A DISCUSSION REGARDING WATER QUALITY STANDARDS FOR FLATHEAD LAKE

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Prepared For:
Flathead Lake Standards Advisory Group
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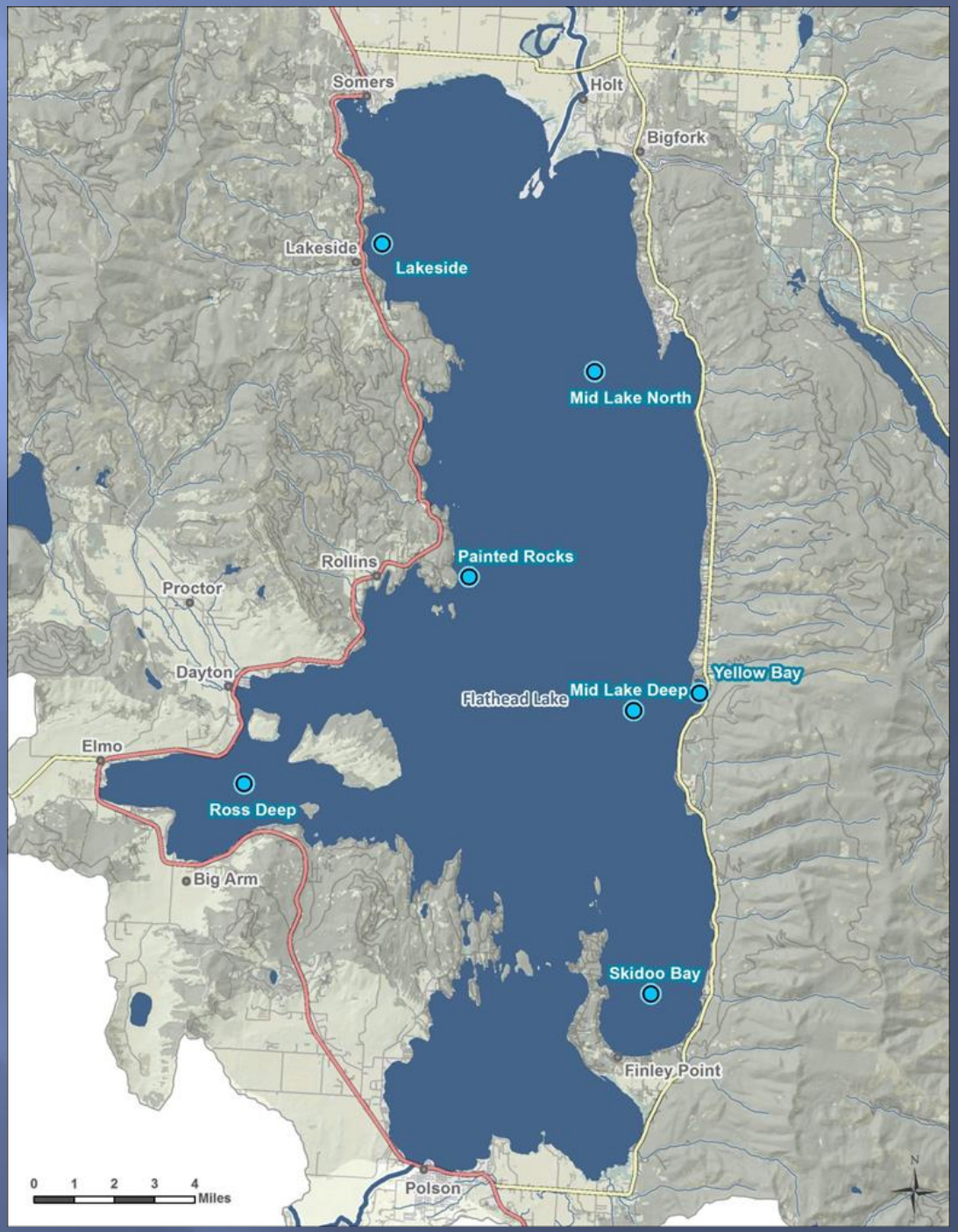
Issues for Us to Consider

- Which criteria as WQ standards?
- The level at which the standards are set
  - May need new beneficial use ("unique scenic beauty")
- Compliance point
  - Midlake Deep ideal, however:
    - On CSKT part of lake
- Implication for dischargers
  - Lake models necessary to allocate loads
    - DEQ: intermediate or complex in-lake model
    - FLBS food-web model
- Public outreach & formal adoption process

Background

- **1970s -present**: Scientific studies by UM's Flathead Lake Biological Station, others
- **1980s**: Basin-wide P ban, Flathead Basin Commission
- **1992-1998**: Flathead TMDL Team develop lake targets
  - Team comprised local, state, federal, and tribal agency representatives, scientists, and other stakeholders
- **2001, 2014**: TMDL Phase I, Phase II
  - Phase II for nutrients pending; reliant on outcome of standards process
- **2014**: DEQ proposes standards to BER for adoption; withdrawn due to concerns about insufficient upfront public input
  - TP, TN, chlorophyll *a*, and secchi depth

Midlake Deep
(and other sampling sites)



Water Quality Parameter	Provisional Recommendations of the Flathead TMDL Team (1995)	Final Recommendations of the Flathead TMDL Team (1998)	Proposed Standards in Circular DEQ-12A (2014)
Total phosphorus (TP)(µg/L)	5.5	5.0	5.0
Total nitrogen (TN)(µg/L)	98	95	95
Phytoplankton chlorophyll *a* (µg/L)	1.01	1.0	1.0
Secchi depth (meters)	10.8	n/a	10.4
Primary productivity (g C/m^2/year)	n/a	70[a]	n/a
Soluble reactive phosphorus (µg/L)	n/a	<0.5	n/a
Nitrate plus nitrite (as N)(µg/L)	n/a	30.0	n/a
Ammonia, as N (µg/L)	n/a	<1.0	n/a
Dissolved oxygen in hypolimnion	n/a	No declining trends	n/a
Algae blooms	n/a	No measurable blooms	n/a
Algal biomass on near-shore rocks	n/a	Stable or declining trend, measured as Chl*a* /m^2	n/a

[a]The Flathead Basin Commission later raised this value to 80 g C/m^2/yr because it was considered interim and could be adjusted later if other targets were not being met.

Setting water quality standards is about establishing the desired condition for the waterbody (within its natural capabilities)

Flathead Lake's class and beneficial uses

- A-1 Use Class: highest level of protection afforded a state water

Water quality standards are normally established below a threshold beyond which harm to the most sensitive beneficial use would occur

- A-1 beneficial uses include:
  - drinking after conventional treatment
  - swimming/recreation
  - growth & propagation of salmonid fishes and associated aquatic life
  - waterfowl
  - agriculture

Criteria thresholds particular to existing beneficial uses

Use(s) Protected:	All	Lake trout fishery	Recreation and aesthetics	Aquatic life & recreation
Source/Objective:	Standards DEQ proposed for Flathead Lake in 2014 (maintain conditions circa 1977 to early 1990s)	Prevent lake trout from a steep decline*†	Lake Champlain aesthetics study. Secchi depth would maintain clarity between 'beautiful' and 'slightly impaired' level*‡	Minnesota standards for Designated Lake Trout Lakes (Class 2A)**
Total P (µg/L)	**5.0**	6.0	6-7	12
Total N (µg/L)	**95.0**	185	200	n/a
Chlorophyll a (µg/L)	**1.0**	1.0	2	3
Secchi depth (m)	**10.4**	8.0	5.0	≥ 4.8

*Rast & Lee (1978)
†Heiskary & Wilson (2008)
‡Smeltzer & Heiskary (1990)
**Adopted Standards for Minnesota (Minn R. 7050.0222)

Standards linked to current beneficial uses are less protective than standards which maintain the lake's earlier/existing conditions

A new beneficial use

"Unique Scenic Beauty"

- Flathead Lake's standards could be associated with this use at levels which maintain historic and current water clarity

- Would be incorporated in rule (ARMs)

Which standards to adopt?

DEQ is relying on the large body of northern temperate lake studies to help identify appropriate standards

- **secchi depth**
- **phytoplankton chlorophyll *a***
- **total P**
- **total N—likely; needs careful review**

Other parameters that have been considered:

- **Primary productivity**
- **Soluble nutrients**
- **Shoreline algal biomass** ☑

Primary productivity and chlorophyll *a*

Primary productivity = *Speed plants grow over a length of time*

TIME (6 weeks)

Primary productivity and chlorophyll *a*

TIME (6 weeks)

Primary productivity = *Speed plants grow over a length of time*

Primary productivity and chlorophyll *a*

TIME (6 weeks)

Primary productivity = *Speed plants grow over a length of time*

Phytoplankton chlorophyll *a* = *Standing crop*

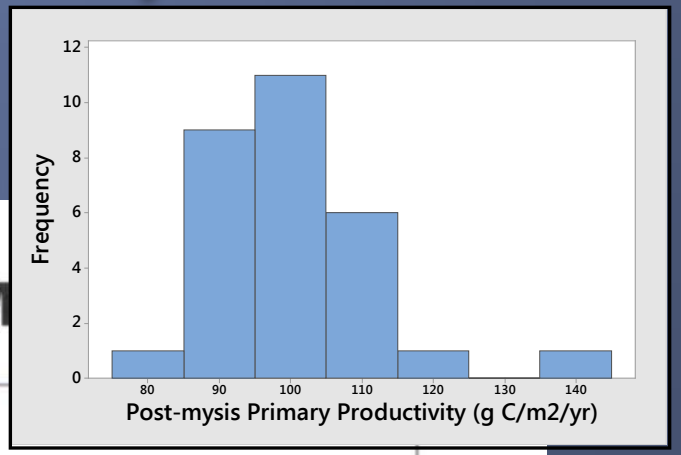
Primary productivity and chlorophyll *a*

