The Influences of Climate Change on Lake Water Quality, Including Recent Case Histories

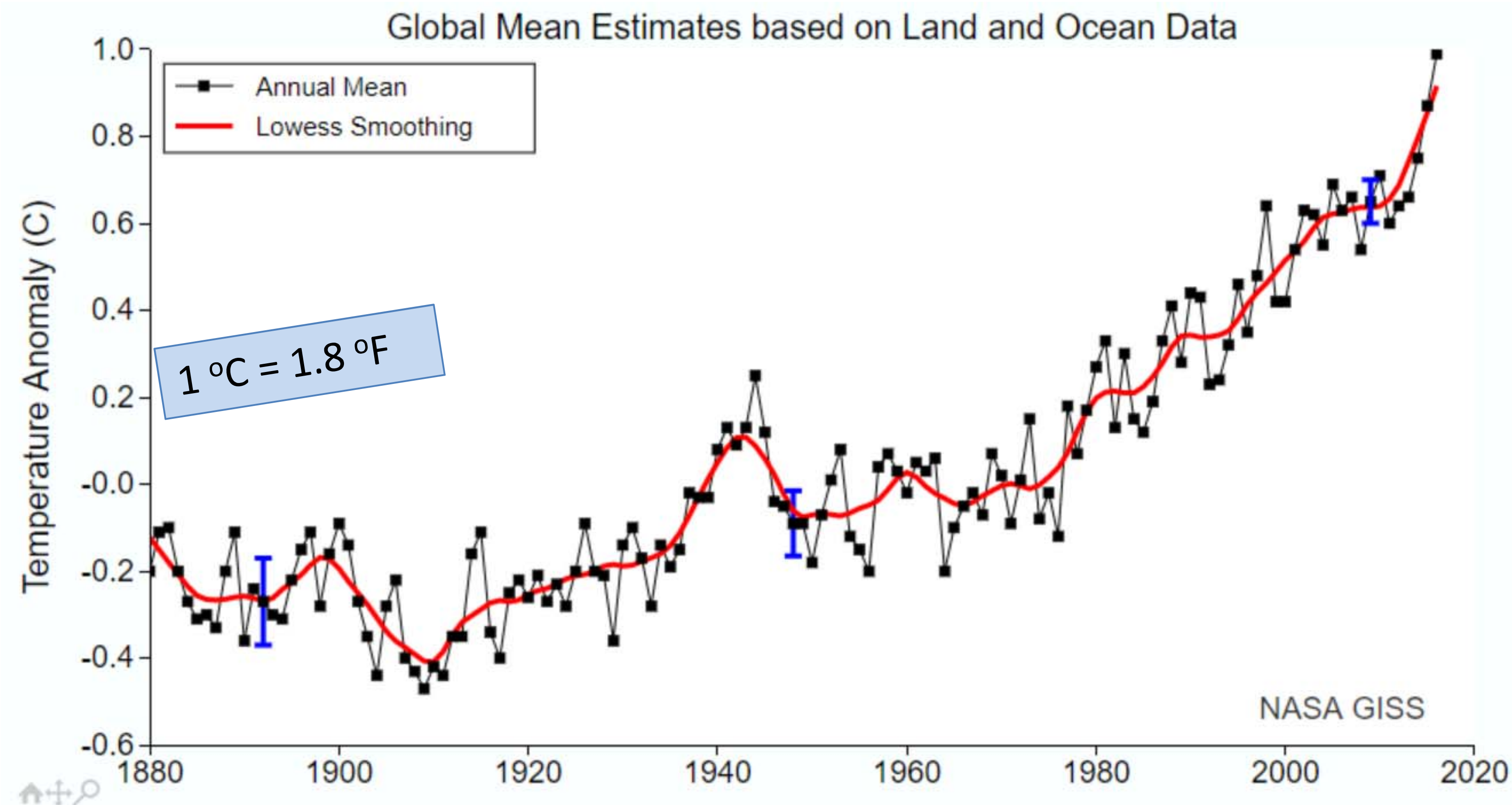
Lake Stewards of Maine Annual Meeting
July 27, 2019

Linda Bacon, Limnologist
Lake Assessment Section Leader

Presentation Overview

- Climate / Effects on Maine Lakes
- Examples of Maine Lakes
- Monitoring Strategies
- Thoughts on Building Resilience

