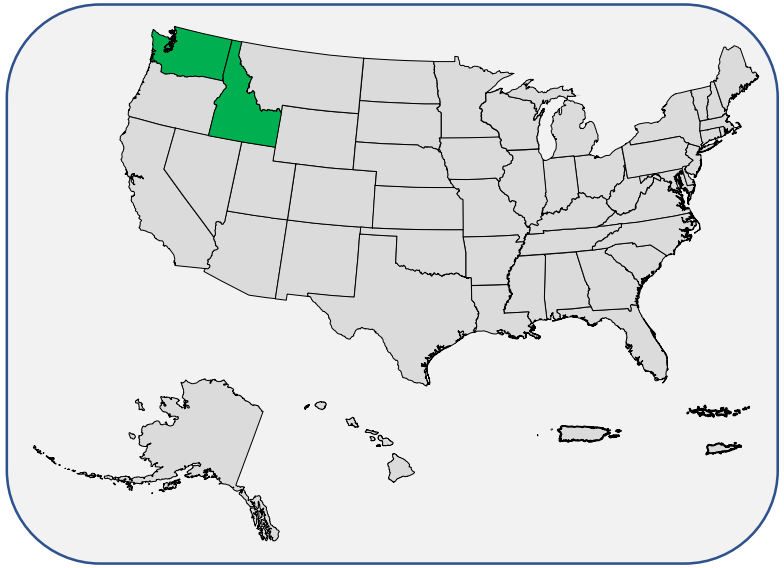

Coeur d'Alene Tribe, Lake Coeur d'Alene
Idaho lakes and reservoirs
North Dakota lakes and reservoirs
Lummi Nation streams and marine waters
Massachusetts estuarine and coastal waters
Colorado lakes and reservoirs
North Carolina coastal waters
Arizona streams
Alabama-Georgia-Kentucky-Tennessee streams
Florida tidal waters
Arkansas streams
Oklahoma lakes and reservoirs

Lummi Nation (Washington), streams and marine waters

- Nutrient criteria to protect aquatic life
- FY18/19 N-STEPS
  - Estimated least-disturbed nutrient conditions
  - Conducted stressor-response modeling
  - Completed report
- R10 exploring local 3-D models in marine waters

Coeur d'Alene Tribe (Idaho), Lake Coeur d'Alene

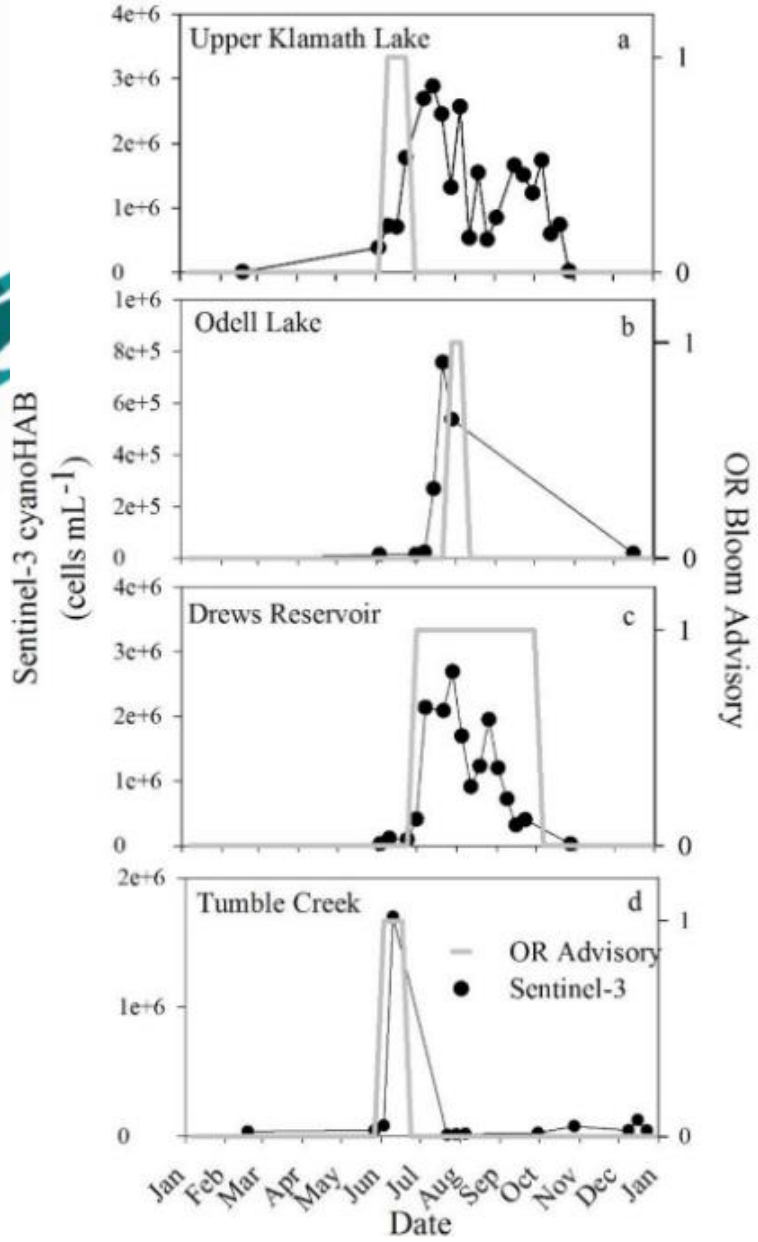
- Nutrient criteria to protect aquatic life
- FY18/19 N-STEPS
  - Lake data analyses for local conditions
- Stressor-response modeling with CyAN data (collaboration with EPA ORD's CyAN project)



