Use of Water Quality Data in Evaluating Plant and Algae Problems

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Northeast Aquatic Research

So you want to collect some lake data ?

1. Lakes are neither healthy or unhealthy - they are.
2. Lakes cannot be treated with an over-the-counter home remedy and made healthy.
3. Lakes cannot be taken to the hospital and put on life support and be made healthy.
4. All lakes are on a trajectory of increasing production that began with the last glacier (New England), and will end with a forest*. We arbitrarily call this Lake Ontology and Trophic State. (10000 yrs vs. 150 yrs of limnology)
5. Humans have learned how to greatly accelerate the momentum of the trajectory.
6. Lakes never go back to the way they were before.

* Shopping center more likely

Lake Trajectory and Momentum

- All lakes are filling in* – all at different rates
- Filling comes from watershed inputs of
  - inorganic sediments –sand and such
  - particulate organic carbon and
  - particulate bound nutrients
- Lakes convert inorganic nutrients and CO_2 into detritus.
  - Detritus is unconsumed carbohydrate (Autumn leaves)
  - Detritus in lakes equates to oxygen demand and nutrient recycling

* We believe that Lake Baikal is still getting deeper

You can stand in front of the train and wave you hands with Alum, aeration, herbicides, 9point plans, harvesting, dredging – what ever - **its not going to stop the train**, let alone make it reverse, however, it may, if done correctly, slow it down for a time.

Water Quality

- The quality of the water in the lake and watershed is the back story to all plant and algae problems, with the possible exception of invasions of non–native species
- Increased phytoplankton and macrophyte growth in lakes is a symptom of eutrophication or the excessive enrichment of nutrients

Water Quality aspects involved in lake productivity

- Water Temperature,
- Dissolved Oxygen,
- Conductivity,
- Water Clarity – as with Secchi disk
- Alkalinity, and maybe hardness
- pH,
- Nutrients,
  - Phosphorus, typically Total but other forms can be useful
  - Nitrogen as Total, Nitrate, and Ammonium

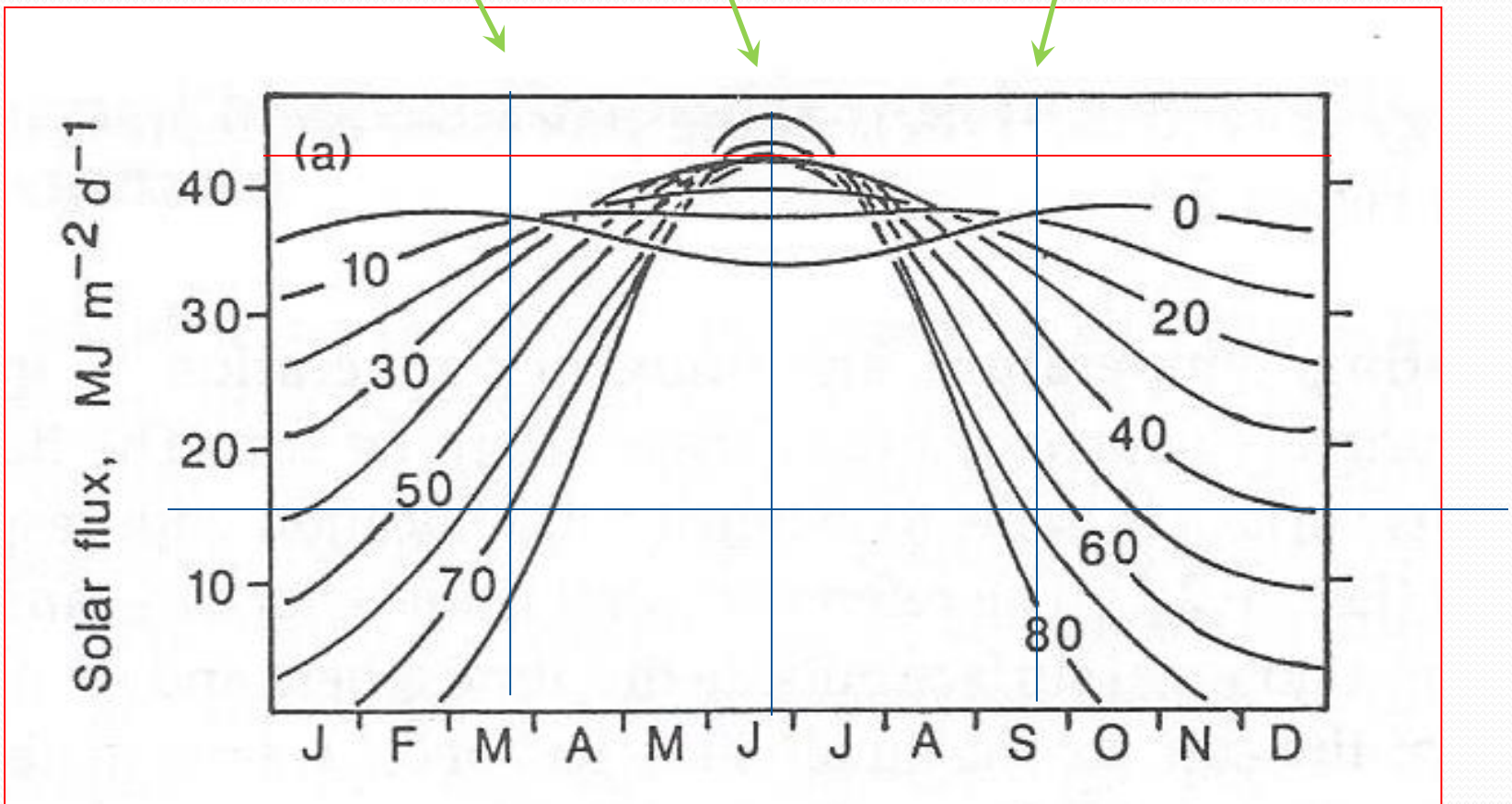
Aquatic Plants

- All plants need:
  - Light (required in PAR)
  - Warm water
  - Nutrients: P (preferred as PO_4^{-3}) and N (preferred as NH_4^+, or as NO_3)
  - CO_2 (preferred as CO_2 but not always–leads to long story)
  - Diatoms and Chryosphytes directly require Silica as $SiOH_4$ --soluble reactive silicon--
  - Other micro–nutrients (K, Mg, Ca, Na, Cl, Fe, Mn, Cu, Zn, B, S, Mo, V, and Co)