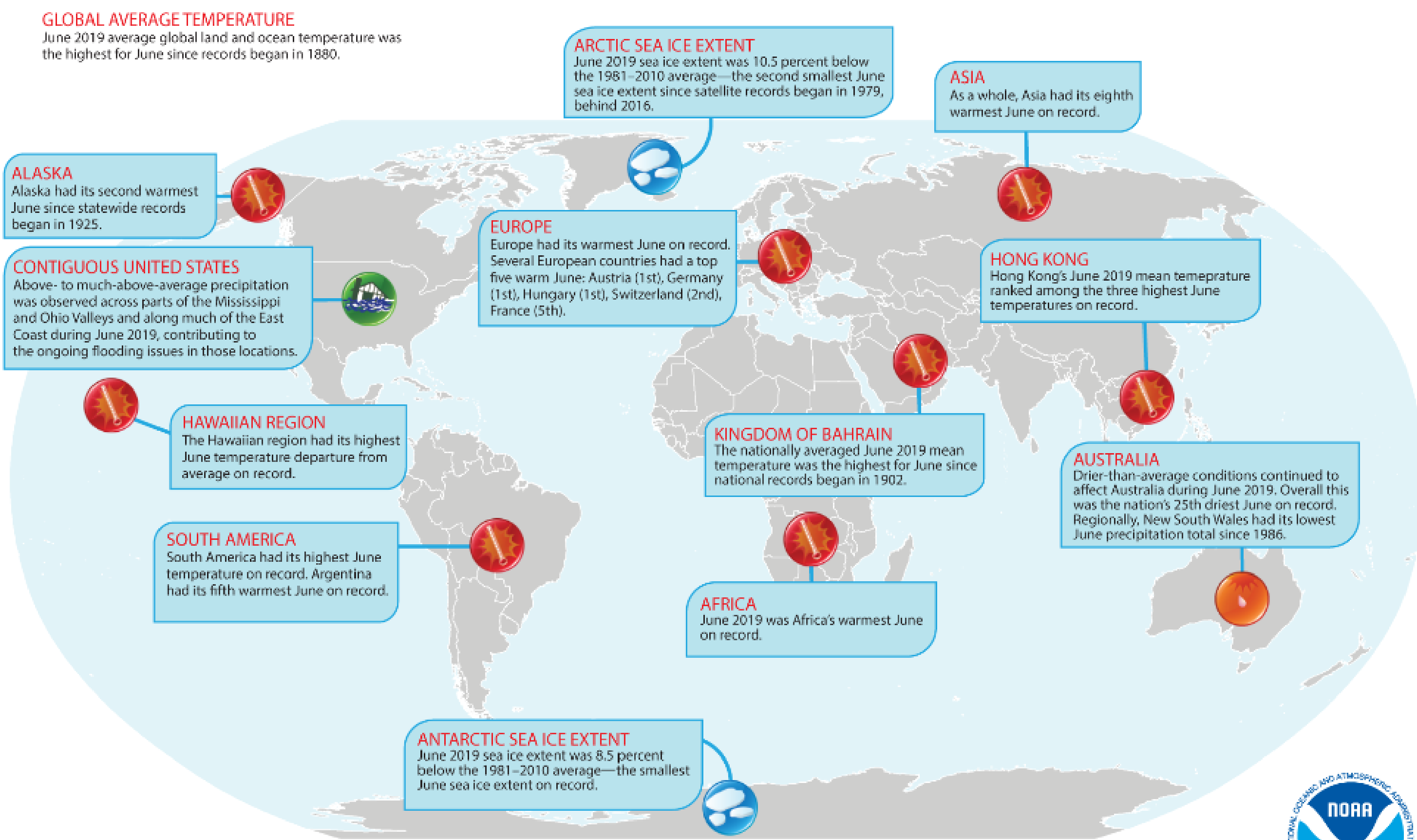
Land & Water are Warming



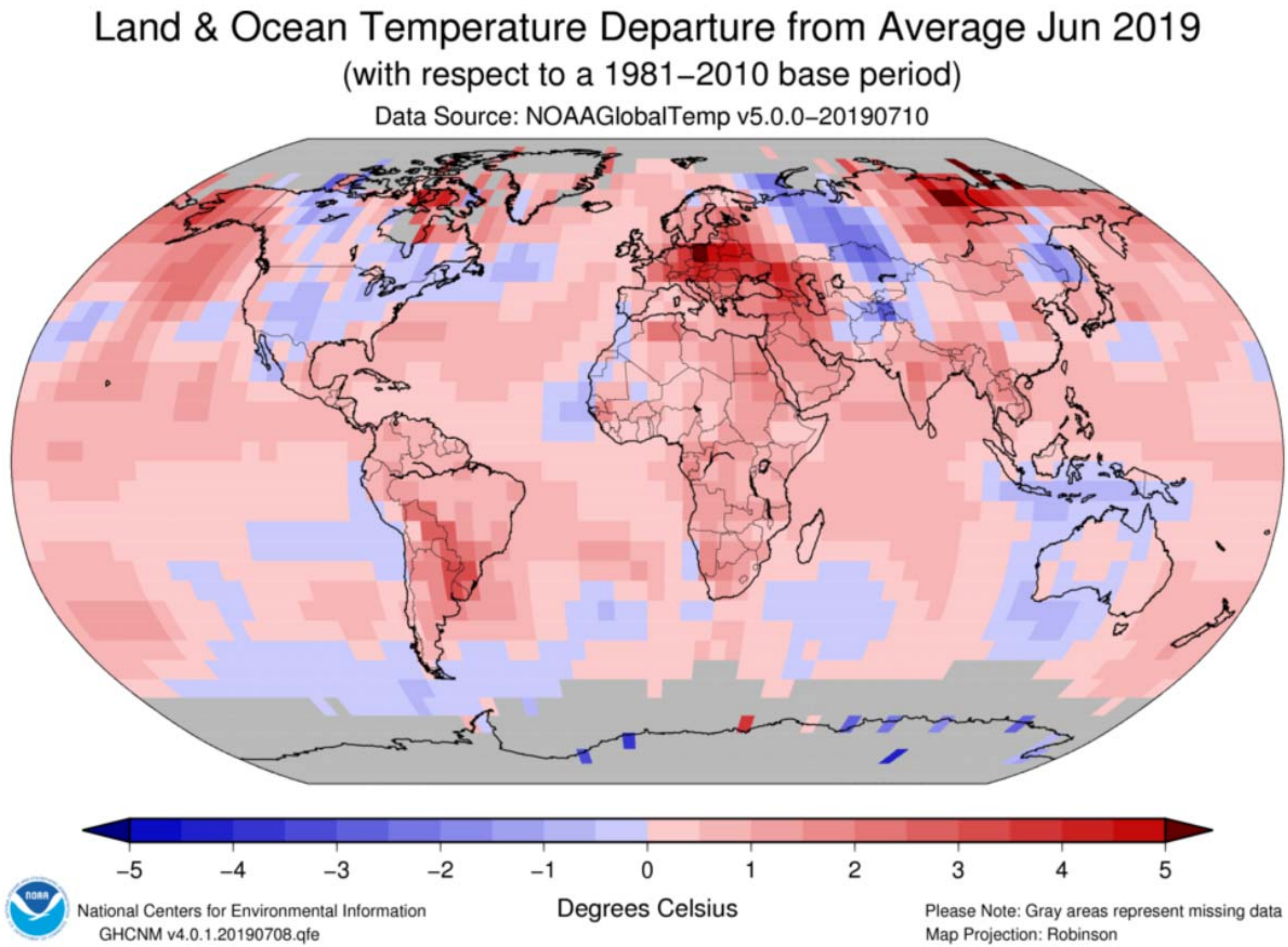
Land-ocean temperature index, 1880 to present, with base period 1951-1980. The solid black line is the global annual mean and the solid red line is the five-year lowess smooth. The blue uncertainty bars (95% confidence limit) account only for incomplete spatial sampling. [This is an update of Fig. 9a in Hansen et al. (2010).]

Extreme Weather - June 2019

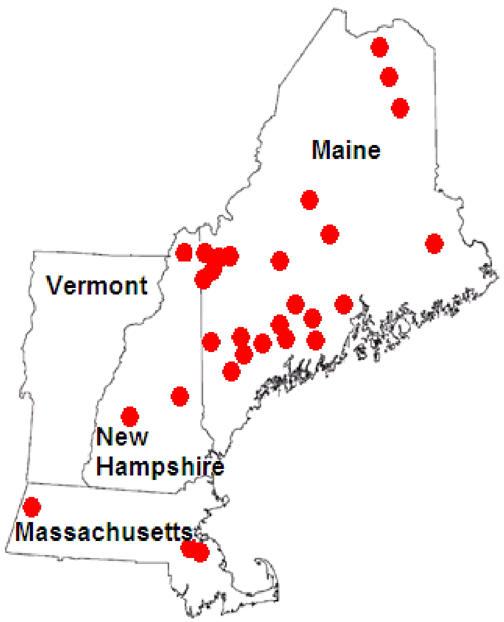
Selected Significant Climate Anomalies and Events June 2019

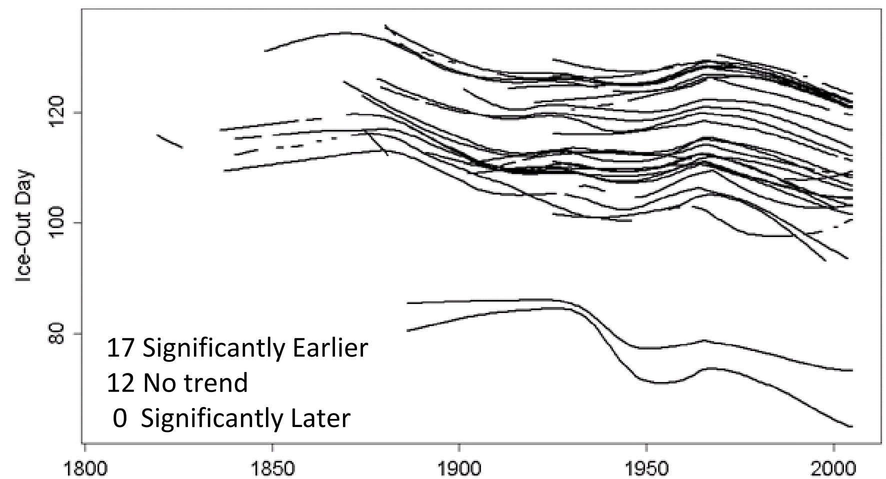


Please Note: Material provided in this map was compiled from NOAA's State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc

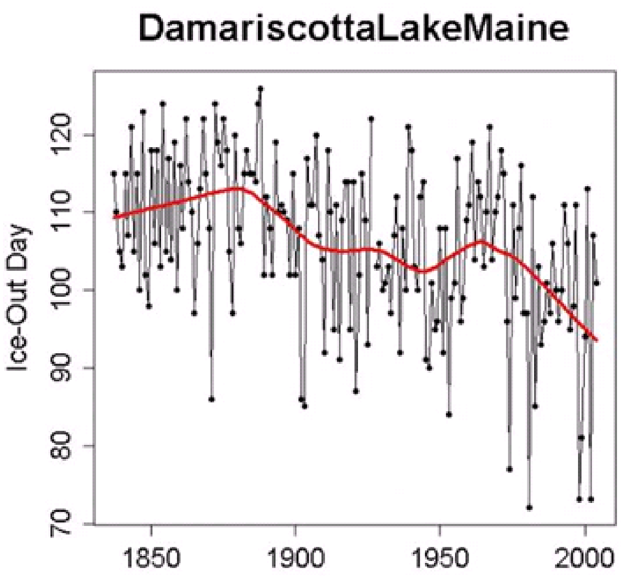

Land & Ocean Temperature Departure from Average Jun 2019
(with respect to a 1981–2010 base period)
Data Source: NOAAGlobalTemp v5.0.0–20190710
−5
−4
−3
−2
−1
0
1
2
3
4
5
Degrees Celsius
National Centers for Environmental Information
GHCNM v4.0.1.20190708.qfe
Please Note: Gray areas represent missing data
Map Projection: Robinson

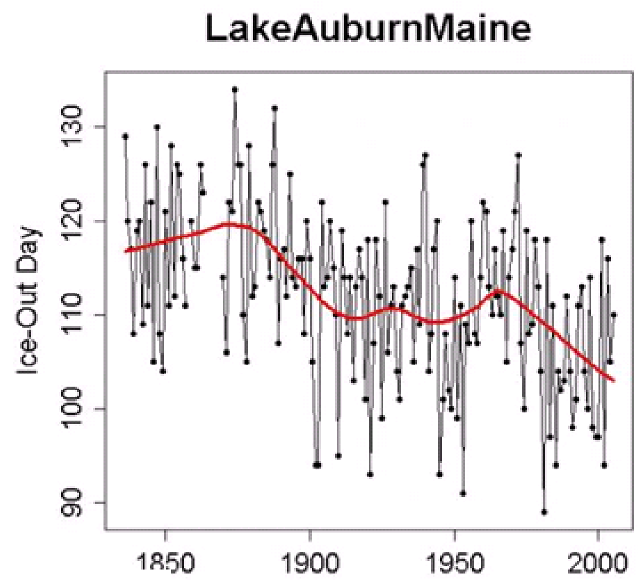
Effects on Lakes:
Earlier Ice Out & Decreased Ice Duration