Region 10

Idaho lakes and reservoirs

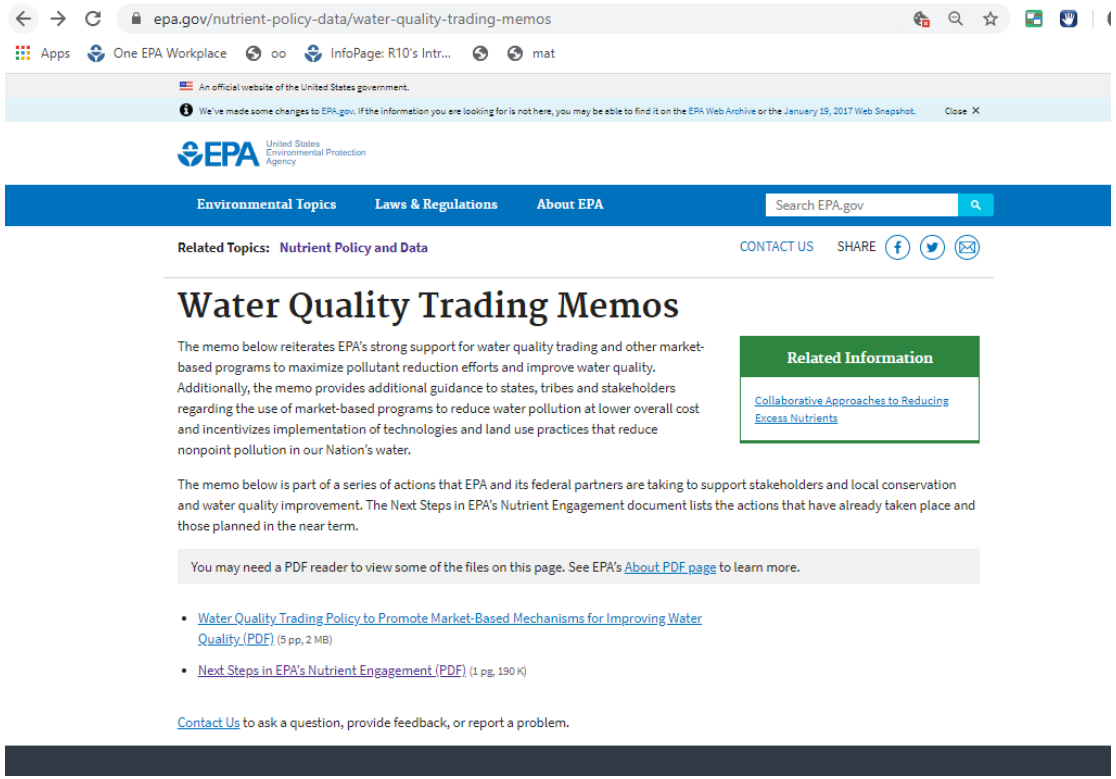
- Nutrient criteria translation to protect HABs-impacted waterbodies (human health and ecological endpoints)
- FY18/19 N-STEPS
  - Data acquisition and analyses
- Exploring watershed predictors of harmful algal bloom risk in downstream lakes and reservoirs (collaboration with EPA ORD's CyAN project)