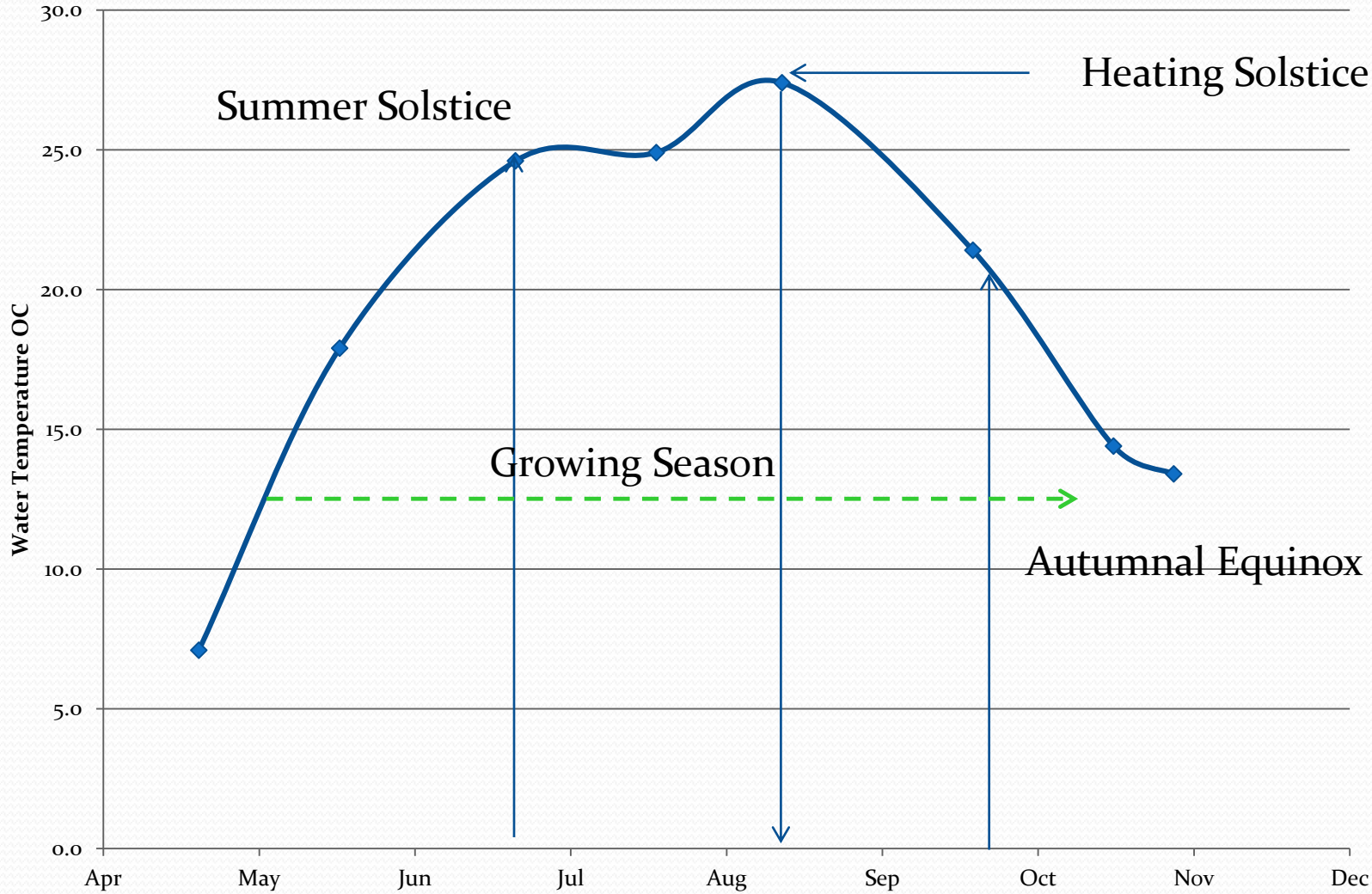
Change in sunlight over a season

Spring Equinox Summer Solstice Autumnal Equinox

Solar flux on the earth surface as a function of month and latitude



Surface Temperature of CT lake



Measuring Water Temperature Dissolved Oxygen

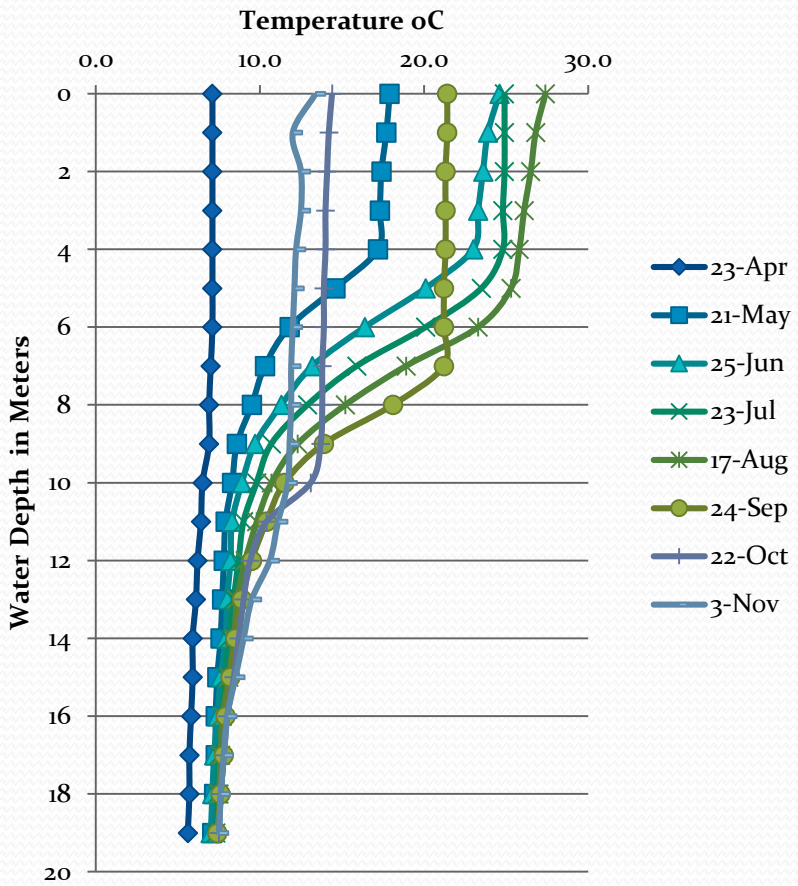
All this field probe stuff is really exciting and tempting but it comes with price!!!
Recommend dissolved oxygen with an LDO meter
1 = Maintenance
2 = Storage
2 = Calibration -some much more than others,
3 = Pay attention to what is happing to the probe
- especially in deep water!
- watch our for the bottom, its easy to get a lot of seeming good numbers from the mud
- watch our for drift

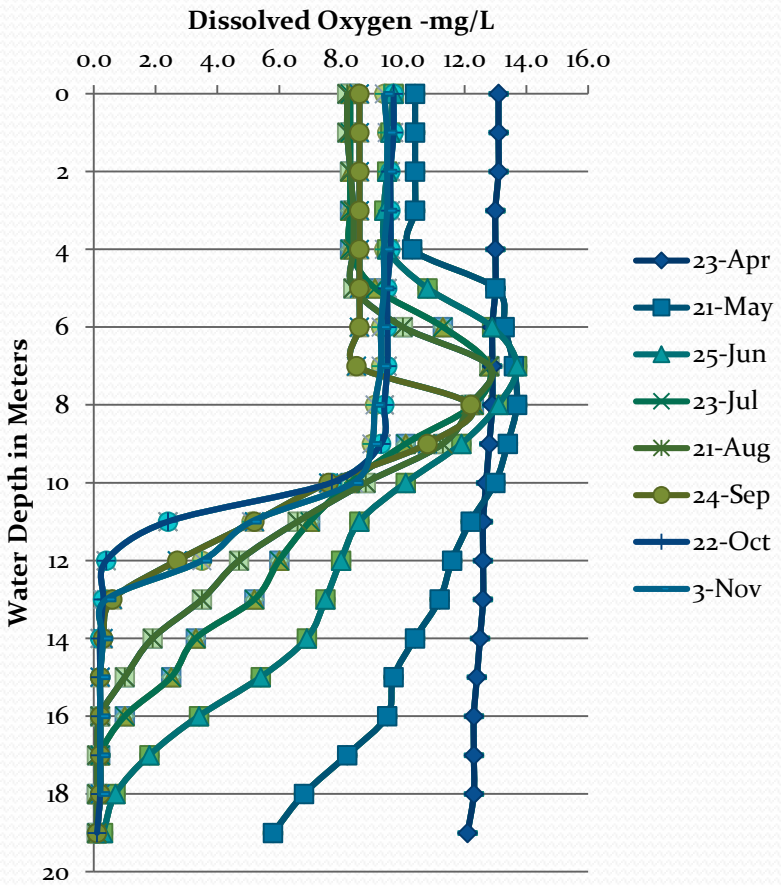
Water temperature and dissolved oxygen readings are fine at one decimal…getting these things to stabilize at 2 decimals can take forever

Get one DO/Temp profile from the deepest water at least once a month!