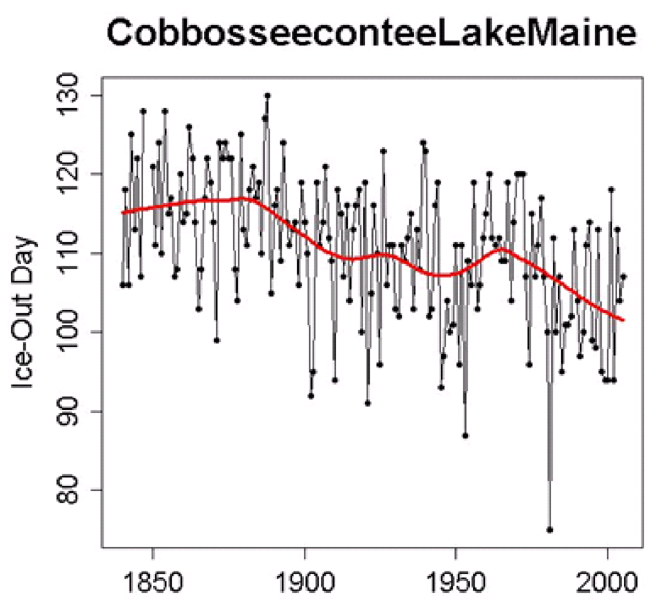




USGS (Hodgkins, James & others, 2002+) compiled ice-out dates from 29 lakes having 64 to 163 years of data.


DamariscottaLakeMaine
Ice-Out Day
70
80
90
100
110
120
1850
1900
1950
2000


LakeAuburnMaine
Ice-Out Day
90
100
110
120
130
1850
1900
1950
2000


CobbosseeconteeLakeMaine
Ice-Out Day
80
90
100
110
120
130
1850
1900
1950
2000

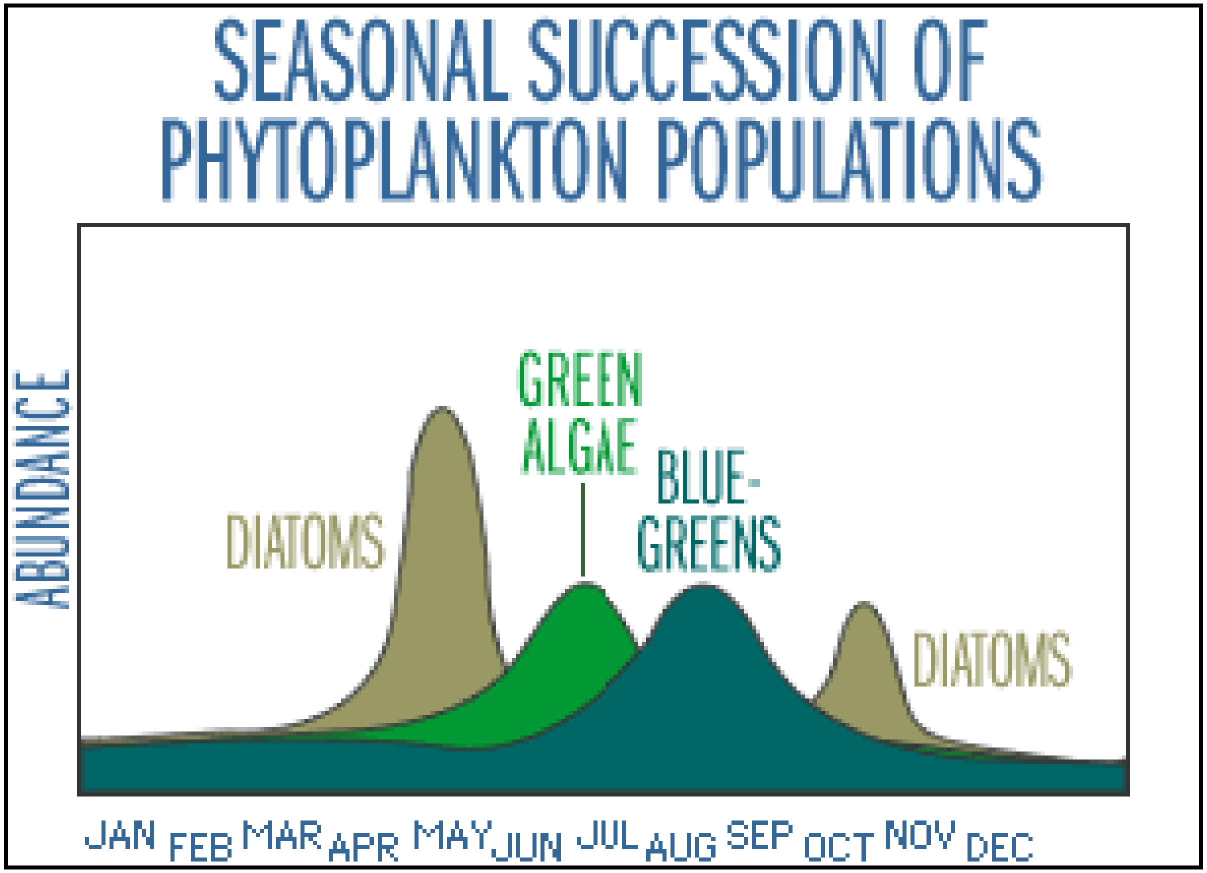
Decreased Duration of Ice Cover Promotes:

- *Longer growing season*
- *Earlier warming of shallows*
- *Longer period of stratification*
- *Increased potential for oxygen loss in deeper water*
- *Increased nutrient cycling from sediments*

Which Can Alter Lake Biology With:

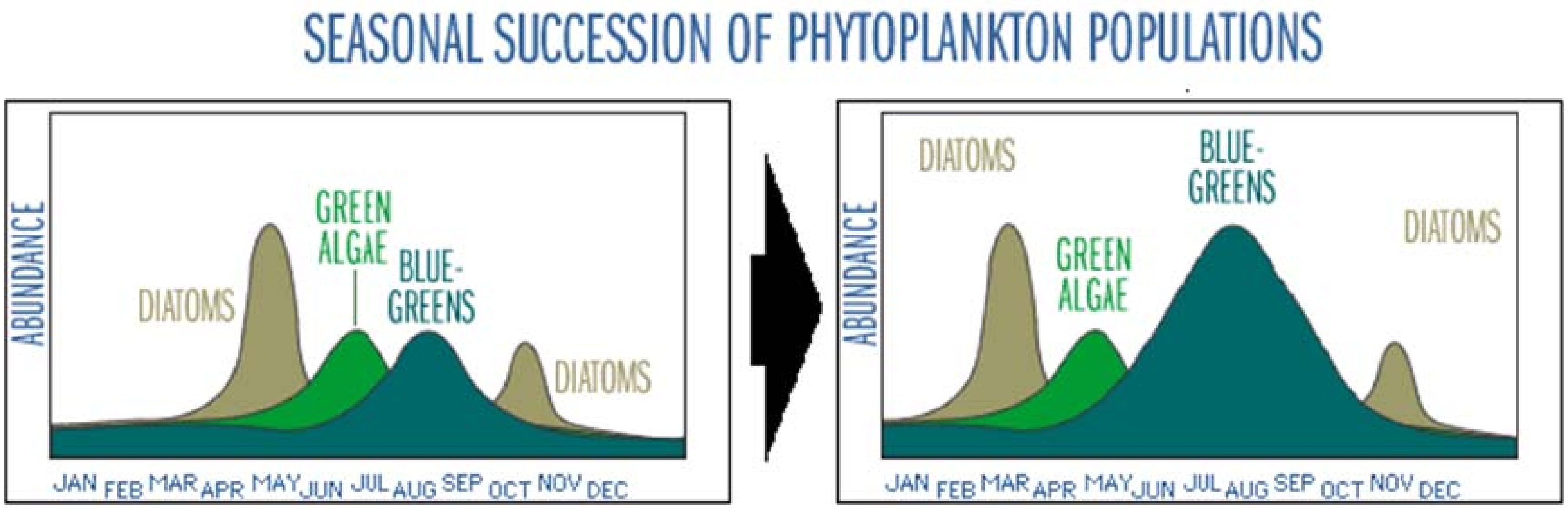
- *Species composition changes*
- *Earlier appearance of some species*
- *Timing of life cycle events disrupted (spawning, emergence, etc.)*
- *Out-of-Sync Interactions between species (succession, predator-prey interactions, etc.)*

Lake Growing Season



waterontheweb.com

Decreased Ice Duration = Longer Growing Season



Possible increase in duration and abundance of Cyanophytes under climate change scenario of increased lake water temperatures.