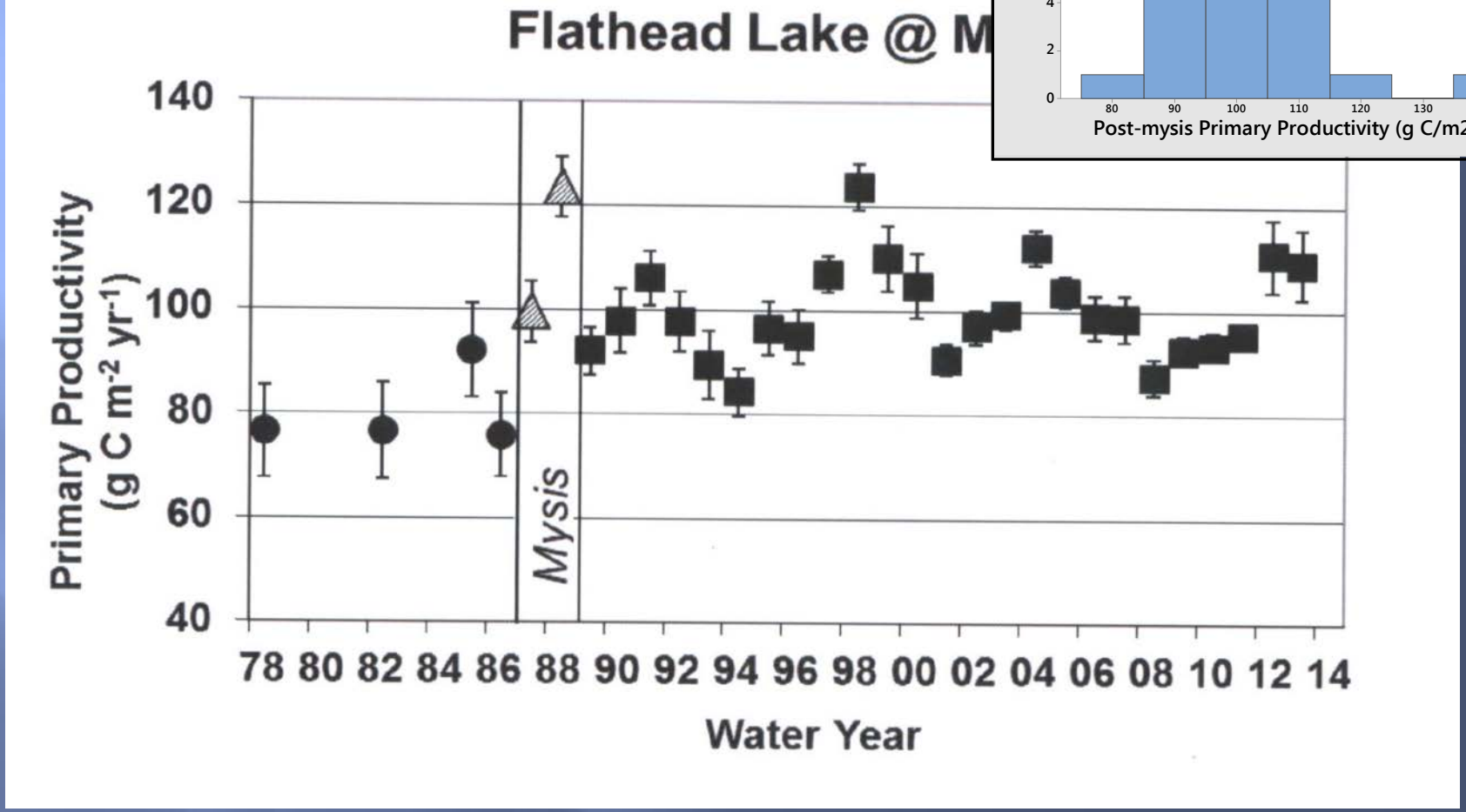
Primary productivity = *Speed plants grow over a length of time*

Phytoplankton chlorophyll *a* = *Standing crop*

Standing crop can be low at a high primary productivity if utilized (grazed)

Primary productivity 1978-2013

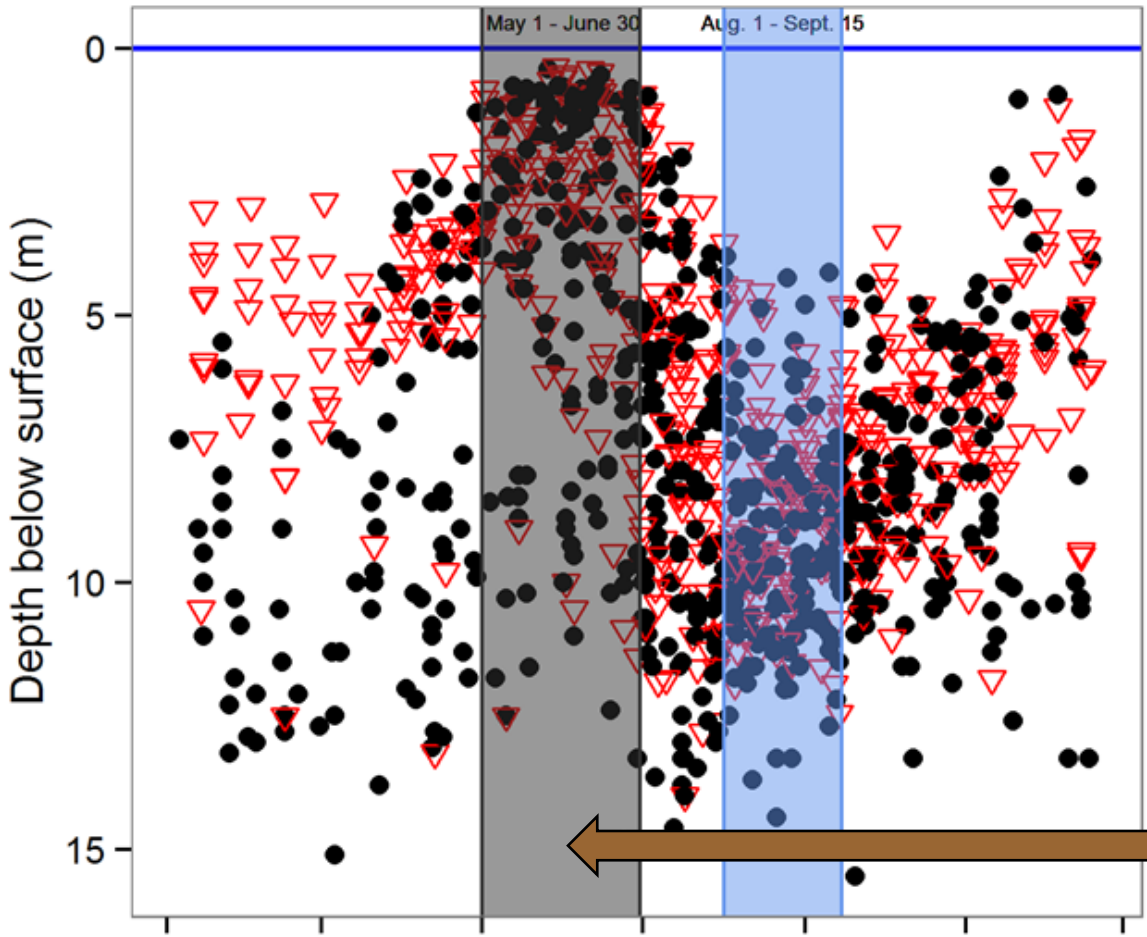




From: Ellis, B. *State of the Lake: Update on Water Quality in Flathead Lake for the 2013 Water Year.*

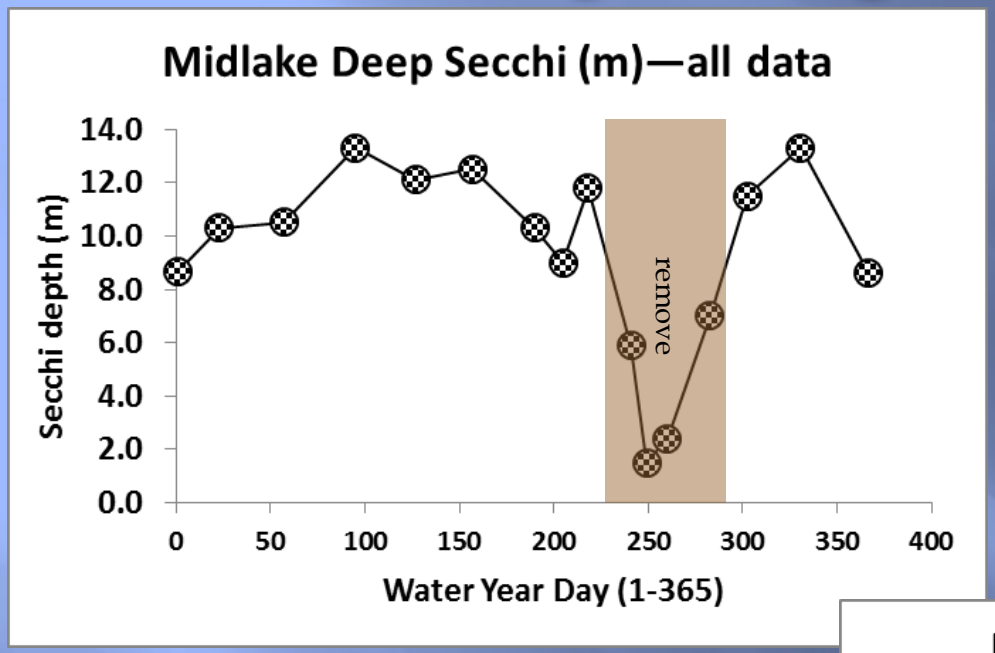
Flathead Lake secchi depth across the year