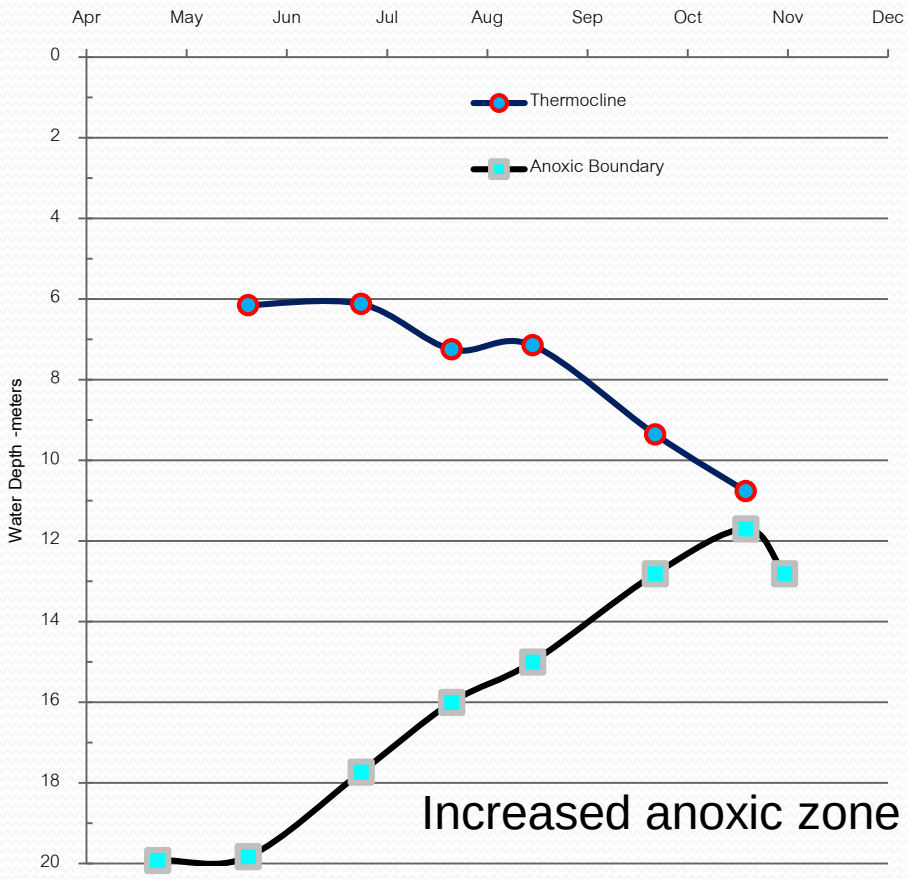
Yes! you must be Anchored and the DO/Temp line must hang vertically!

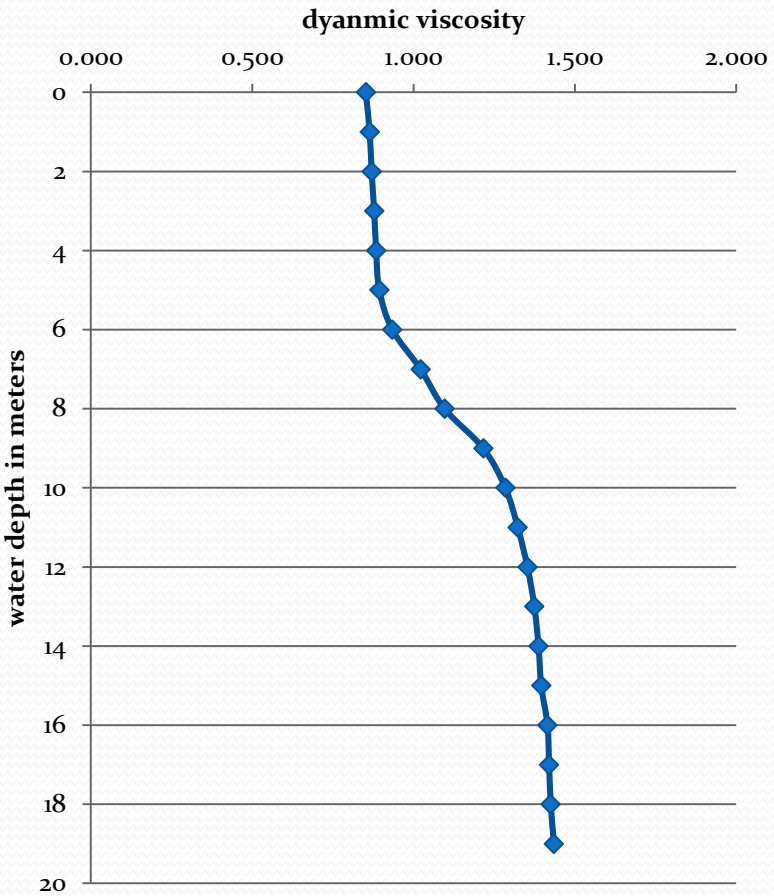
Examples of vertical gradients using probes





Further Examples of Vertical Profiles

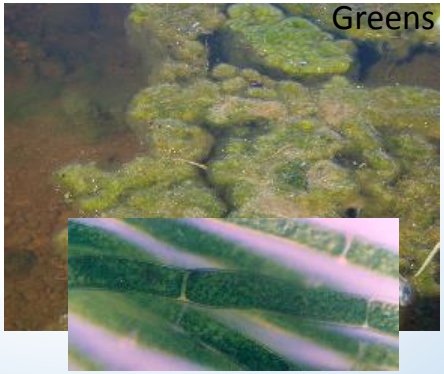




Thermal Impacts

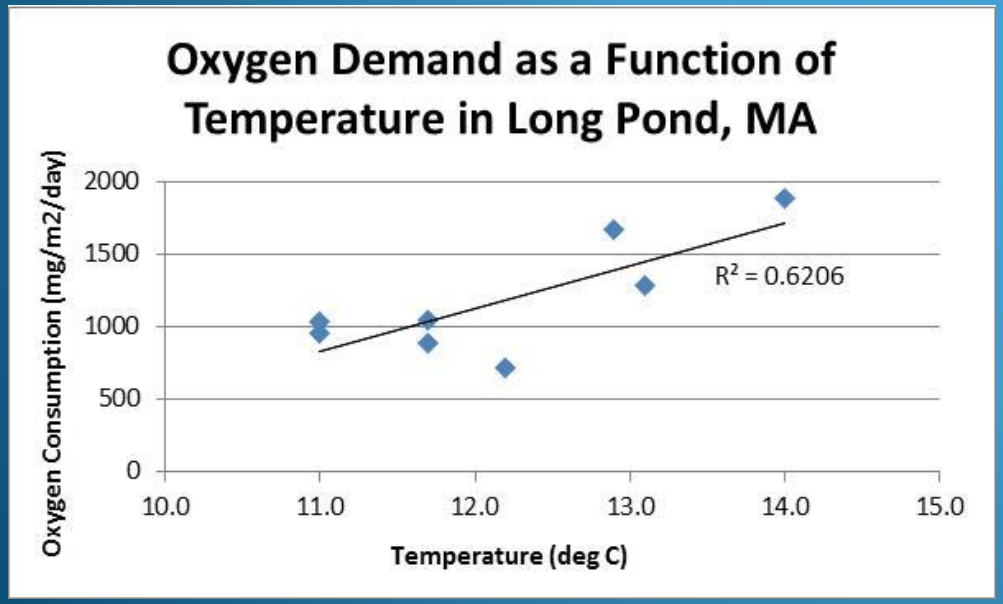
- Seed germination and die-off of plants partly triggered by temperature