Which Can Lead to:

- Increase in metaphyton
- Increase in cyanobacteria (Gloeotrichia)
- Increase in picocyanobacteria
- Possibility of cyanotoxin production
- Increase in deep water anoxia
- Release of phosphorus from sediments
- Stress on coolwater & coldwater fish

Recent Stories

…but first, an analogy…

If 'life is like a box of chocolates,' Lakes are like a game of Jenga…

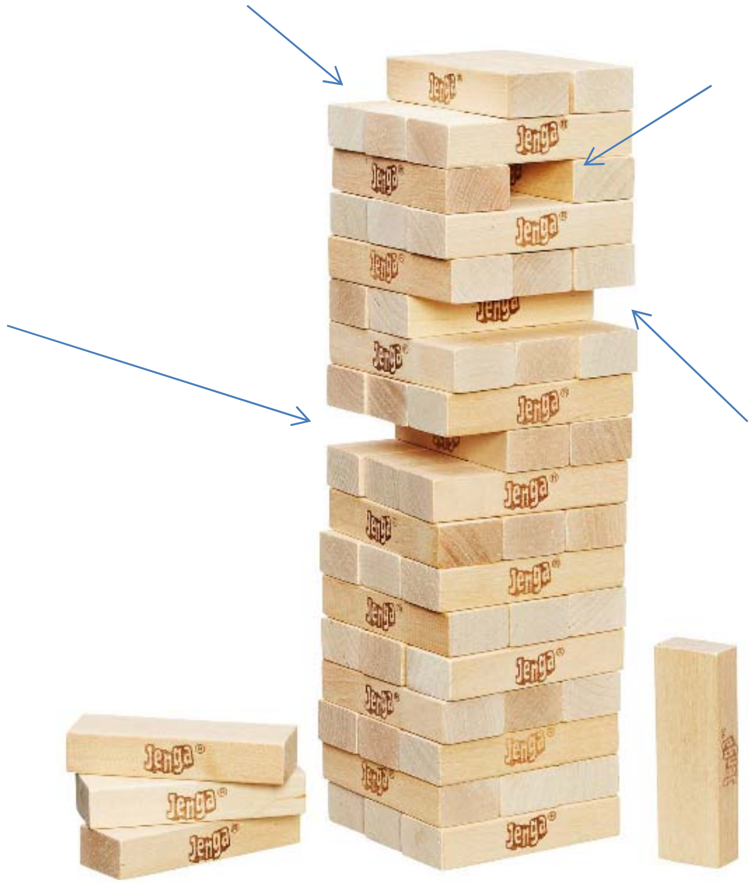
Forrest Gump's Mom

The Jenga tower is like a lake in balance with its environment.

Biology and water chemistry are a result of the physical properties of the lake, its location on the earth and features of its watershed – some of which can't change, others of which can.

400 years ago, the forces acting on most Maine lakes had little variation. Occasionally a tree might fall, or a few trees due to a rare intense storm, but the climate was fairly predictable and there were only paths through watersheds.

Jenga Lake



Then as populations grew…

…trees were removed

…agriculture developed

…the industrial age began to thrive

…dams were installed

…cities formed

…roads and homes built

…and so on

All of which began to…

…disrupt balance

…disrupt equilibrium

Jenga Lake

Then, despite remaining in the exact same location, some foundational climate controls on biology and water chemistry began to erode the base of the tower…

…the duration of ice cover shortened

…the lake growing season lengthened

…water temperatures got higher

…higher intensity storms increased runoff

…increased runoff brought more phosphorus

…drought intensified in-lake phosphorus

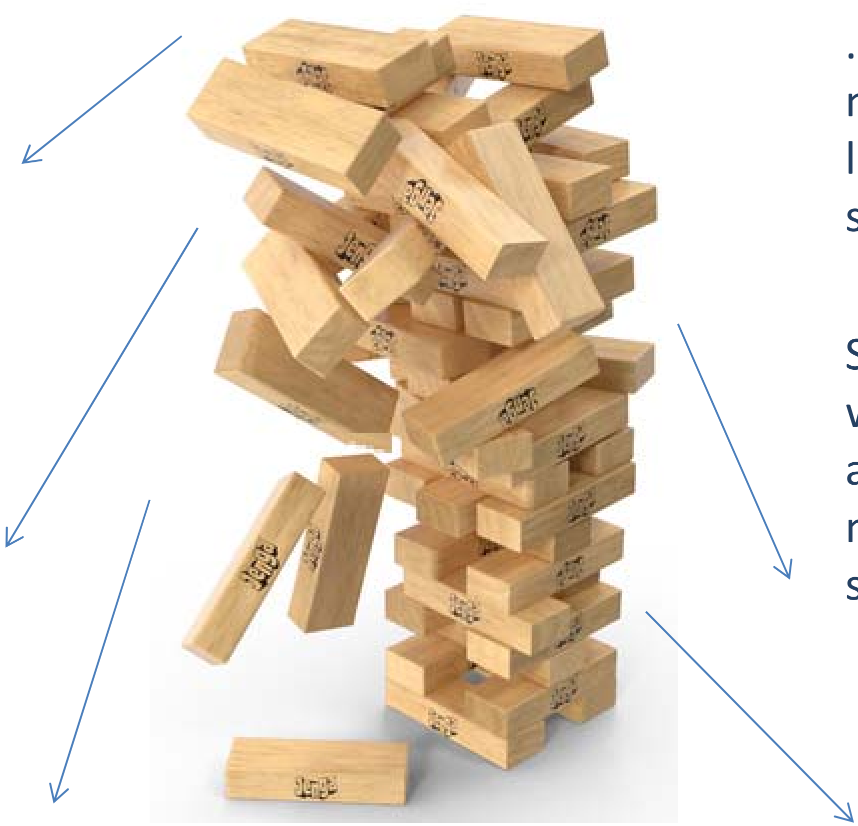
…deep lakes stratified for longer periods

…deep water dissolved oxygen used up sooner

…warmwater fish replaced coldwater fish

Resilient Lakes remained, but…

Jenga Lake



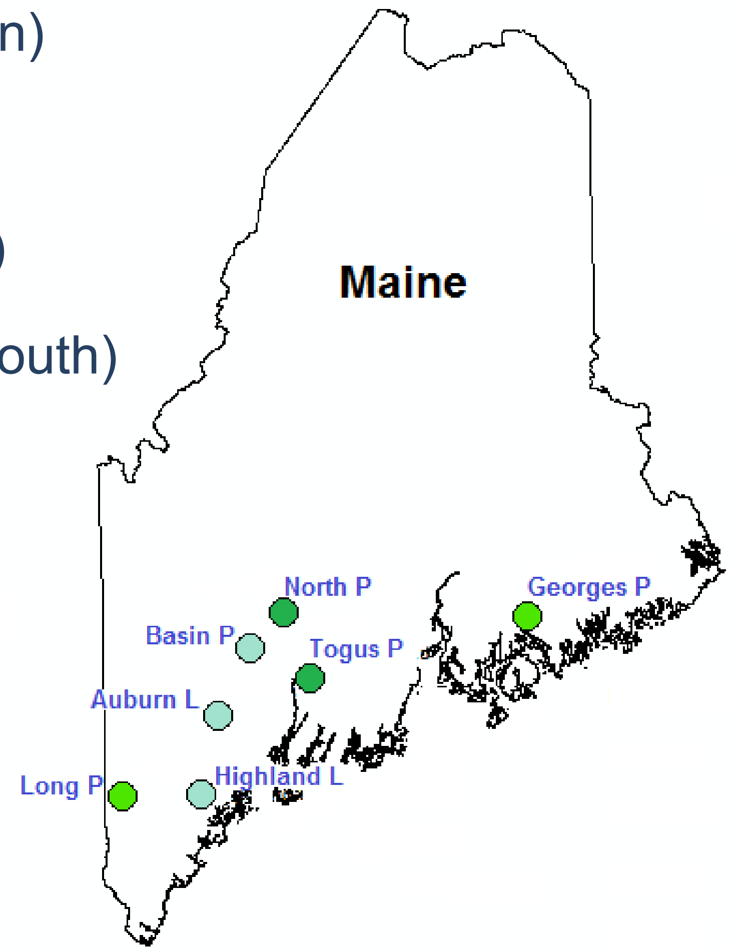
…some lakes began to seek a new 'normal' which might look like a lake located 1000 miles south of Maine.

Sure, they are still lakes, but with lots of algae, the threat of algal toxins, more metaphyton, more invasive plant and animal species.