Secchi Disc



Spring turbidity plume

Calculating average annual secchi depth



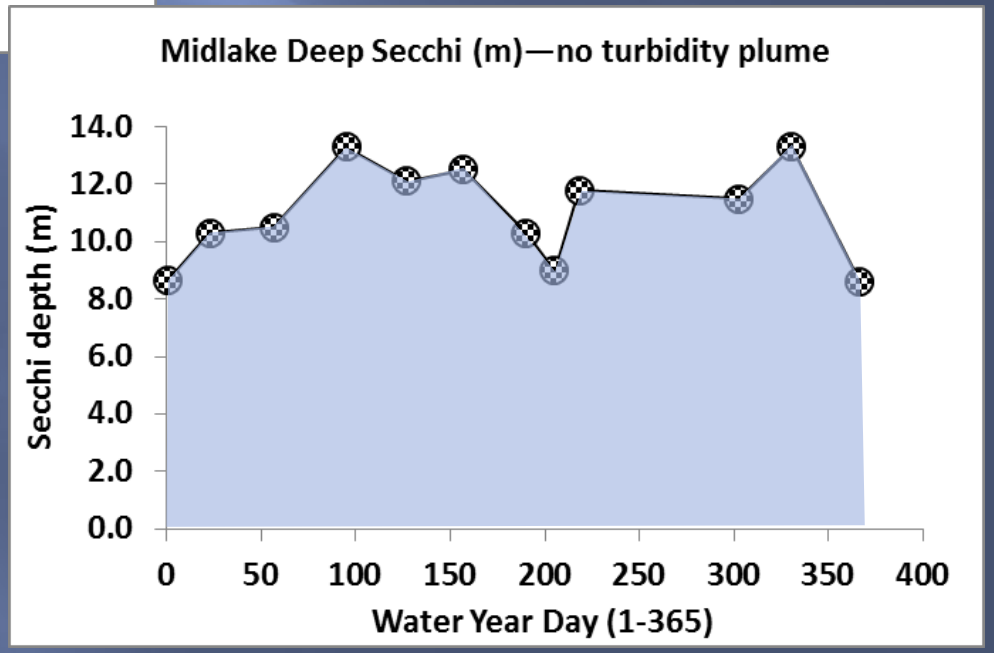
Water Year

October 1—September 30

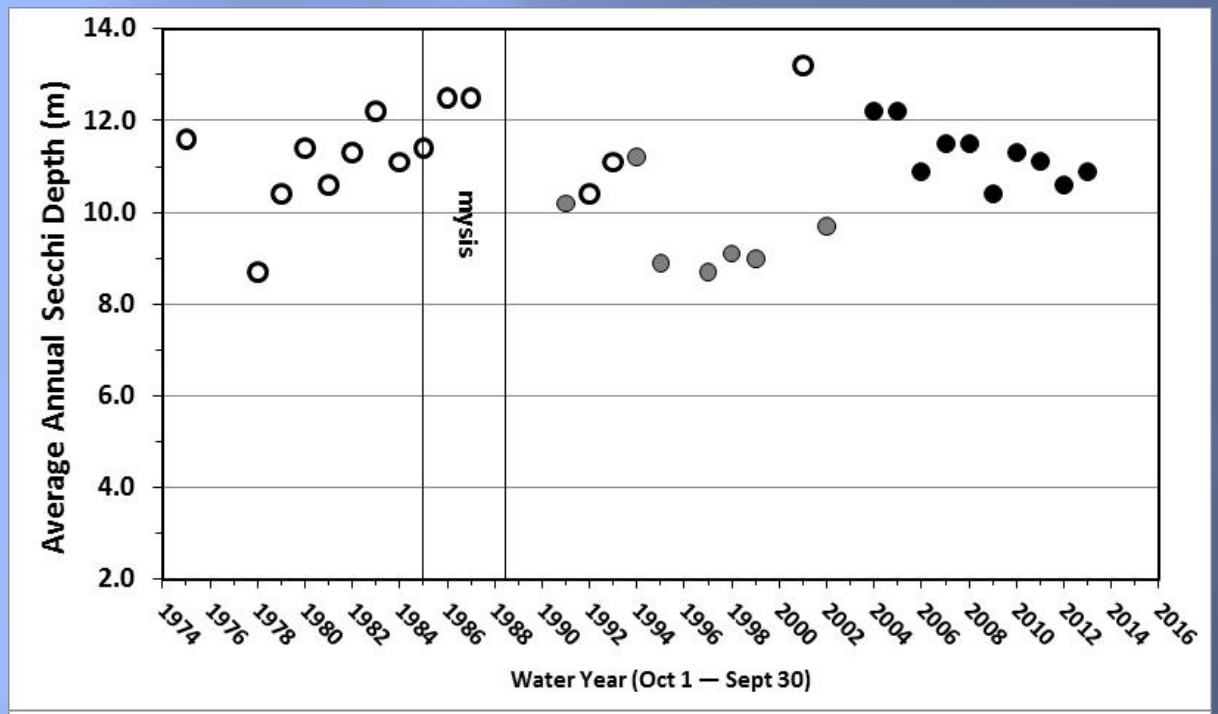
2008 average annual secchi depth (m) =

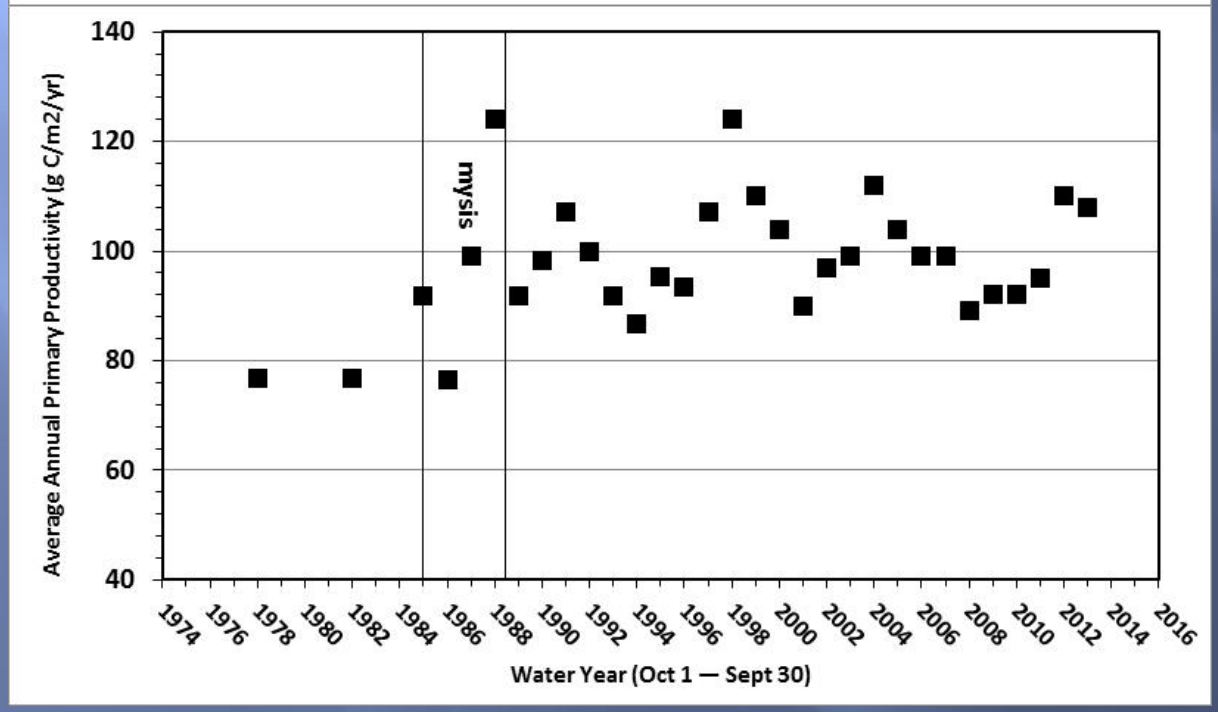
Integrated area (non-turbidity plume) ÷ 365

11.4 m



Time trends



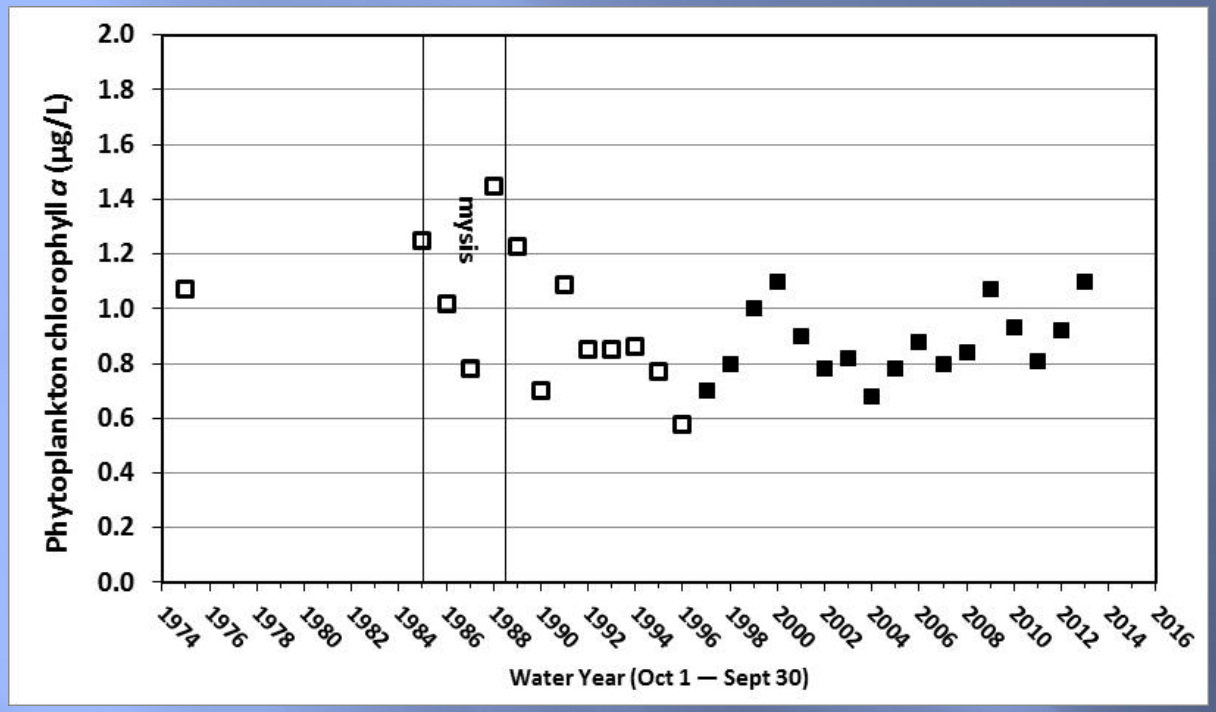


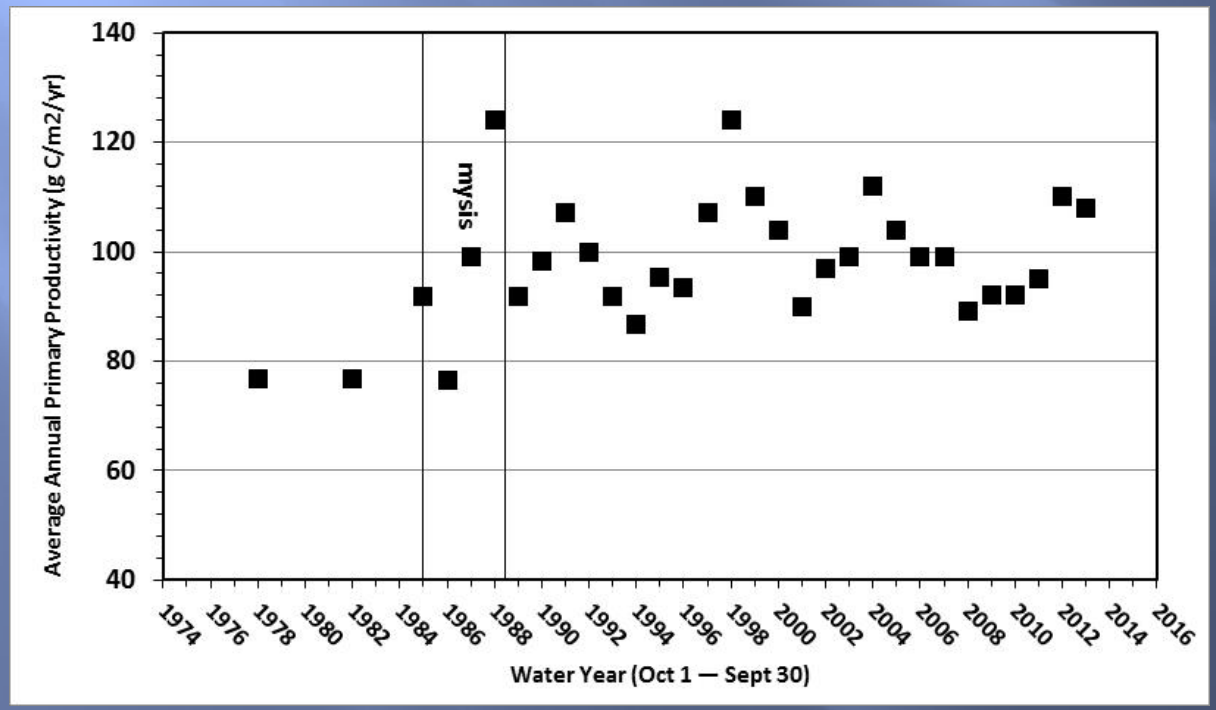
1975-2013
Average annual secchi depth and primary productivity