- Types of algae influenced by T through metabolism of stored food



Thermal Impacts

- Rate of metabolism strongly influenced by temperature
  - Affects growth of plants and algae
  - Affects sediment oxygen demand

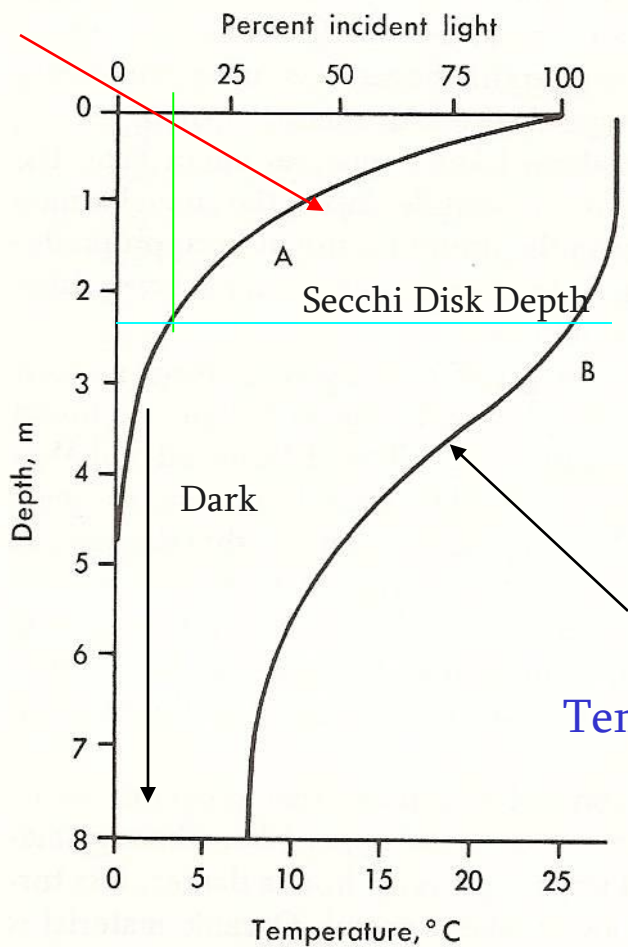


Research in press indicates increased cyanobacteria toxicity with warmer temperatures; we know we get more cyanos, but may also be getting more toxic cyanos

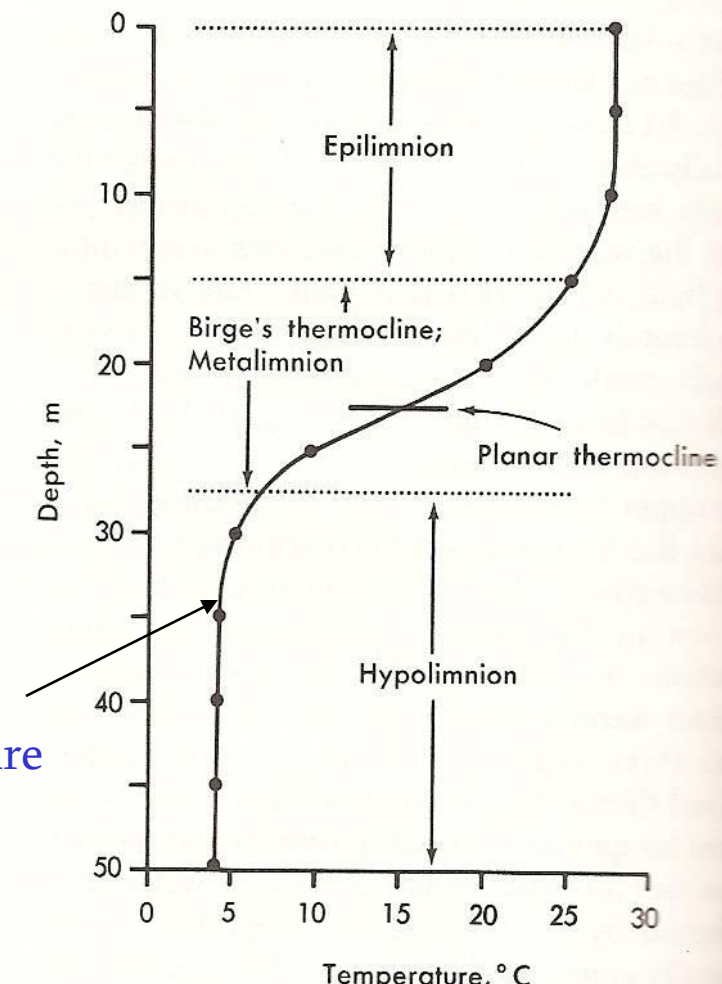
Light and the Layering of a Lake

Distinction between light and dark is significant
Secchi tends to indicate the depth of 15%ish of surface irradiance
Secchi disk also tends to estimate maximum depth of plant colonization but don't rely on an equation measure the outer edge with a Down-imaging Sonar

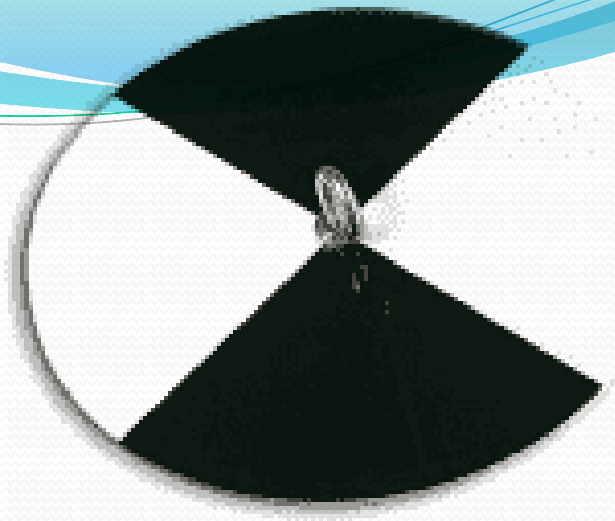
Light Transmission



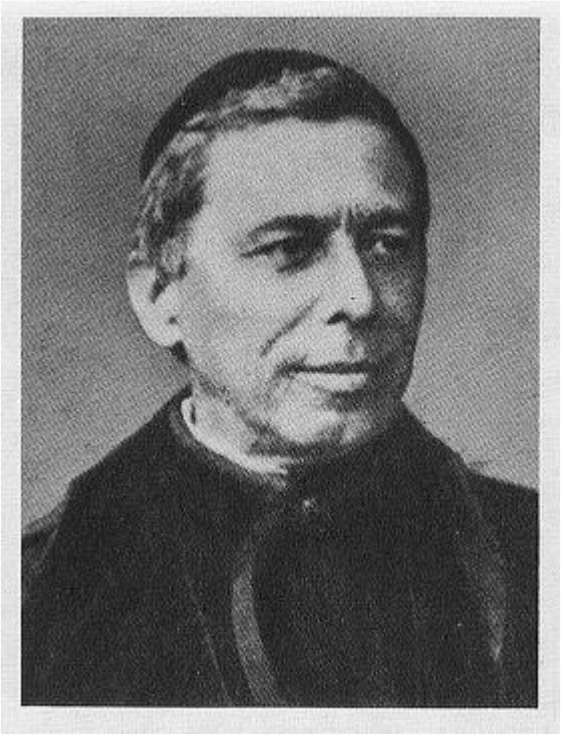
Water Temperature



Light and Secchi



The familiar Secchi disk of four quarters of black and white- not the one that Secchi used



Luckily for limnology (if not for Secchi), the Jesuits were expelled from Rome in 1848, an exile that eventually led Secchi to Georgetown University in Washington D.C., where he befriended Commander Matthew Fontaine Maury, who would become superintendent of the United States Naval Observatory. This friendship led Secchi to devote at least a little bit of his attention to aquatic, rather than astronomic, matters. This served him well when, as one of the scientific advisers to the Pope, Secchi was asked to quantify water clarity in the Mediterranean Sea. The rest, as they say, is history and, on April 20, 1865, Secchi stood on the papal yacht and plopped the first disk into the (presumably clear) Mediterranean waters.