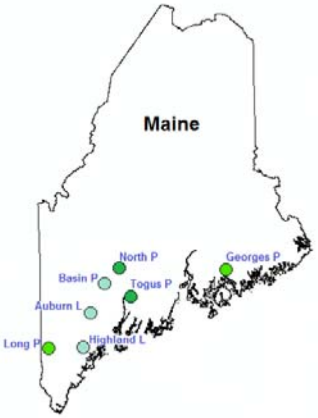
Case Studies

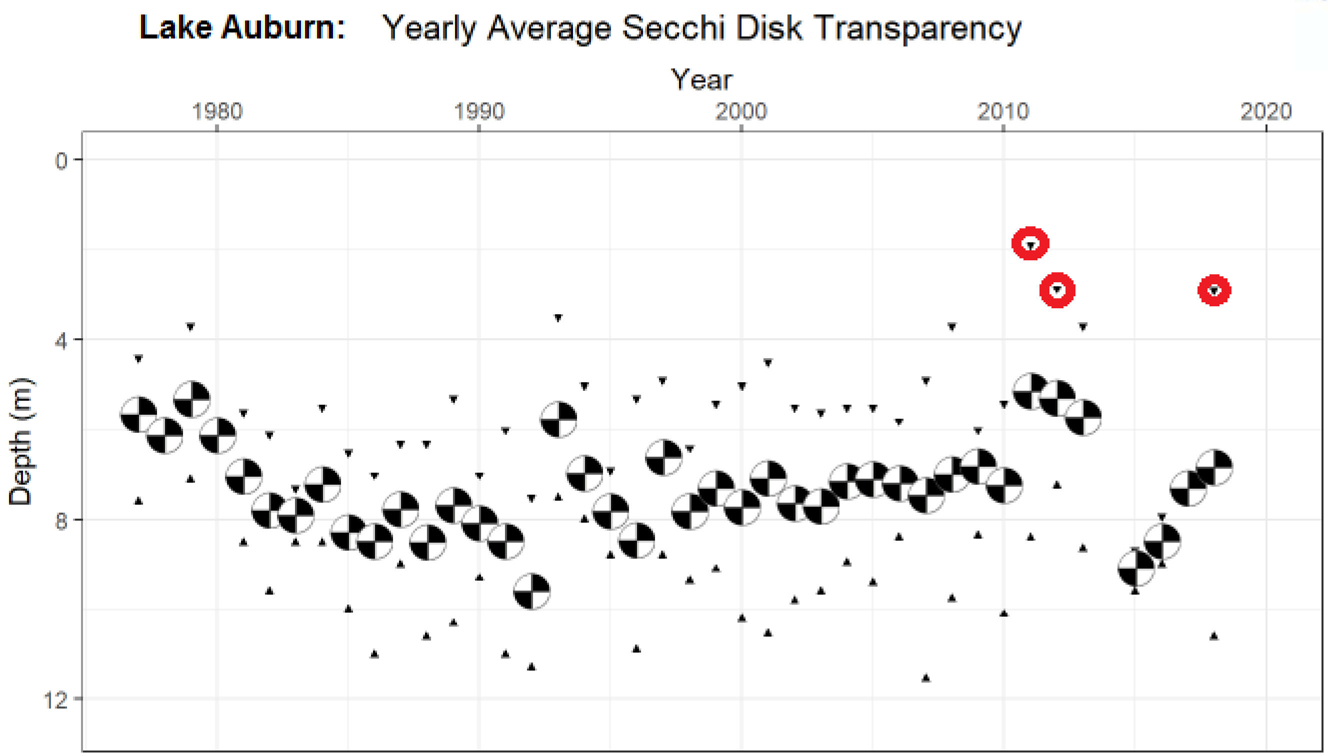
- Lake Auburn (Androscoggin/Auburn)
- Long Pond (York/Parsonsfield)
- Georges Pond (Hancock/Franklin)
- Highland Lake (Cumberland/Falmouth)
- Basin Pond (Kennebec/Fayette)

- Togus Pond (Kennebec/Augusta)
- North Pond (Kennebec/Smithfield)



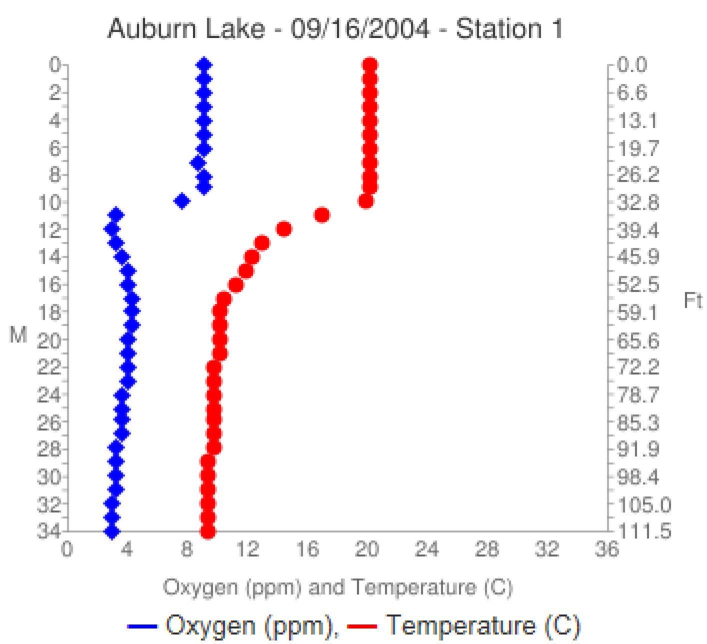
Lake Auburn (3748)