Filled (black): Biostation calc., Midlake Deep

Open: Suplee calc., Midlake Deep

Filled (gray): Suplee calc. , multiple sites >200 m from shore





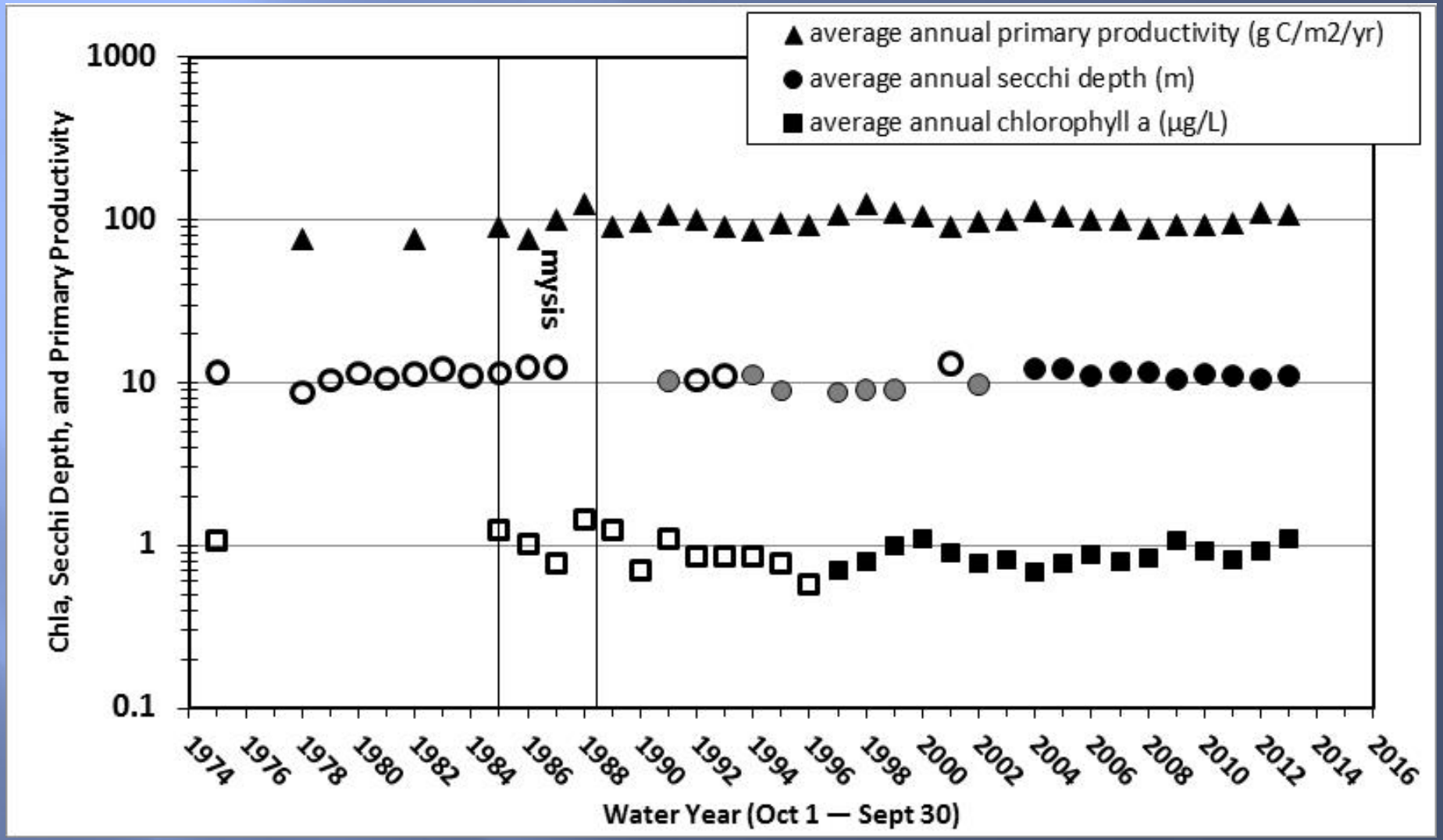
1975-2013

Average annual phytoplankton chlorophyll *a* and primary productivity

Filled: Biostation calc., Midlake Deep

Open: Suplee calc., Midlake Deep

Flathead Lake: Chlorophyll *a*, secchi depth, and primary productivity (1975-2013) on $\log_{10}$ scale



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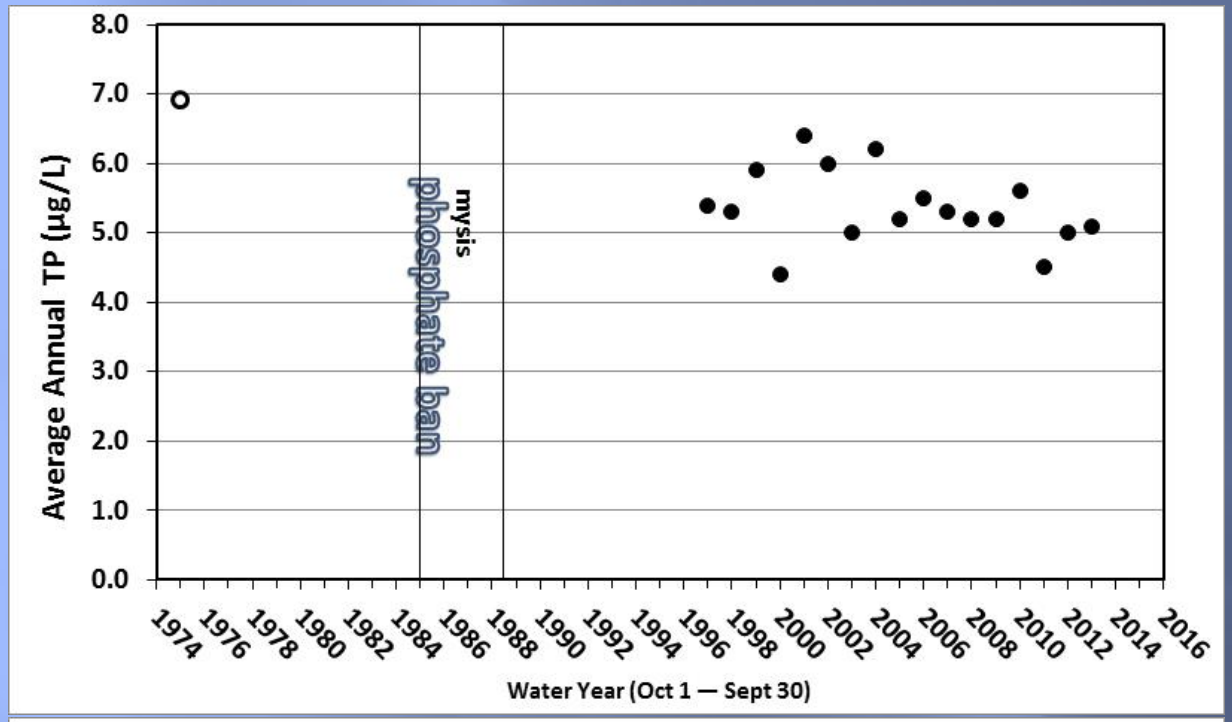
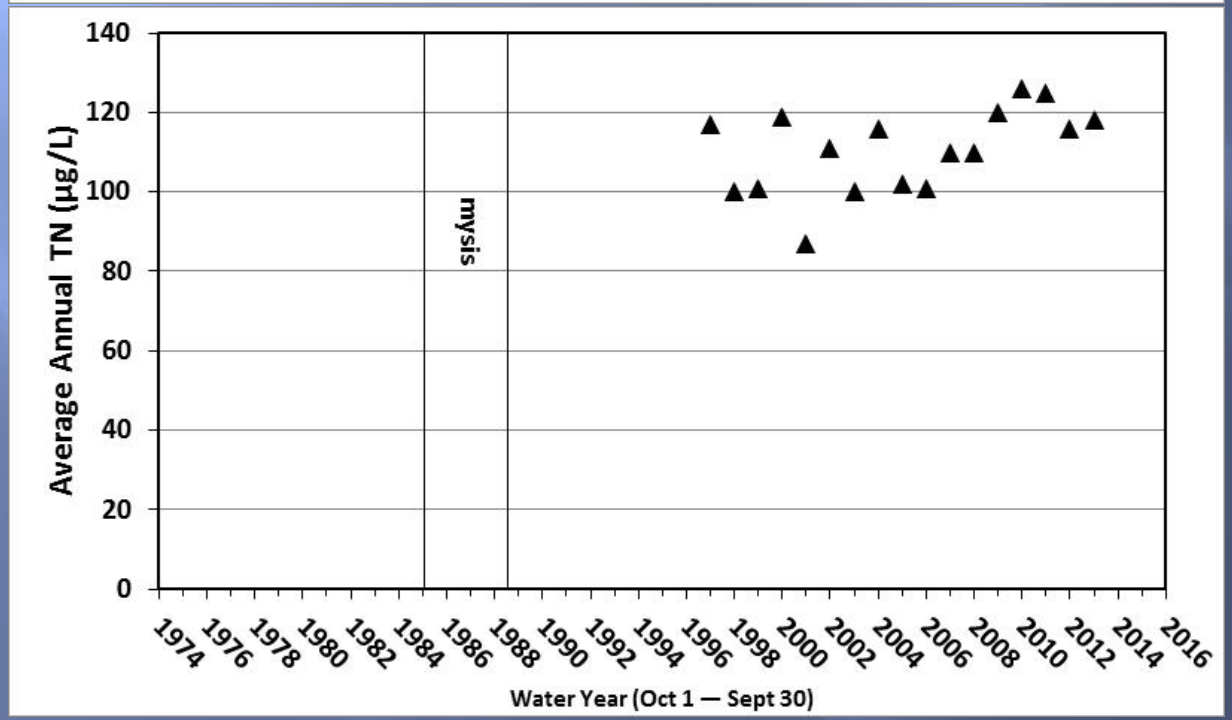