Availability of Light

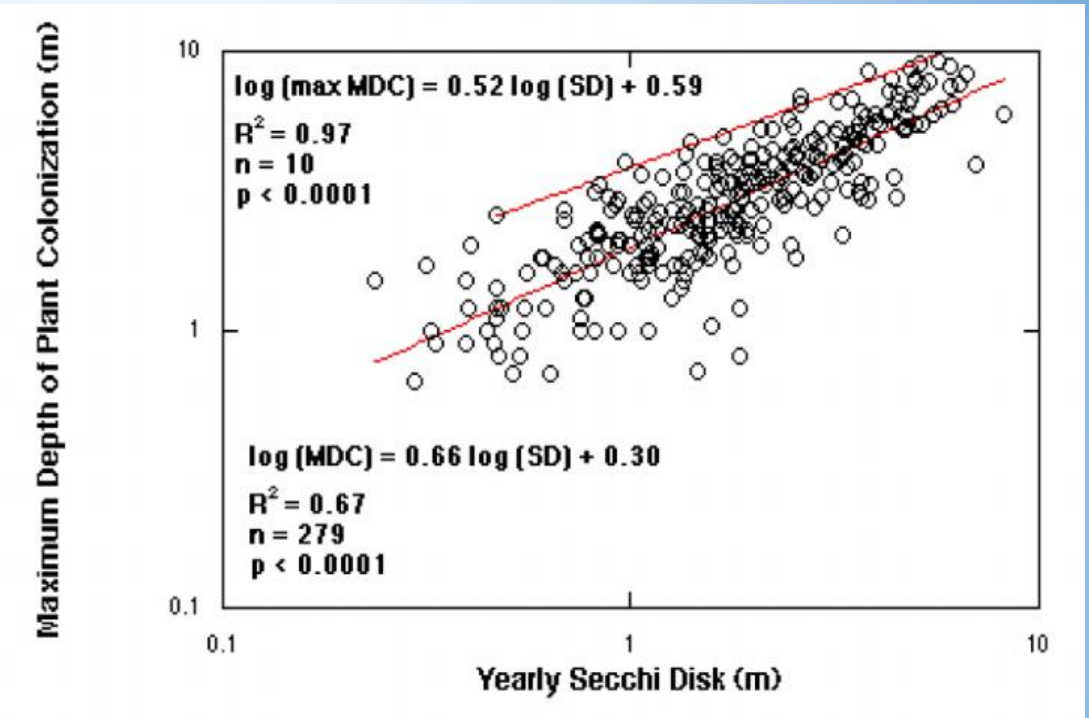
- Which plants grow at which depths depends on pigment composition and sediment features
- Chlorophyll-a is main photosynthetic pigment, but many other pigments used in energy transfer (other chl, carotenes, xanthophylls)
- Pigment composition is also very influential to optimal depth for algae
- Any WQ feature that affects light will therefore affect types of plants and algae (e.g., color, TSS)






Availability of Light

- Extinction with depth, color, non-algal suspended solids
- More P means more algae but that means less light and fewer rooted plants
- Equations predict depth to which plants can grow (from Caffrey 2006, expands older but similar work by Canfield et al.)
- Negatively correlates to chl-a, color, TP and TN



So SDT = 1 m leads to plants growing to about 2.5 m
SDT= 5 m leads to plants growing to about 9 m
Does not tell us much about what plants will be found

Measuring Secchi Disk Depth

Yes! you must be Anchored and the Secchi line must hang vertically!

1. Measure the Secchi disk depth with a view scope on the shady side of the boat.

2. Keep in mind the time of day- measurements earlier than about 10:00AM and later than about 6:00PM will be under-estimates.

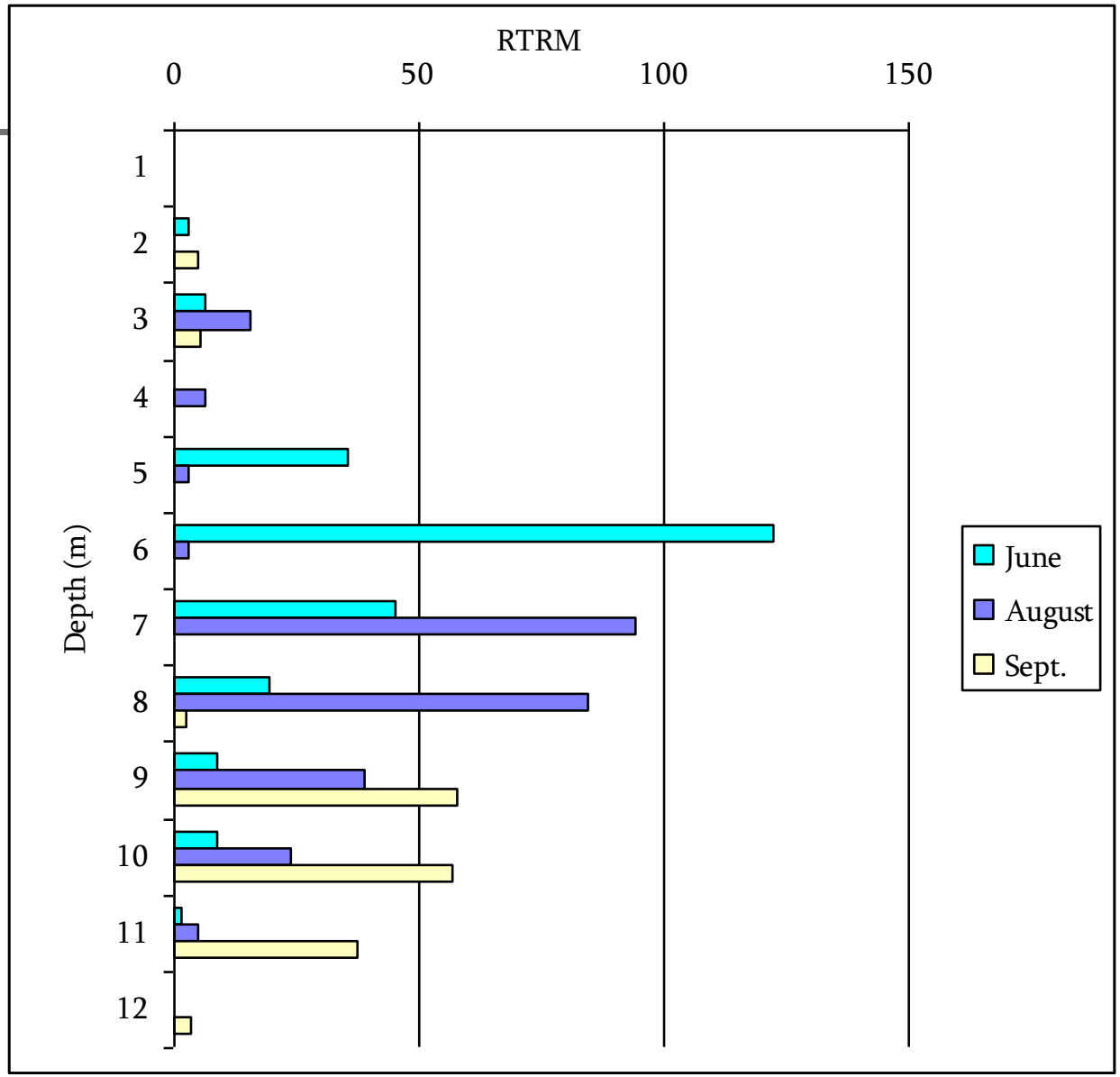
3. Beware of Secchi disk depths measured in different places of the course of the same lake on a warm summer day.