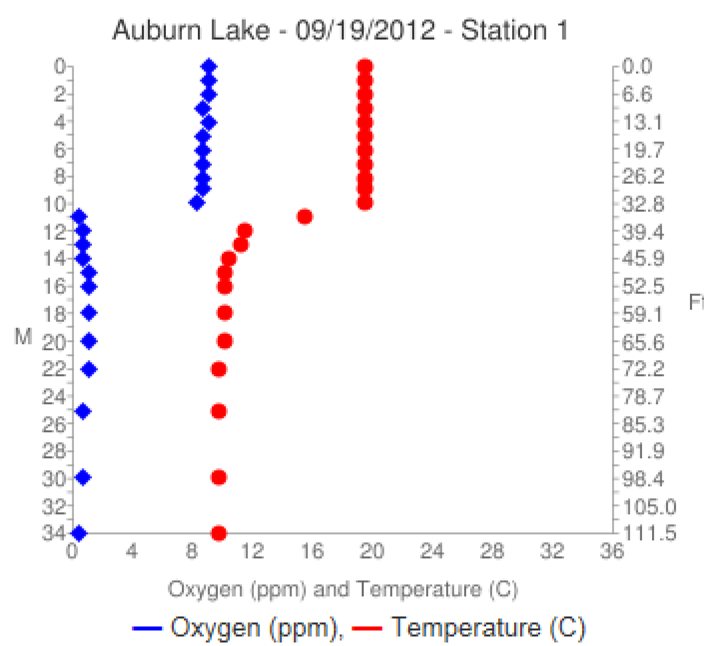




2277 acres
118’ deep

Lake Auburn

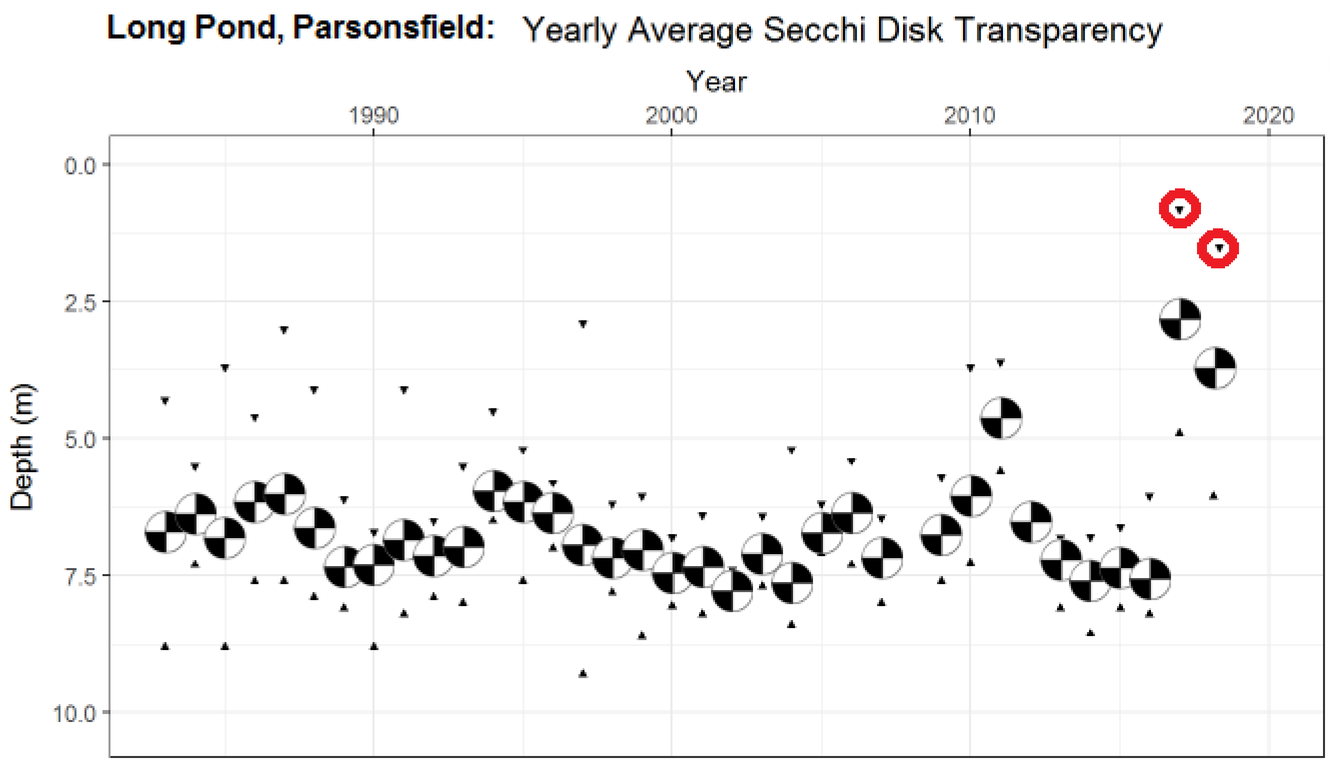


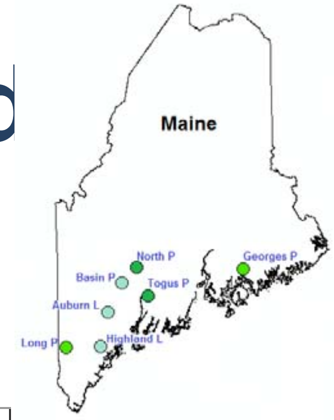


TP: 9 mC = 4 ppb
(8/12/04)

TP: 10 mC = 19 ppb
20 mG = 28 ppb

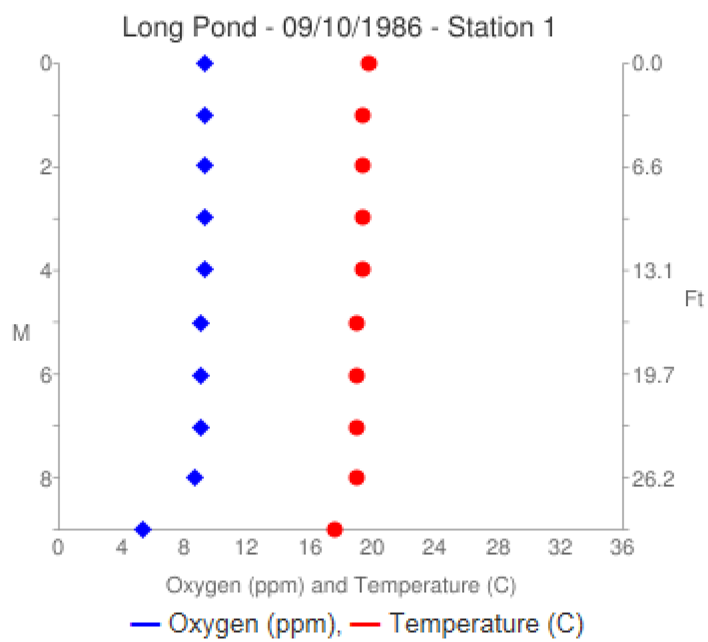
Long Pond, Parsonsfield

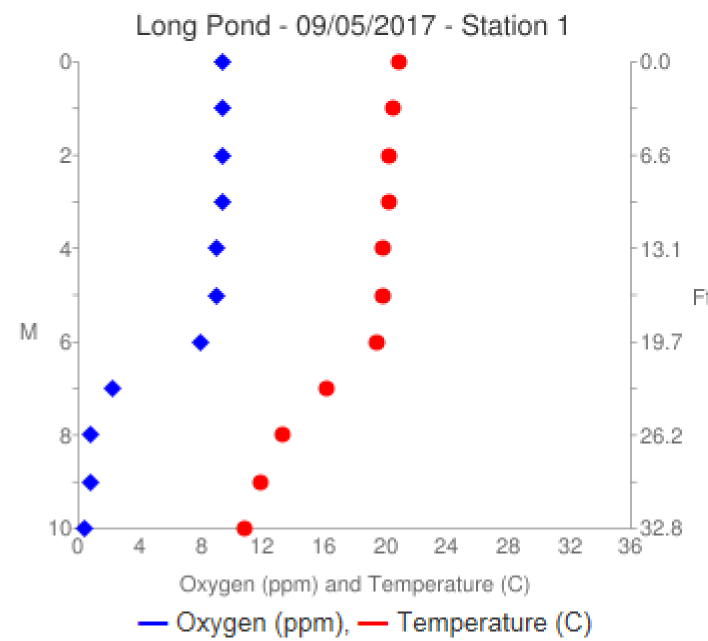




263 acres
33’ deep

Long Pond, Parsonsfield (9701)