1975-2013:
Average annual total phosphorus, total nitrogen

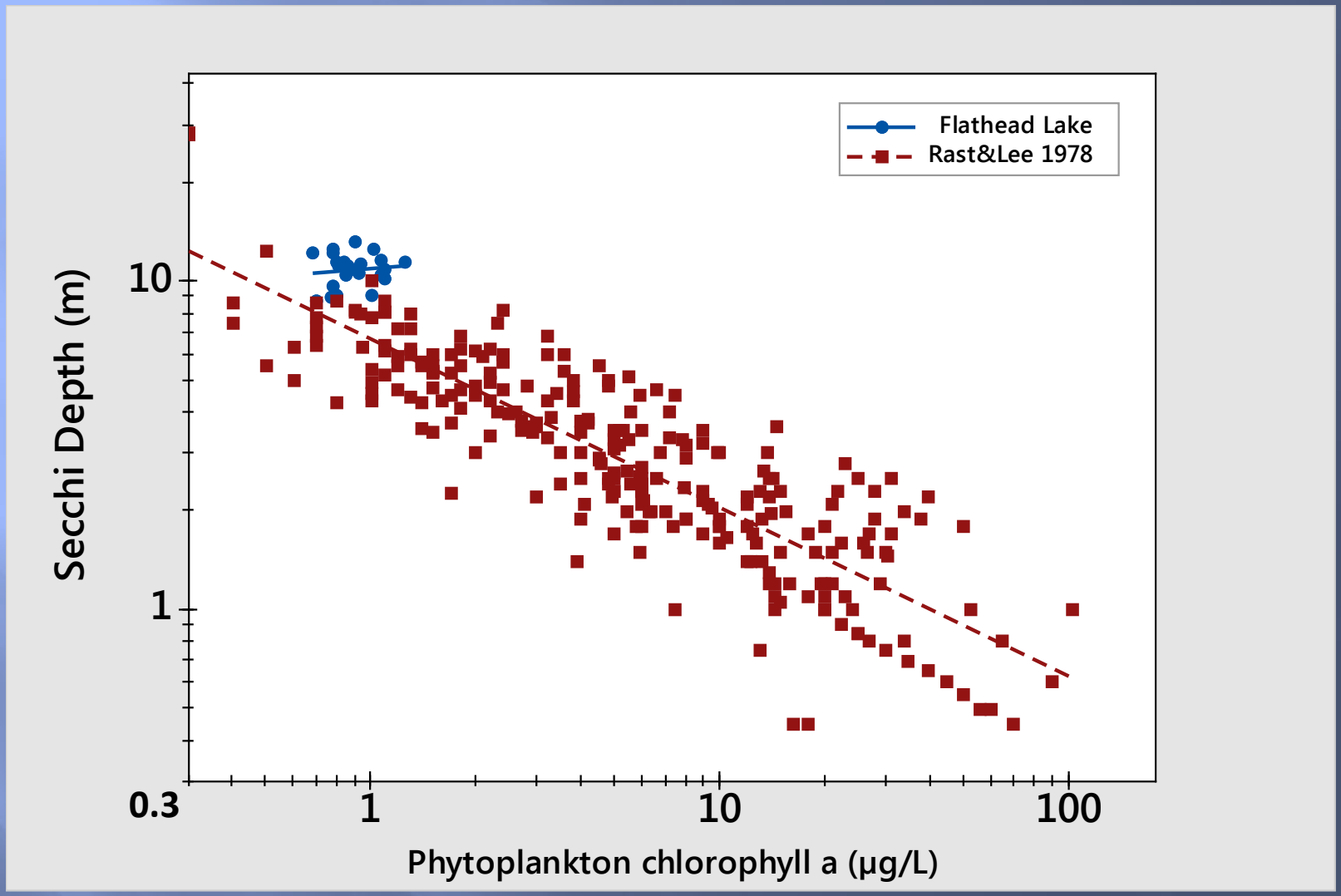
TN:TP ratio (mass)
Late 1980s: ~16:1
Today: 23:1

Filled: Biostation calc., Midlake Deep

Open: Suplee calc., Midlake Deep

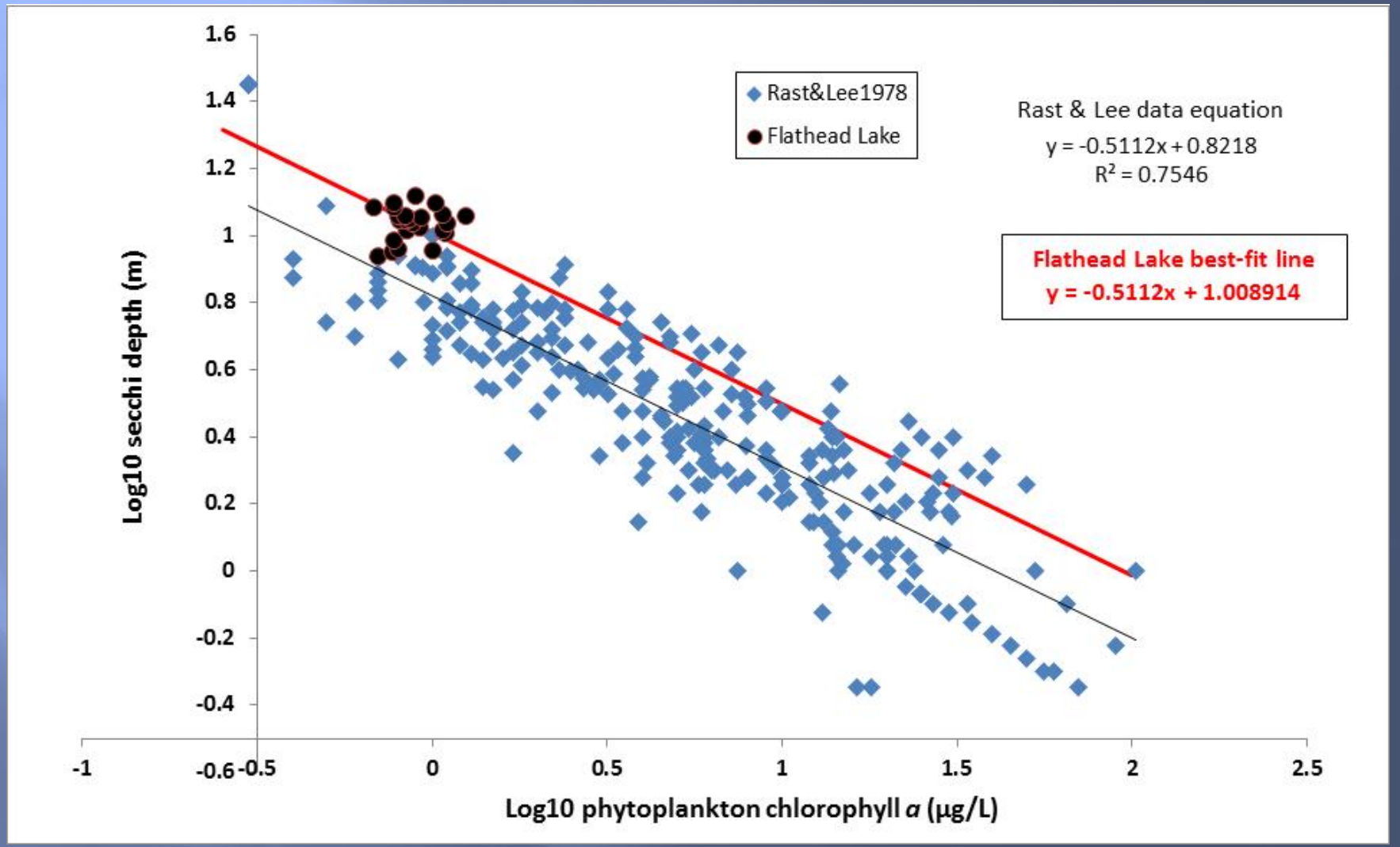
Secchi depth and primary productivity
- a closer look

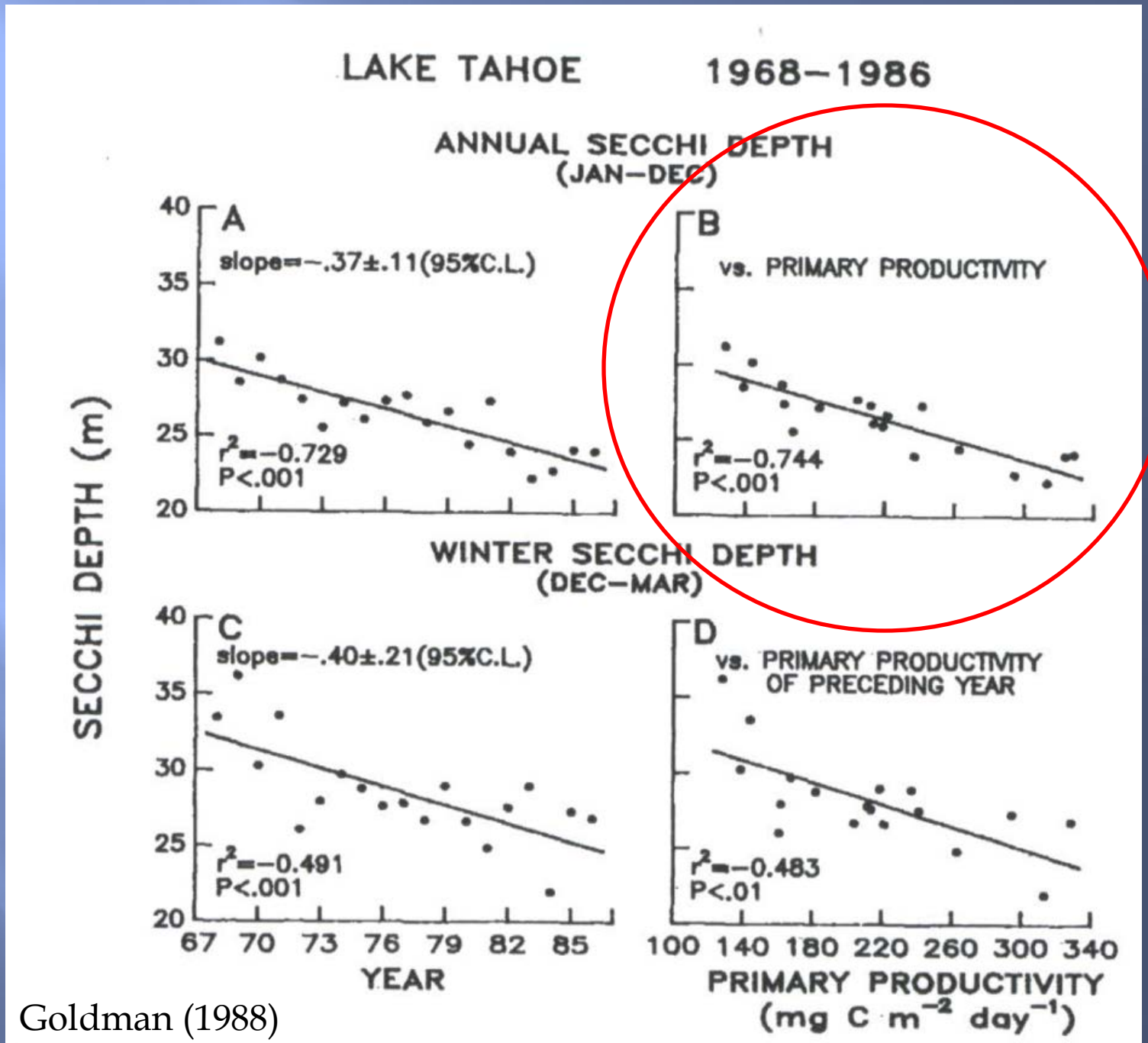
Secchi depth and phytoplankton chlorophyll *a* in lakes