4. Measure over the course of season to get all lake phases.

5. Goes without saying to keep it clean or get a new decal

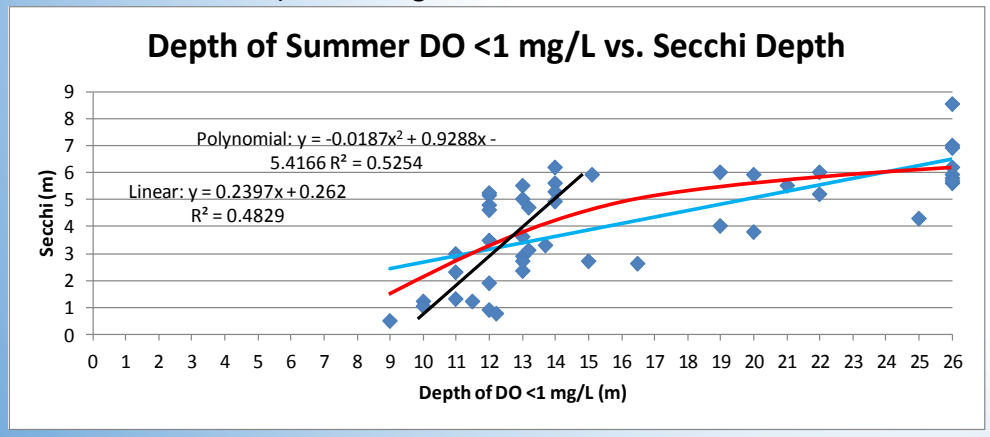
Profile of Thermal Resistance

Note the change in mixed depth over the course of the season



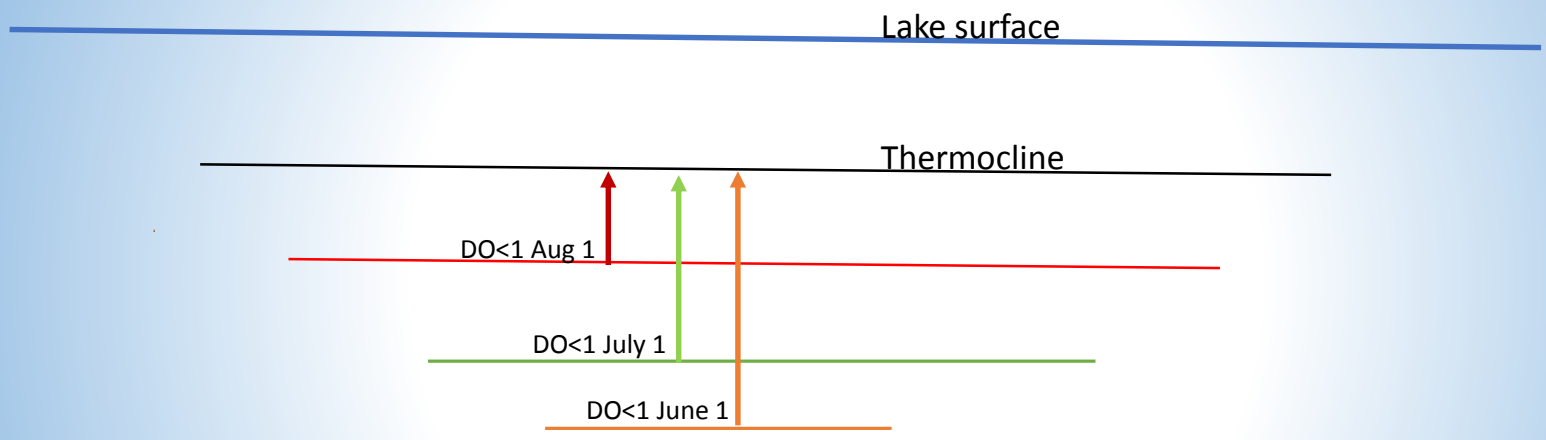
Oxygen Impacts

- Oxygen essential for life as we understand it (even anaerobes use oxygen; they just get it from compounds other than dissolved O_2)
- Warmer water holds less oxygen (saturation level is T dependent)
- Increased metabolism from higher T increases oxygen demand
- Low oxygen at sediment-water interface causes undesirable reactions (P release, ammonia build up, H_2S formation)
- Low oxygen slows conversion of many undesirable compounds to more desirable forms (e.g., NH_4 to NO_3, breakdown of toxins, dissolved P to particulate P)



Nothing good comes from loss of oxygen

Oxygen Impacts

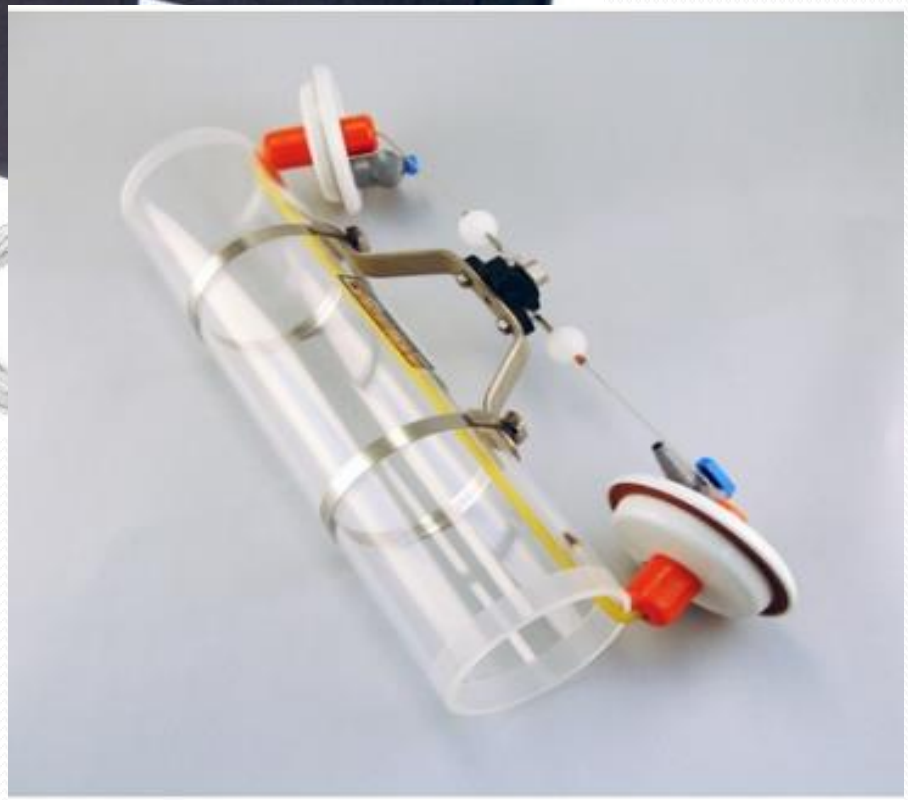


As the top of the anoxic zone rises in the water column, the portion of the lake bottom exposed to anoxia increases, the distance to the thermocline (where light is available) gets shorter, and the probability of released P becoming available increases.