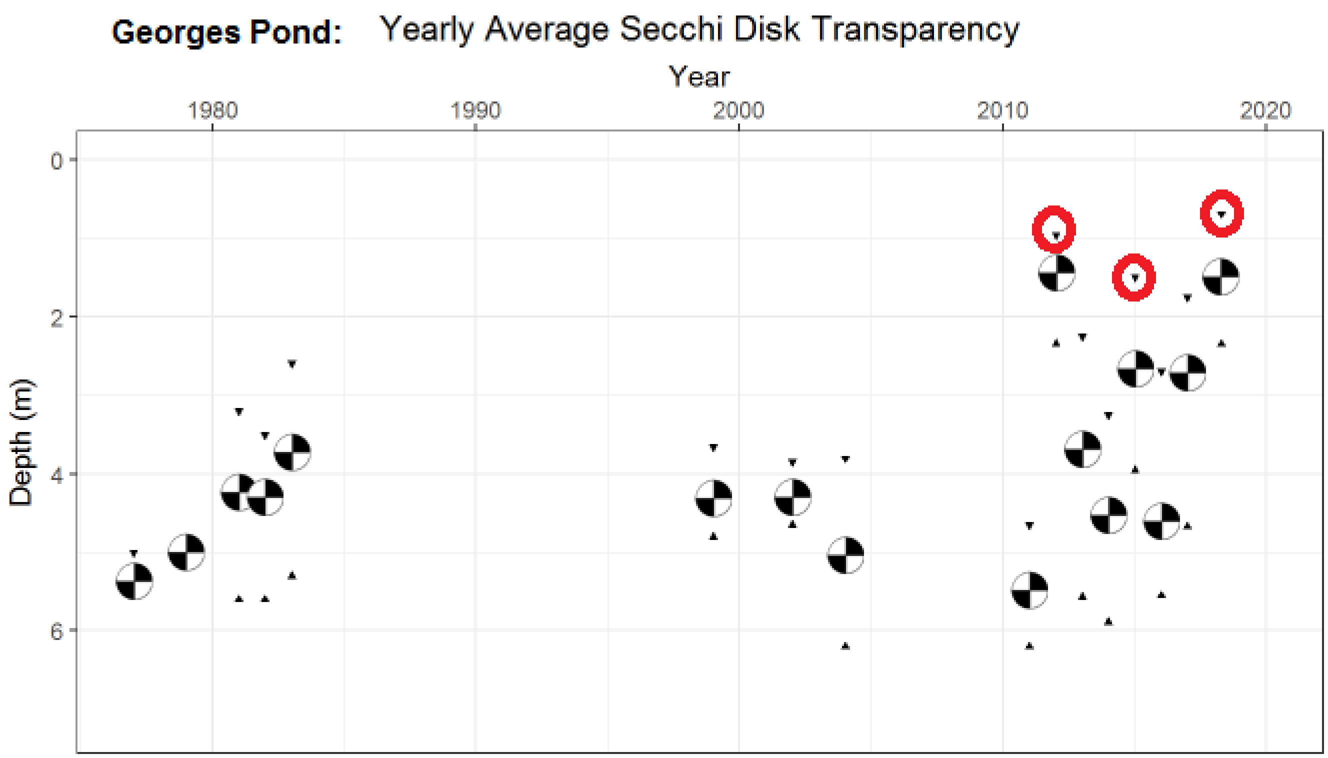


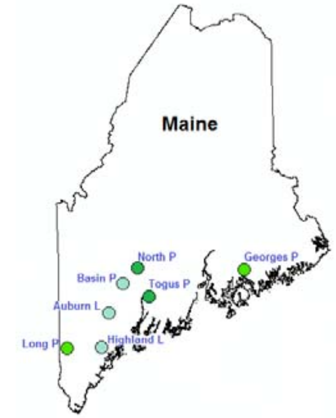


TP: 7 mC = 7 ppb

TP: 6 mC = 13 ppb
9 mG = 39 ppb

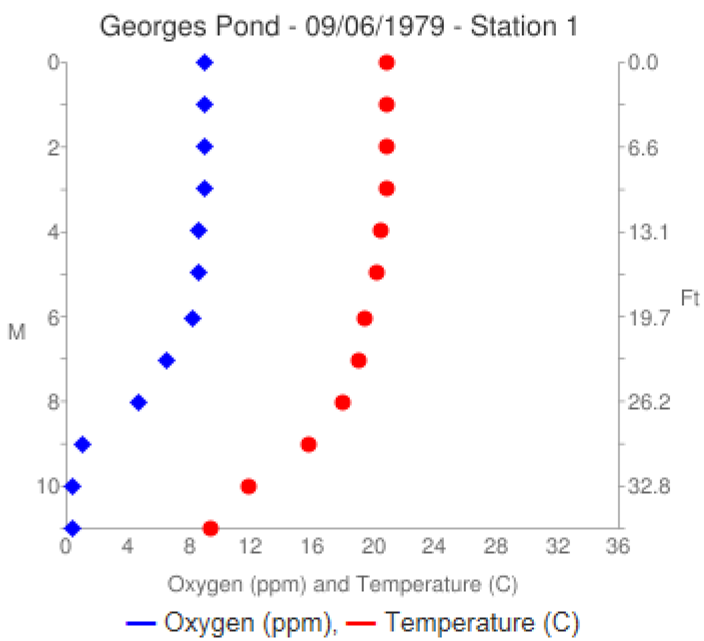
Georges Pond (4406)

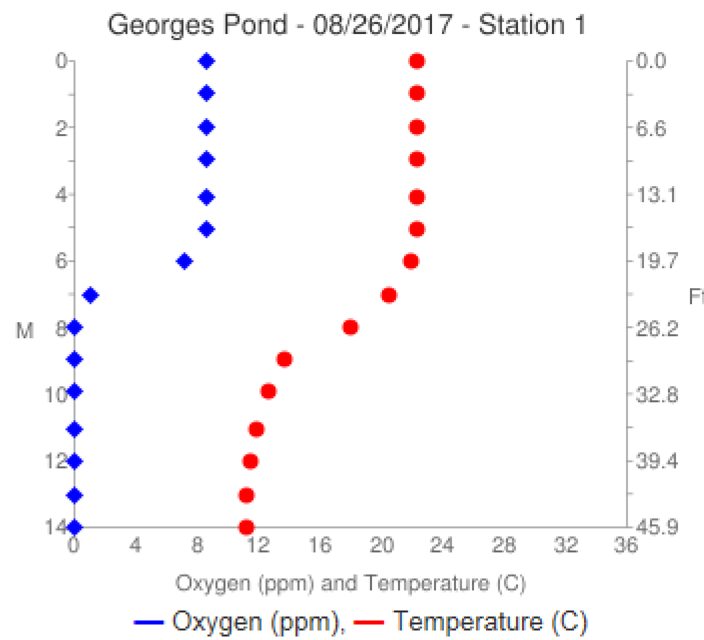




358 acres
45’ deep

Georges Pond

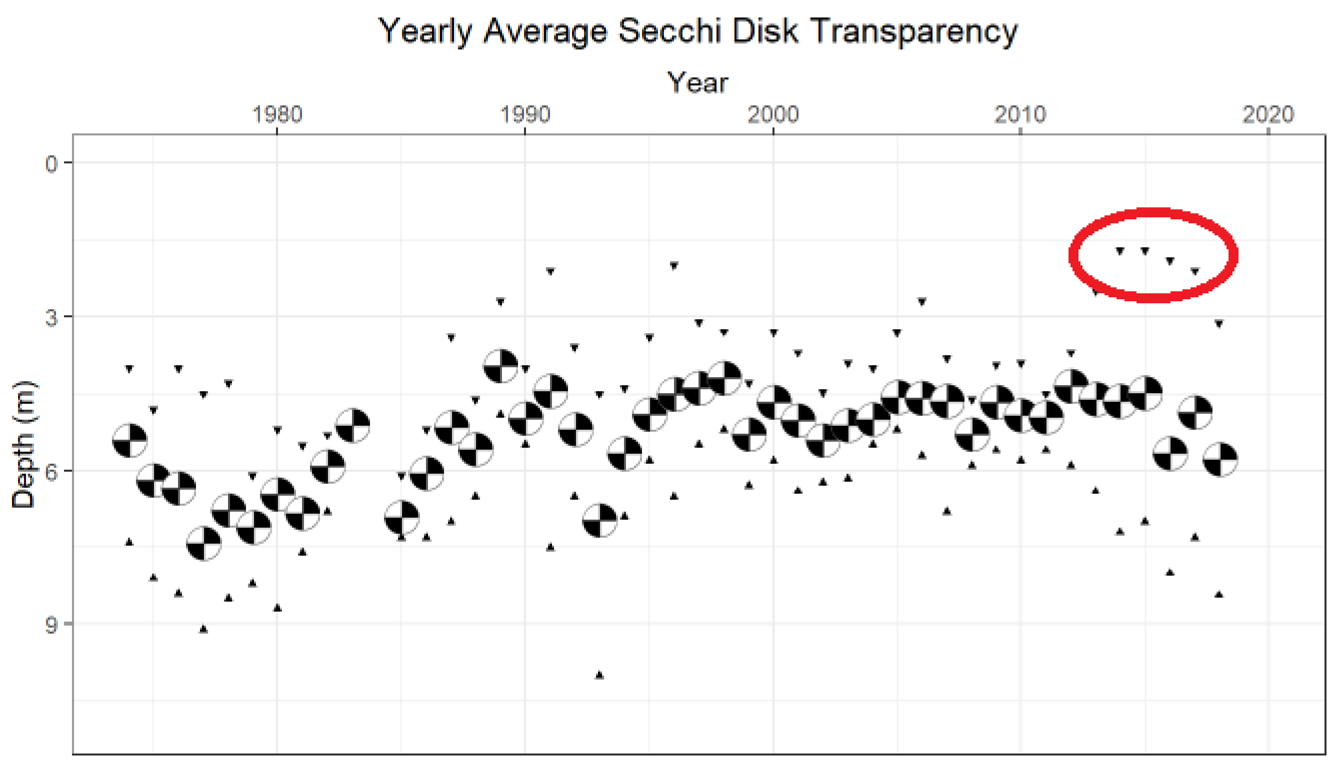


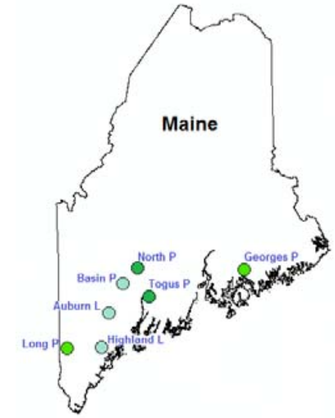


TP: 10 mC = 13
10 mG = 34

TP: 0 mG = 17 ppb
(8/29/18) 4 mC = 24 ppb
6.7 mG = 65 ppb

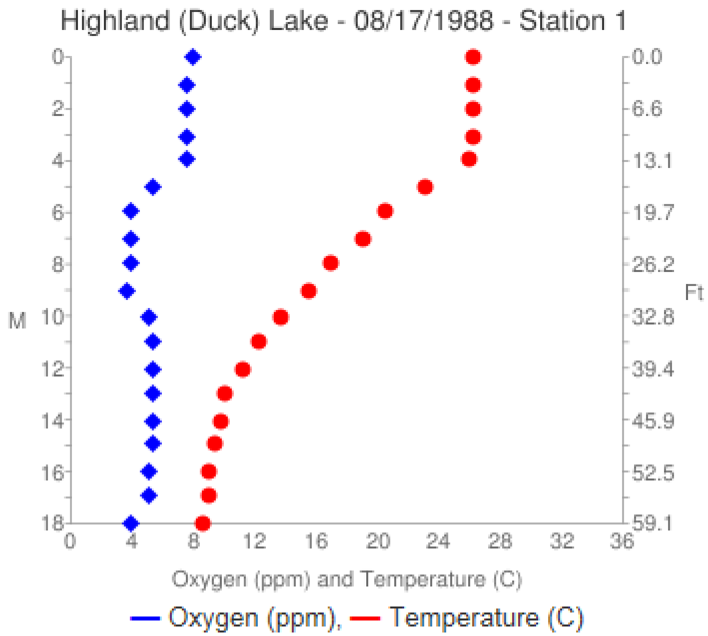
Highland Lake (3734)