Red data points from Table 27 *In* Rast, W., and G. F. Lee (1978). "Summary Analysis of the North American (US Portion) OECD Eutrophication Project: Nutrient Loading-Lake Response Relationships and Trophic State Indices". EPA-600/3-78-008.

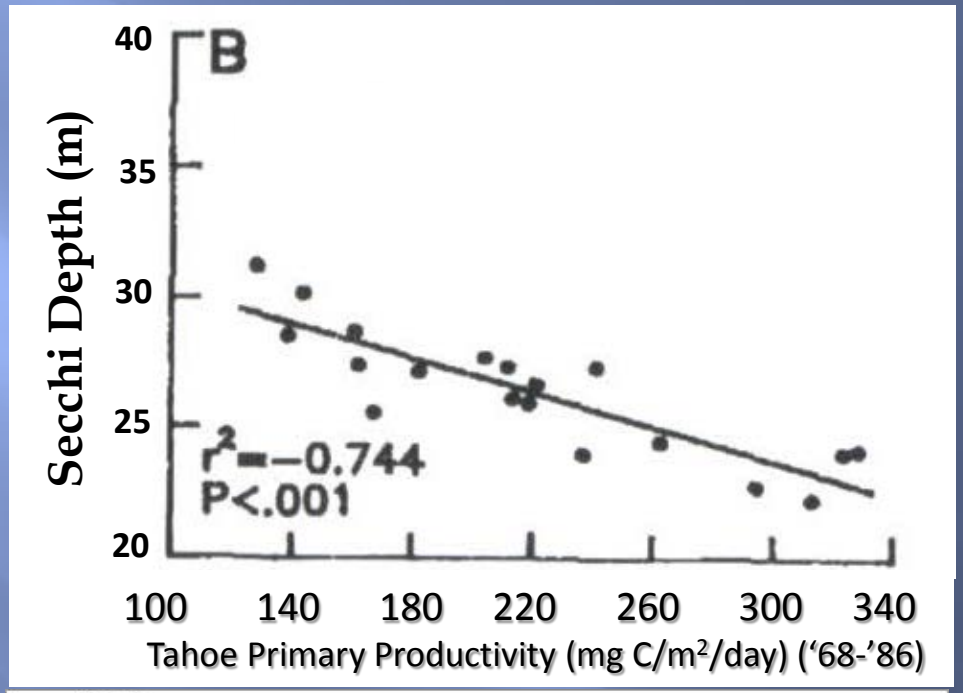
A chlorophyll *a* – secchi depth model for Flathead Lake

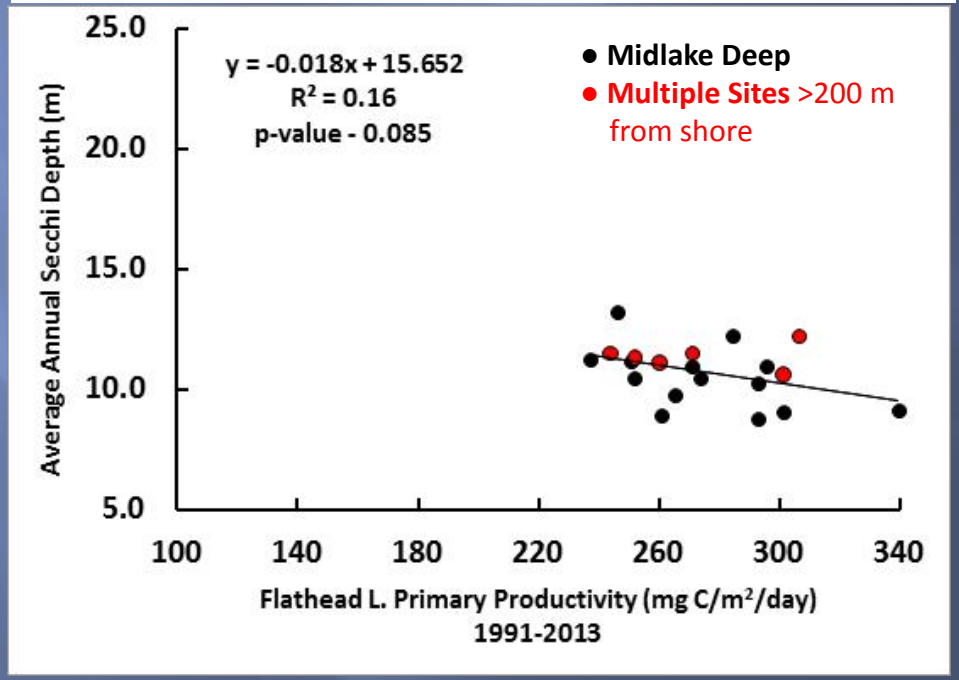




Goldman (1988)

Flathead Lake (post-*mysis*) Compared to Lake Tahoe





Note: Flathead's annual average productivity was converted to daily values to normalize the x-axes of the two figures.

Secchi depth is as useful a measurement as primary productivity, and…

- Easy, economical to measure
- One of the best overall parameters that the public could respond to for improved water quality
- Links directly to a highly-valued, widely recognized feature of Flathead Lake—its clarity

Evaluating candidate criteria linked to the unique scenic beauty use for Flathead Lake

(TP = 5 µg/L, TN = 95 µg/L, Chla = 1.0 µg/L, secchi = 10.4 m)

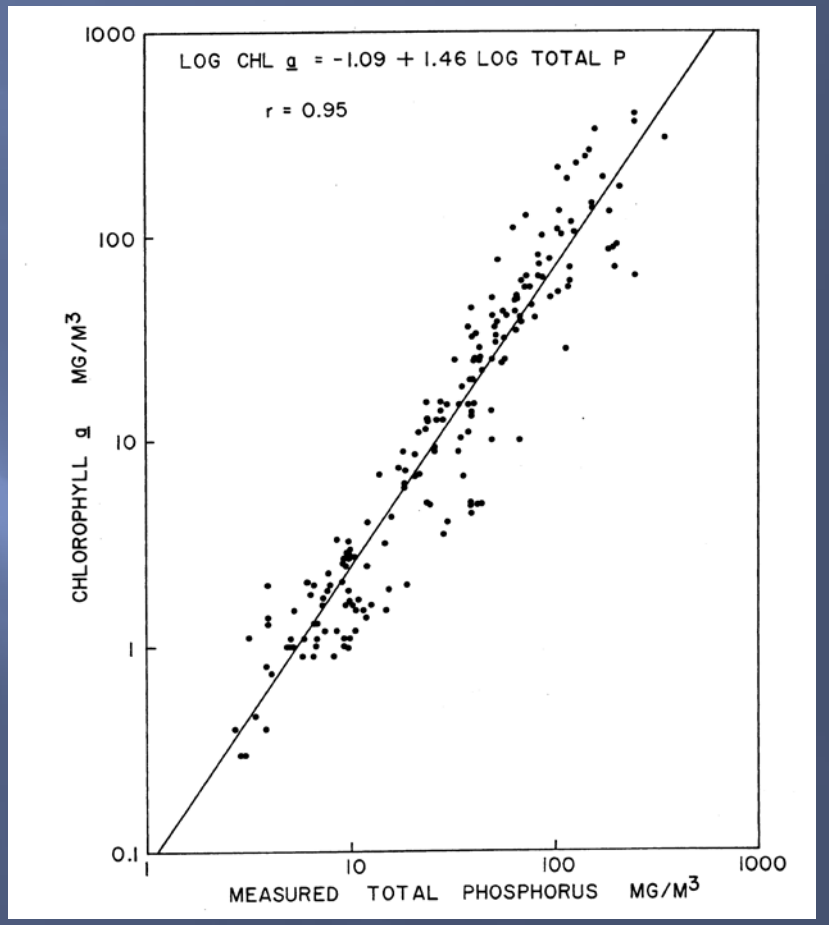
- Phytoplankton Chl*a* given the candidate TP criterion
  - Rast & Lee (1978), Jones & Backmann (1976), Bartsch and Gakstatter (1978), Currie (1990)-several equations
    - P-limited models, data sources were good fit to our datasets
- Phytoplankton Chl*a* given the candidate TP + TN criteria
  - Smith (1982): TN + TP multiple regression
    - Gives comparable weight to N and P (co-limitation)
- Carlson Trophic State Index (TSI; Carlson, 1977) for TP, TN, Chla, and secchi depth
- Flathead L. compared to Vollenweider P-loading model

- P-only models:
  - 5 µg TP/L = 0.9 to 2.3 µg Chl*a*/L (range)
    (average: 1.7 µg Chl*a*/L)

  Other equations available (spring TP)
- Smith(1982) N+P model:
  - 5 µg TP/L + 95 µg TN/L = 1.05 µg Chl*a*/L

The P-only models tended to over-predict Flathead's Chla

- Carlson Trophic State Index using candidate criteria:
  - Range: 20.5-30.6 (average = 26.2)
  - Secchi depth TSI = 26.3
  - Criteria equate to "classic oligotrophy" (clear water, O_2 all year, salmonid fishery), which has TSI range 20-30



TP *vs.* Chla, Jones & Bachmann (1976)

Flathead Lake in relation to the Vollenweider (1975) P-Load model

(Predicts 5 µg TP/L, very close to Midlake Deep conc.)