Oxygen Impacts

- Oxygen demand features to consider
  - Oxygen loss <0.5 $g/m^2/day$ may not create any anoxia
  - Oxygen loss >1 $g/m^2/day$ likely to create anoxia by late summer
  - Oxygen loss >2 $g/m^2/day$ likely to create anoxia in early summer
  - Oxygen loss of 4 $g/m^2/day$ is extreme
  - More than about 10% of bottom exposed to anoxia can cause issues; >50% is almost guaranteed to cause problems
  - Nurnberg's Anoxic Factor is a good measure to apply (# of days per year equivalent of whole lake bottom is anoxic; if half the lake bottom is exposed to anoxia for 8 days AF=4)
  - Annual AF <10 is desirable, AF>30 undesirable

Collecting Water Samples



Collecting water samples follow the same importance to details as the probes:
1 = Maintenance is the Biggy
2 = Storage
2 = Calibration - Pay attention to line and the calibration of the meters marks..
the line can stretch over time or break at the wrong time!!

When using a horizontal sampler, like shown, get good horizontal flushing

Keep note of the depth of the bottom from the probe profile show the bottom water is off the bottom.

Getting Good Chemistry Results

Sampling

Getting good flushing of horizontal samplers

Collect samples primarily in the center of the lake were deep water was identified by the profile

Keep bottom sample free of suspended sediments

Limiting nutrient concept

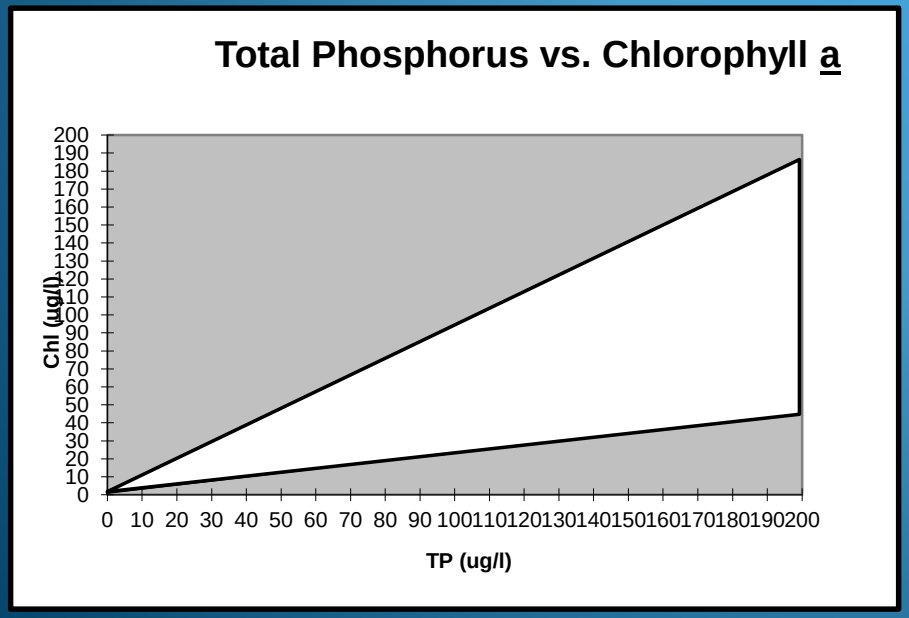
Element	Plant Content %	Average Supply %	Ratio of content to supply
Oxygen	80.5	89	1
Hydrogen	9.7	11	1
Carbon	6.5	0.0012	5,000
Silicon	1.3	0.00065	2,000
Nitrogen	0.7	0.000023	30,000
Phosphorus	0.08	0.000001	80,000
Potassium	0.3	0.00023	1,300

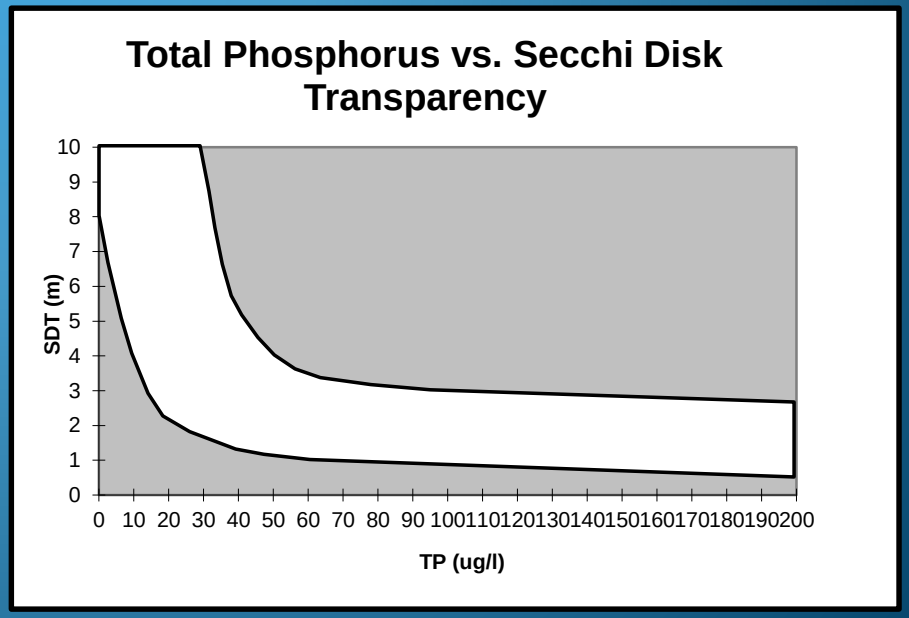
CT DEEP Trophic Categories

Category	T.P. (ppb)	Chlorophyll *a* (ppb)	T. Nitrogen (ppb)	Secchi Depth (m)
Oligotrophic	0 – 10	0 – 2	0 – 200	6+
Oligo-mesotrophic	10 – 15	2 – 5	200- 300	4 - 6
Mesotrophic	15 – 25	5 – 10	300 - 500	3 - 4
Meso-eutrophic	25 – 30	10 – 15	500 - 600	2 - 3
Eutrophic	30 – 50	15 – 30	600 - 1000	1 - 2
Highly Eutrophic	50+	30+	1000+	0 - 1

Availability of Nutrients

- Algae and floating plants (not anchored to sediment with real roots – Lemna, Wolffia, Ceratophyllum, southern forms like Azolla or Pistia) must get nutrients from the water column.
- Rooted plants get most N and P from the sediment, but may take other nutrients from the water column, especially C





Detection limits

- TP should be 1 ppb
- TN should be 8ppb
- NH_3 should be 3ppb
- NOx should be 3ppb

- 10ppb as upper PQL
- 50ppb as upper PQL
- 10ppb as upper PQL
- 25ppb as upper PQL

Quick conversation

ppb

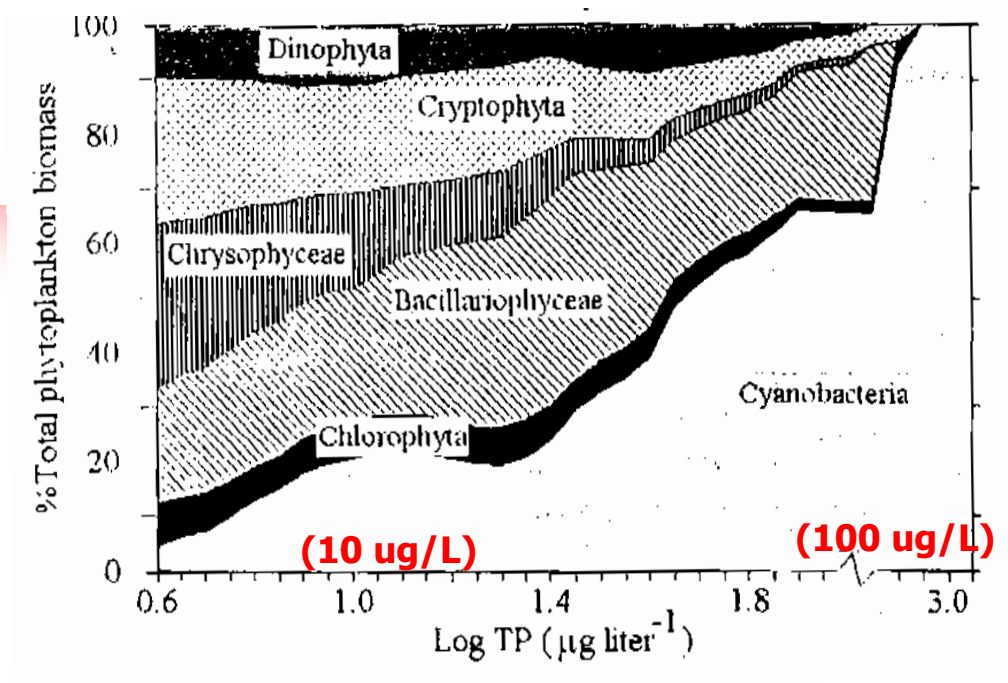
- 1 pp
- 5 ppb
- 10 ppb
- 50 ppb
- 100 ppb
- 1000 ppb