App at google play store for android devices. Desktop tool under development

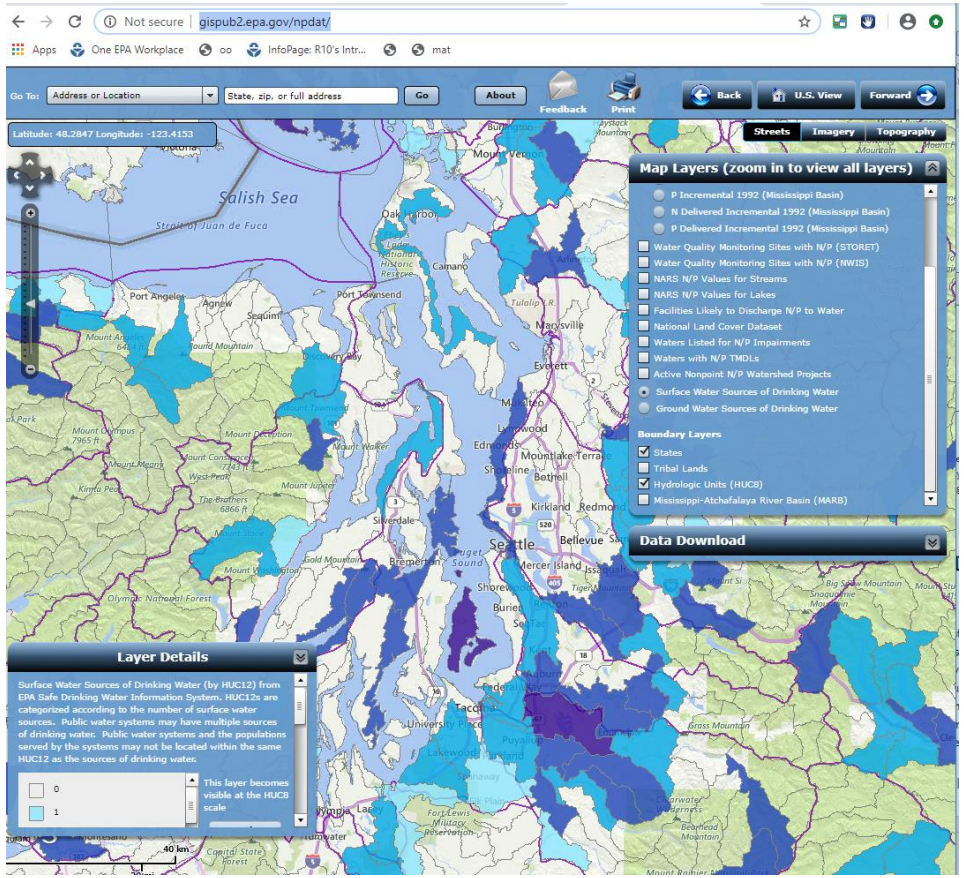
https://www.epa.gov/water-research/cyanobacteria-assessment-network-mobile-application-cyan-app