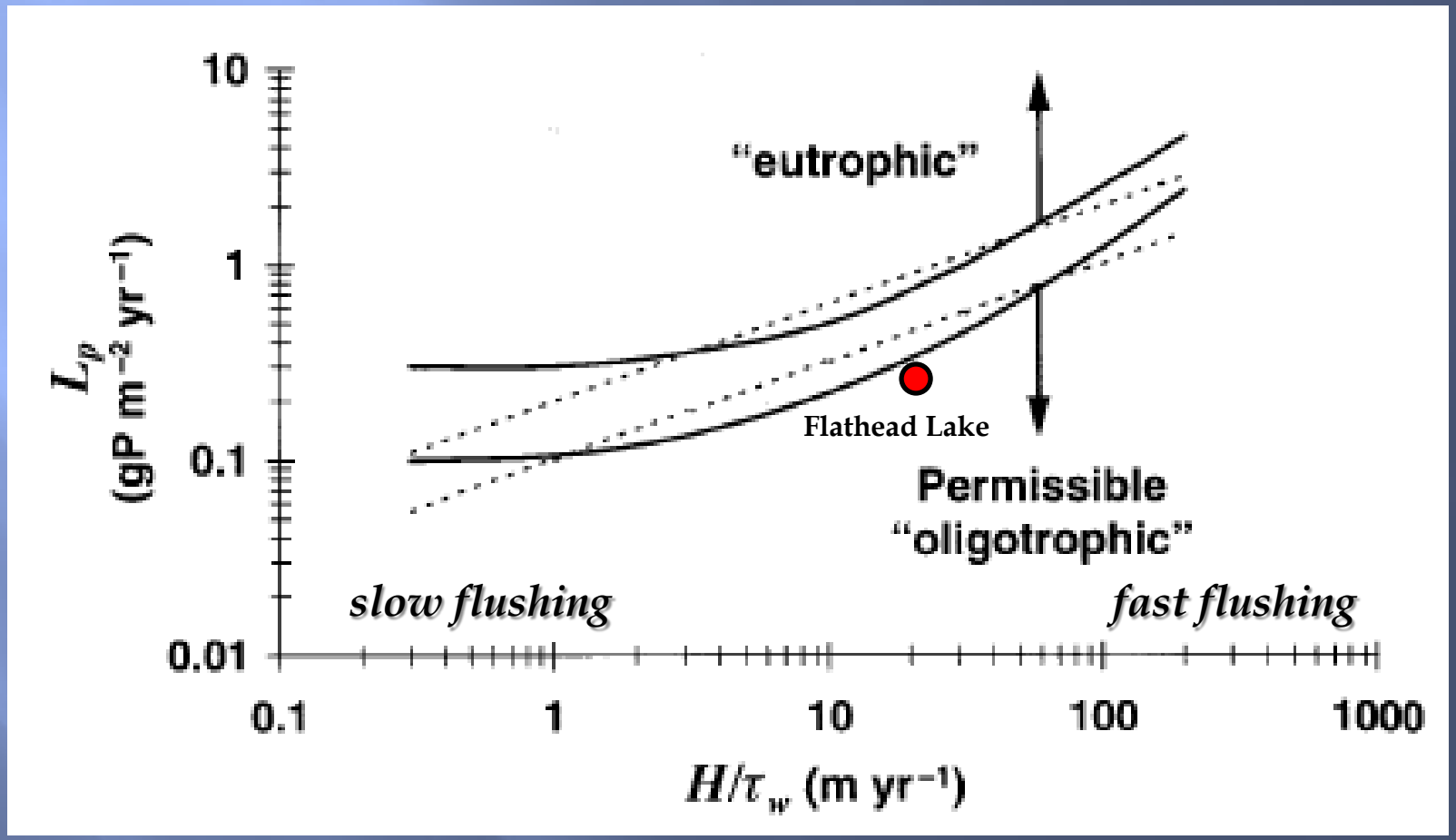


Figure from Chapra (1997) *Surface Water Quality Modeling*

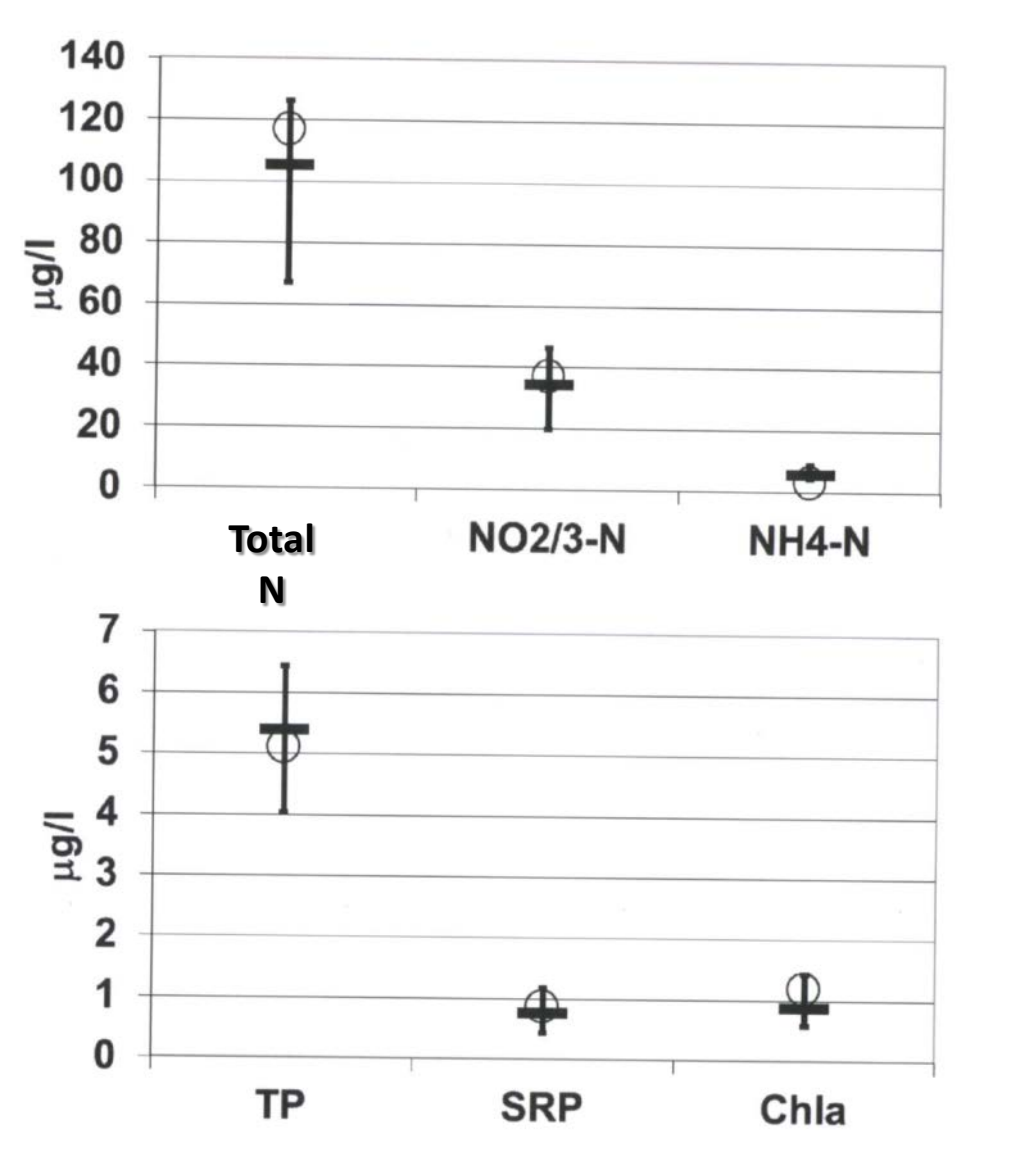
Well-cited science for northern temperate lakes indicates the candidate criteria DEQ considered in 2014 are generally correct for maintaining the phytoplankton chlorophyll *a* criterion

- **shortfall of equations is residual variability**

Flathead Lake's average annual P-load puts the lake near the threshold where movement to mesotrophy can occur with modest P increases

Candidate criteria, current conditions

(TP = 5 µg/L, TN = 95 µg/L, Chl*a* = 1.0 µg/L, secchi = 10.4 m)



Midlake Deep (1988-2013)

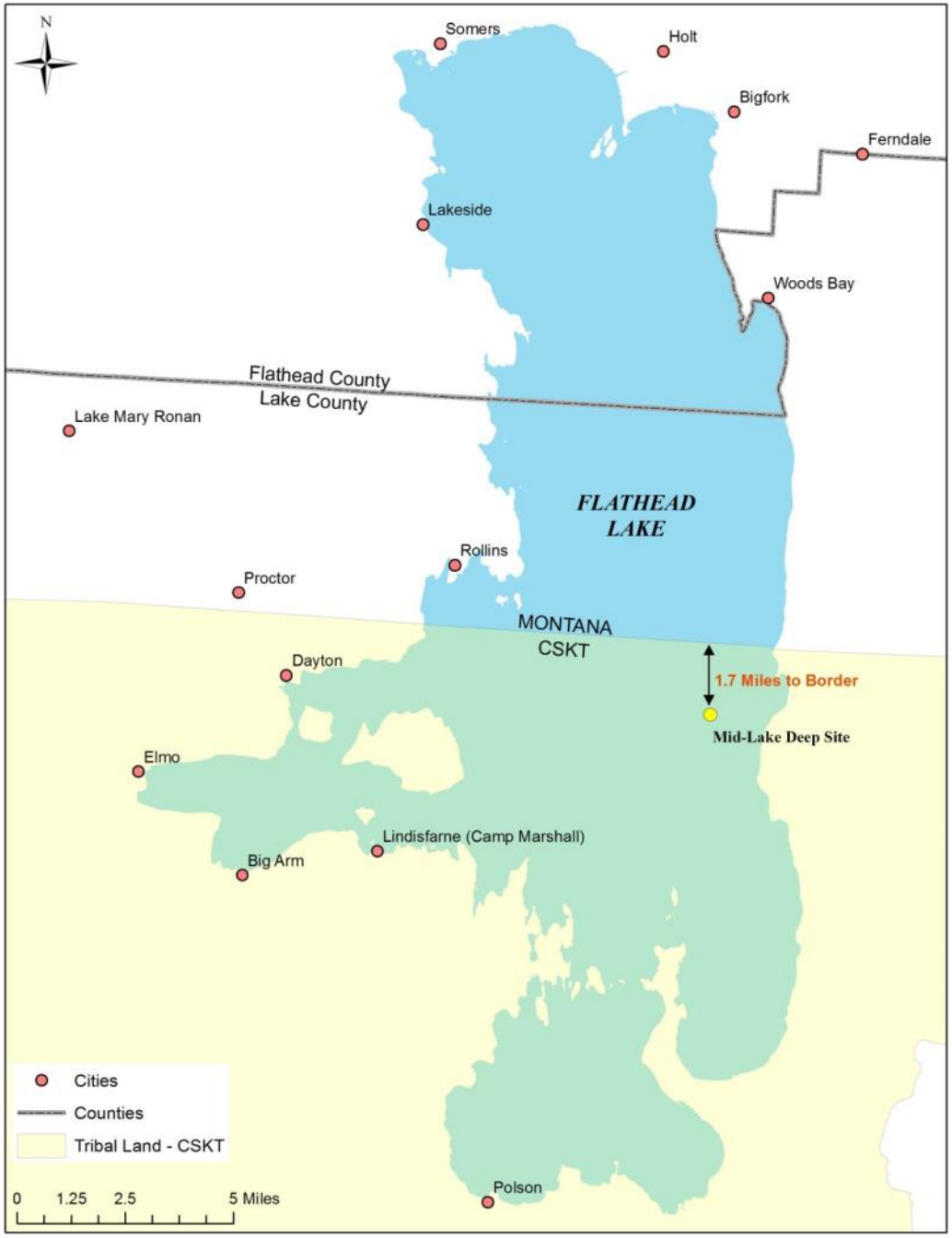
- Vertical bars = range of annual averages
- Horizontal bars = long-term annual average
- **Circles = 2013 water year**