Mg/L

- 0.001 mg/L
- 0.005 mg/L
- 0.010 mg/L
- 0.050 mg/L
- 0.100 mg/L
- 1.000 mg/L

Availability of Nutrients

More P means more algae and more cyanobacteria



From Watson, S.B., McCauley, E. and Downing, J.A. 1997. Patterns in phytoplankton taxonomic composition across temperate lakes of differing nutrient status. Limnol. Oceanogr. 42:487-495.

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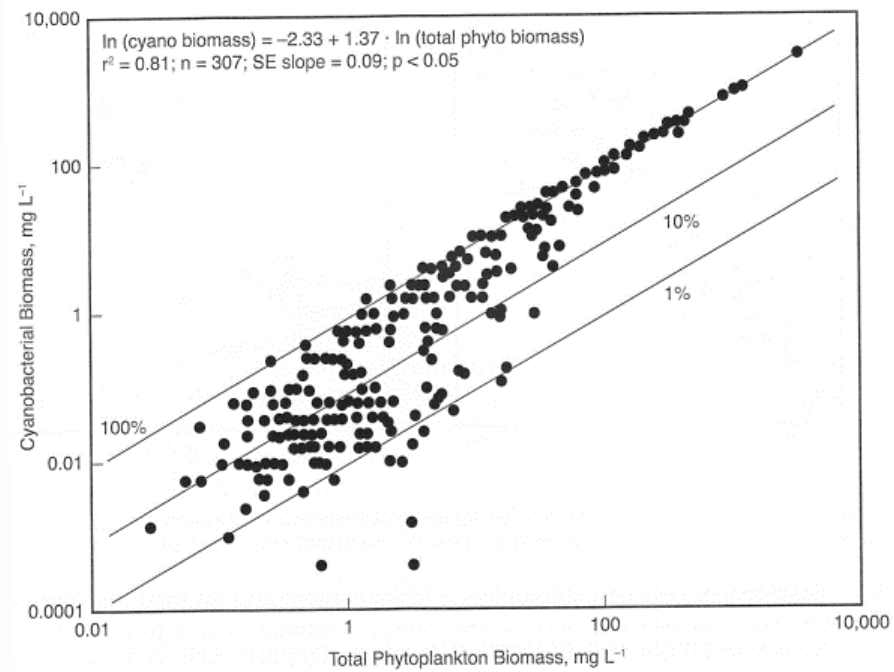
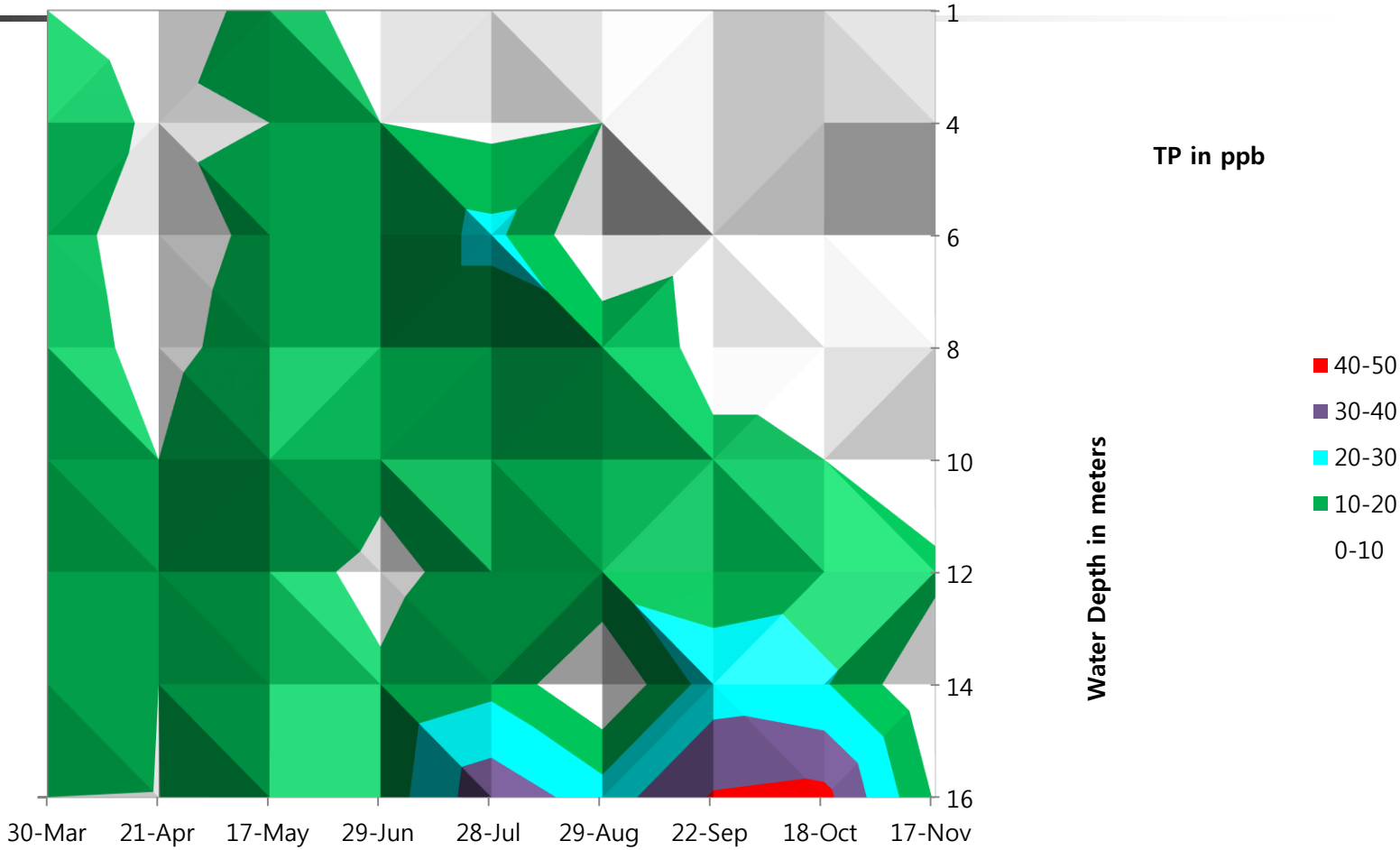


From Canfield, D.E., Philips, E. and Duarte, C.M. 1989. Factors influencing the abundance of blue-green algae in Florida lakes. Can. J. Fish. Aquat. Sci. 46:1232-1237.

Depletion of TP in the Epilimnion



Dates in 2016

Comments and Questions?

Now this is water chemistry I can understand!