Challenges - Implementation

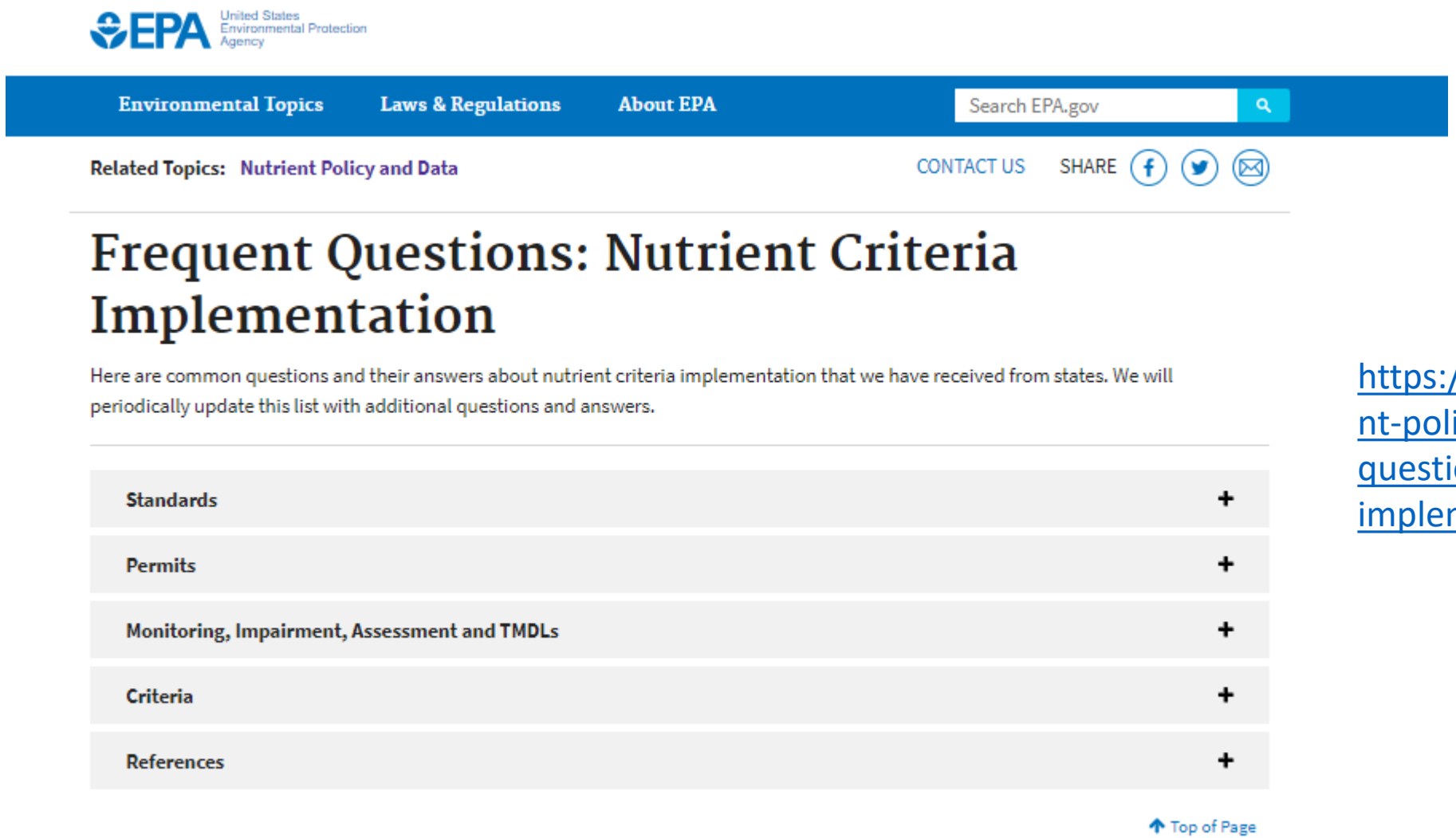


Trading Policy – R10 contact is Claire Schary: schary.Claire@epa.gov

https://www.epa.gov/nutrient-policy-data/water-quality-trading-memos



NP Dat: https://gispub2.epa.gov/npdat/



https://www.epa.gov/nutrient-policy-data/frequent-questions-nutrient-criteria-implementation

Regional examples of creative implementation

Dixie Drain, Boise River, Idaho

Additional Sources of Technical Assistance or Other Support

- RTAG for Nutrients: planning for 2021 meeting
- Contractor technical support (as resources allow) for nutrient management planning projects- ask Rochelle
- R10 Laboratory – accredited laboratory for LC MS MS and ELISA methods for certain cyanotoxins

EPA Nutrients Research Page
https://www.epa.gov/water-research/nutrients-research

Contact

- Rochelle Labiosa –R10 Nutrients Coordinator and HABs Lead for Ambient Waters Labiosa.Rochelle@epa.gov 206-553-1172