Allowable exceedence rate (1 in 3) and at what level the criteria are set will define impairment status

Figure from: Ellis, B. *State of the Lake: Update on Water Quality in Flathead Lake for the 2013 Water Year.*

DEQ is open to further discussion as to which criteria are adopted as standards, and at what levels

Beneficial uses applicable to the lake will affect the level (magnitude) each criterion is set at



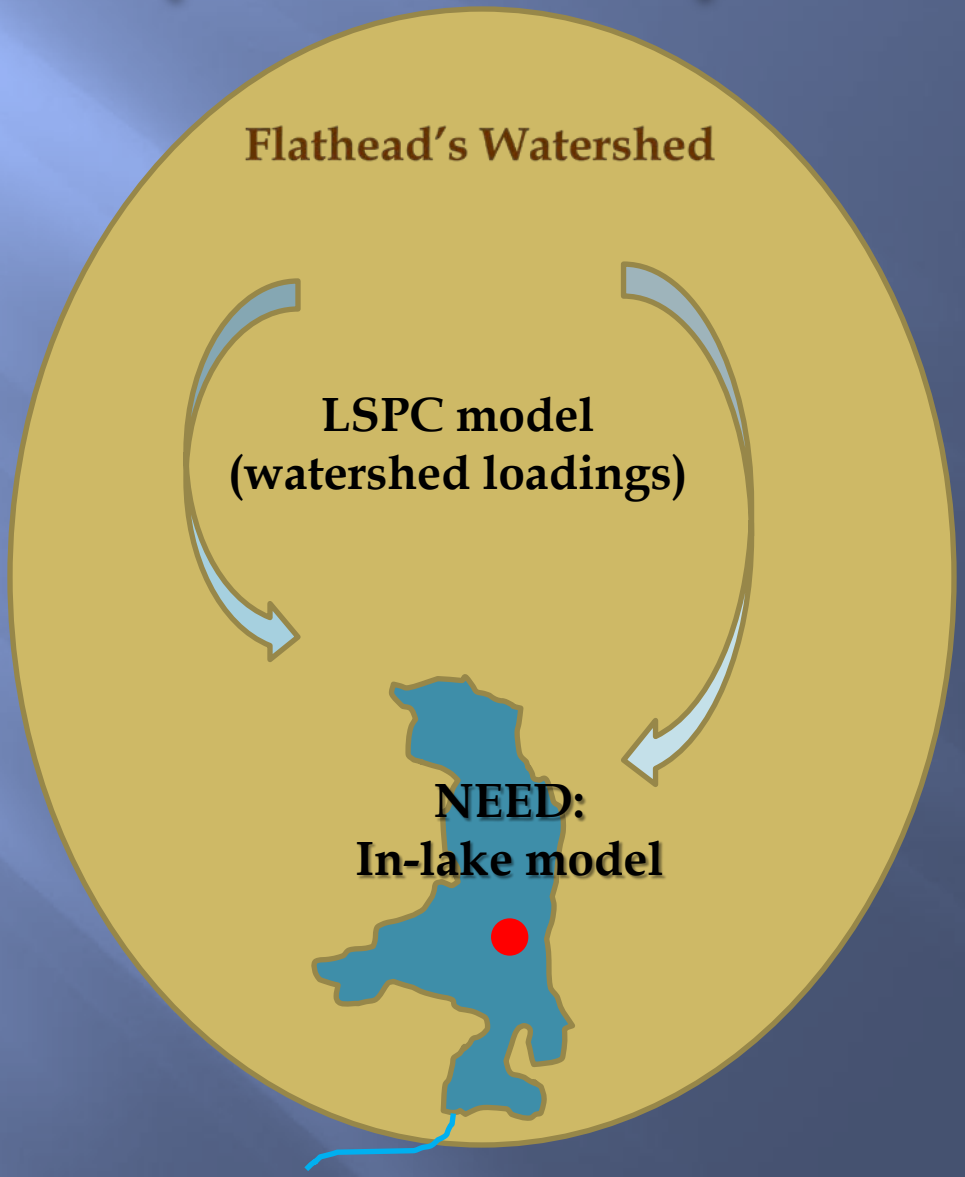
Midlake Deep site is in CSKT jurisdiction

1. DEQ understands CSKT is generally OK with Midlake Deep as monitoring site
   - An MOU would be ideal, for EPA purposes

2. Rules would clarify that the standards apply to the State side of the lake

3. Perhaps CSKT could adopt similar standards?
   —simplifies things

If standards are adopted, how will they be related to point & nonpoint sources?



If standards are adopted, how will they be related to point & nonpoint sources?

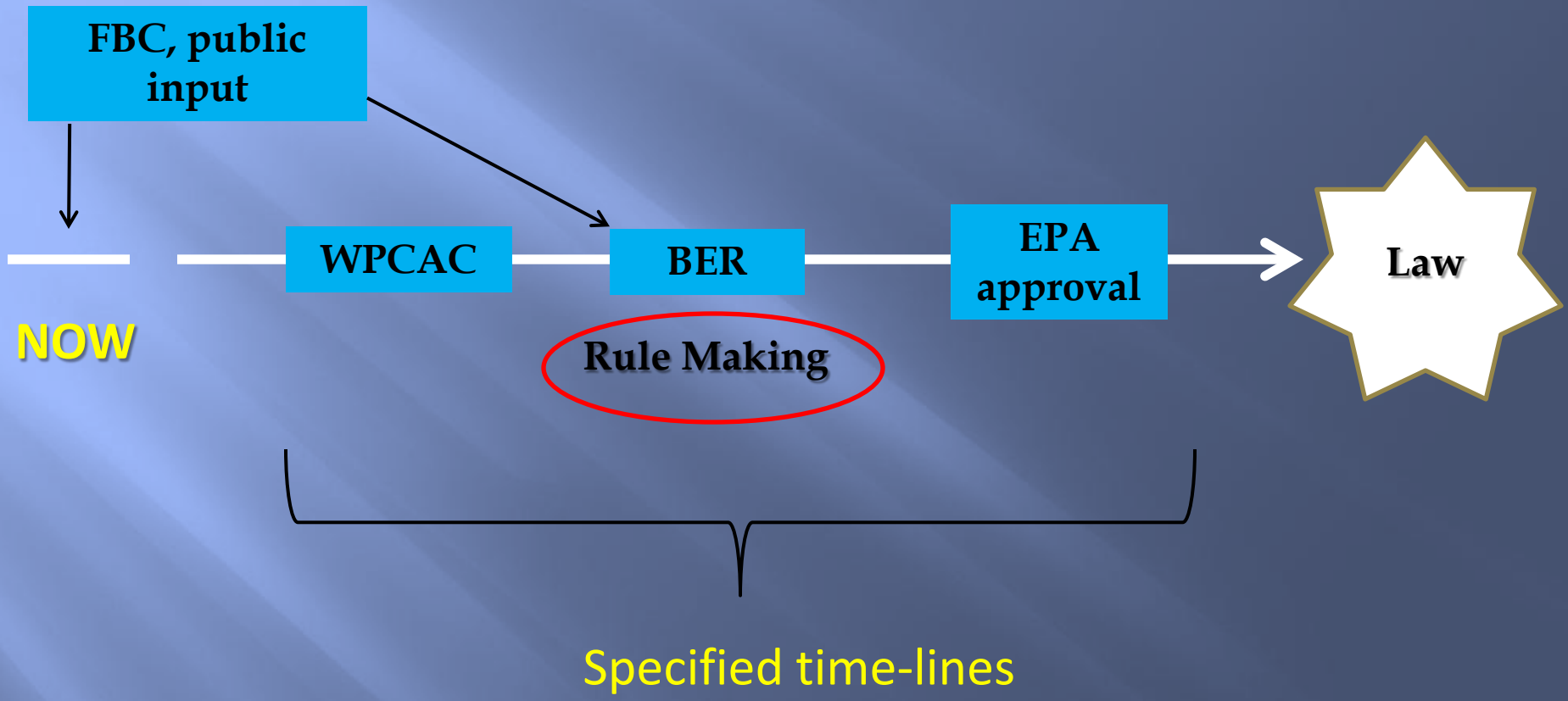
In-lake Model:

- DEQ
  - *EASY:* Chapra (1977) P model for Great Lakes (0-D, completely mixed)
    - Simulate average annual P values—Midlake Deep, empirically link to chl*a*/secchi
    - Assumes P limitation; will not provide for N-load allocations
  - *HARDER:* Mass balance model, multiple limiting nutrients, phytoplankton, zooplankton, etc. (1-D vertically segmented, e.g. LAKE2K)
  - *HARDEST:* 2- or 3-D hydrodynamic model; multiple sampling sites, >> time $$
- **FLBS lake food-web model** — how much time, $$ for this application?

Watershed model:

- **LSPC — nearly complete**
- Gives daily estimates of loads from all sources (point & non-point)
- Understand point & non-point source contributions spatially, temporally

Role of FBC, Public, WPCAC, & BER in Standards Setting for Flathead Lake



Discussion Points

- Which standards to adopt
- Magnitude of each standard, potential need to adopt a new beneficial use
  - Implications for listing/delisting the lake
- Compliance point, coordination with CSKT
- Which in-lake model, who models, timelines
- Schedule for public input, rule adoption

Thank You

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