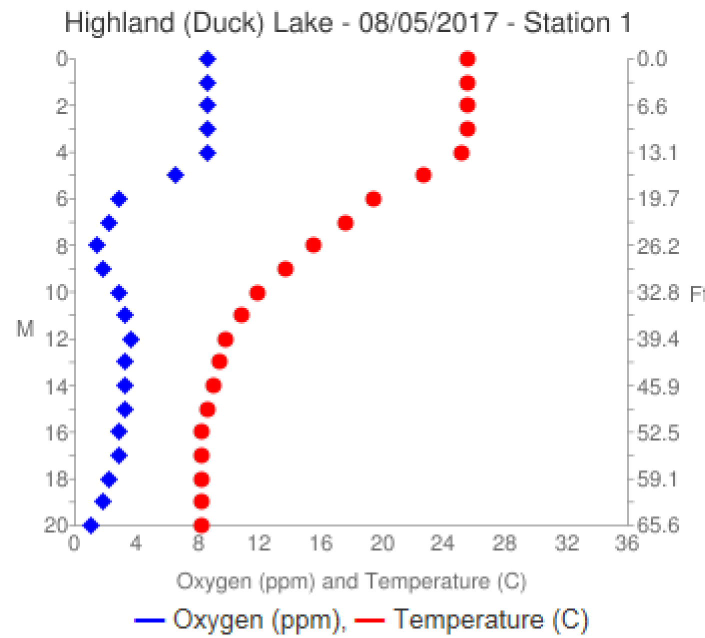




640 acres
67’ deep

Highland Lake



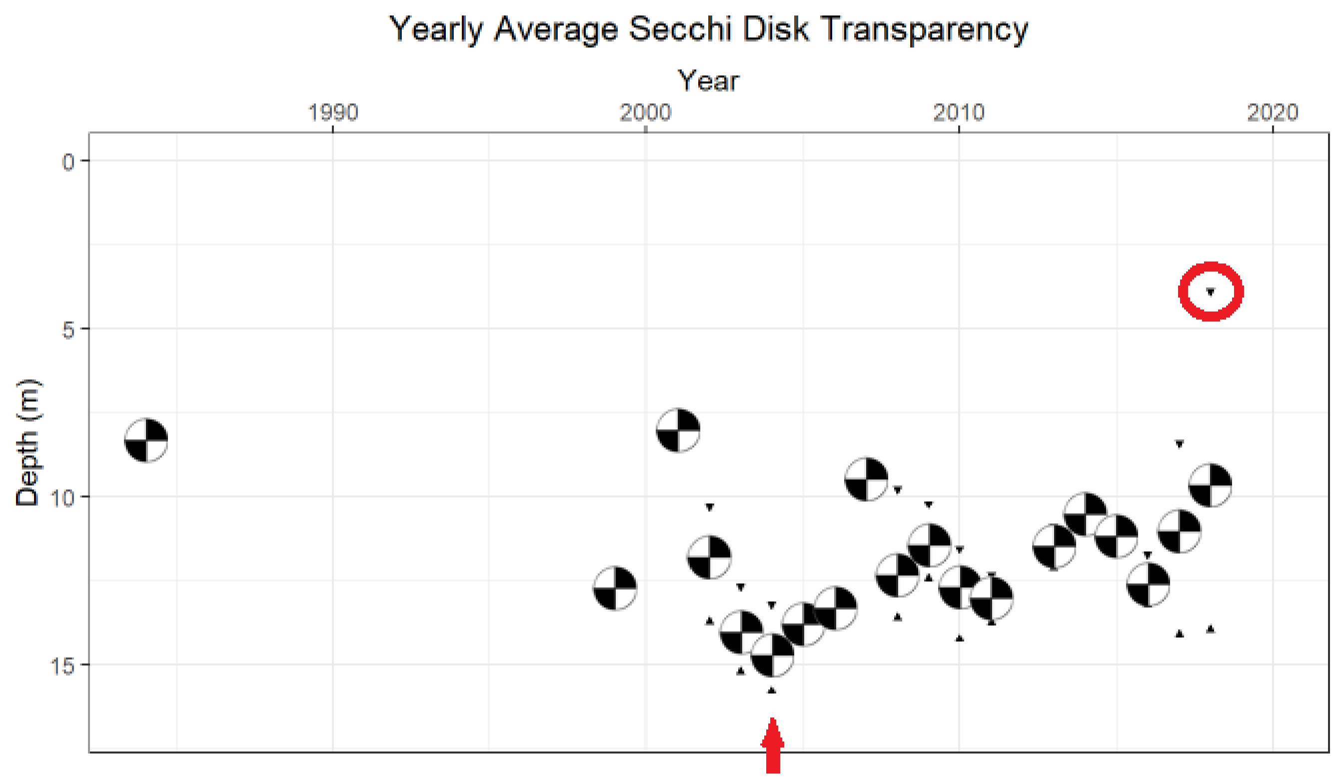


Depth(m)	Type	TP (PPB)
1	Grab	6
3	Grab	8
5	Grab	13
7	Grab	8
9	Grab	5
11	Grab	6
13	Grab	7
15	Grab	8
17	Grab	8

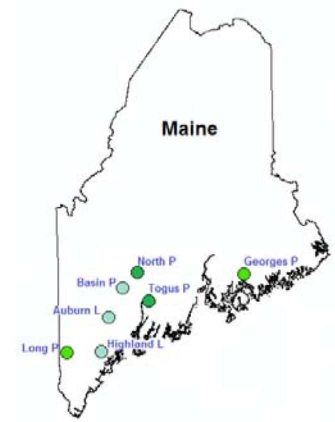
TP: 5 mC ~ 9
17 mG = 8

TP: 5 mC = 13
18 mG = 10

Basin Pond (5654)

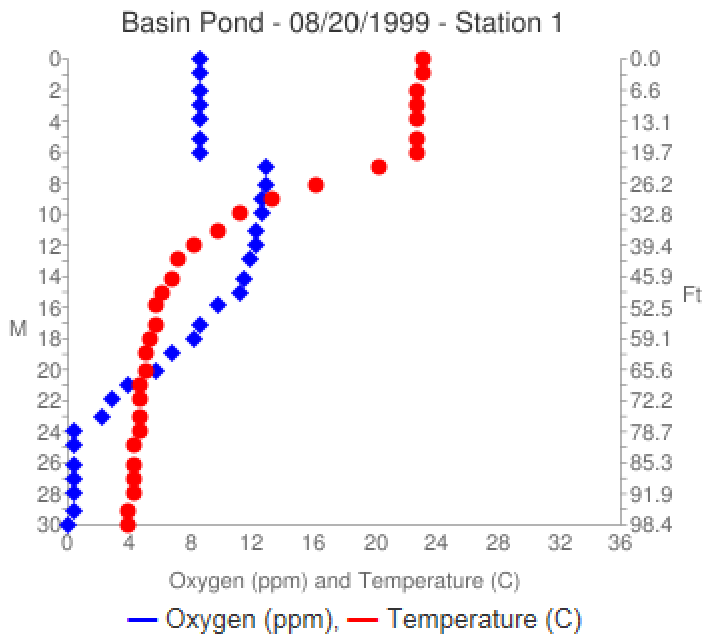


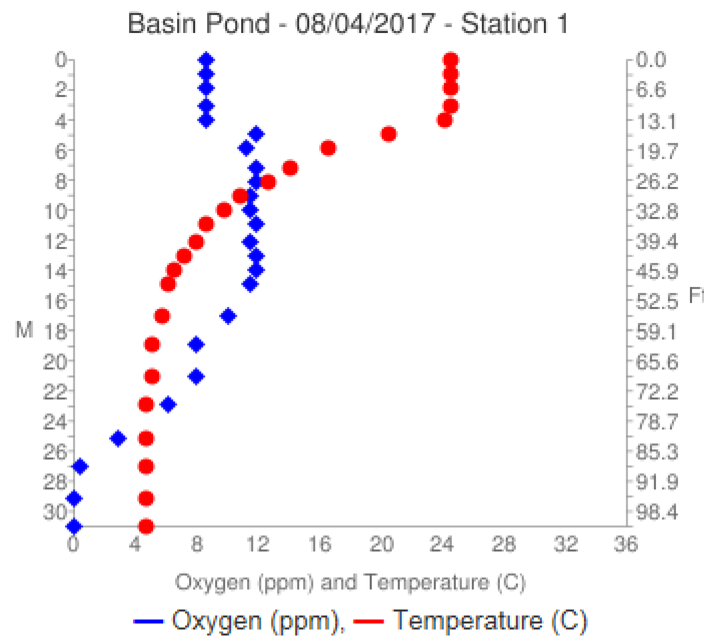
2018 Average Monthly Secchi Disk Transparency



33 acres
106’ deep

Basin Pond

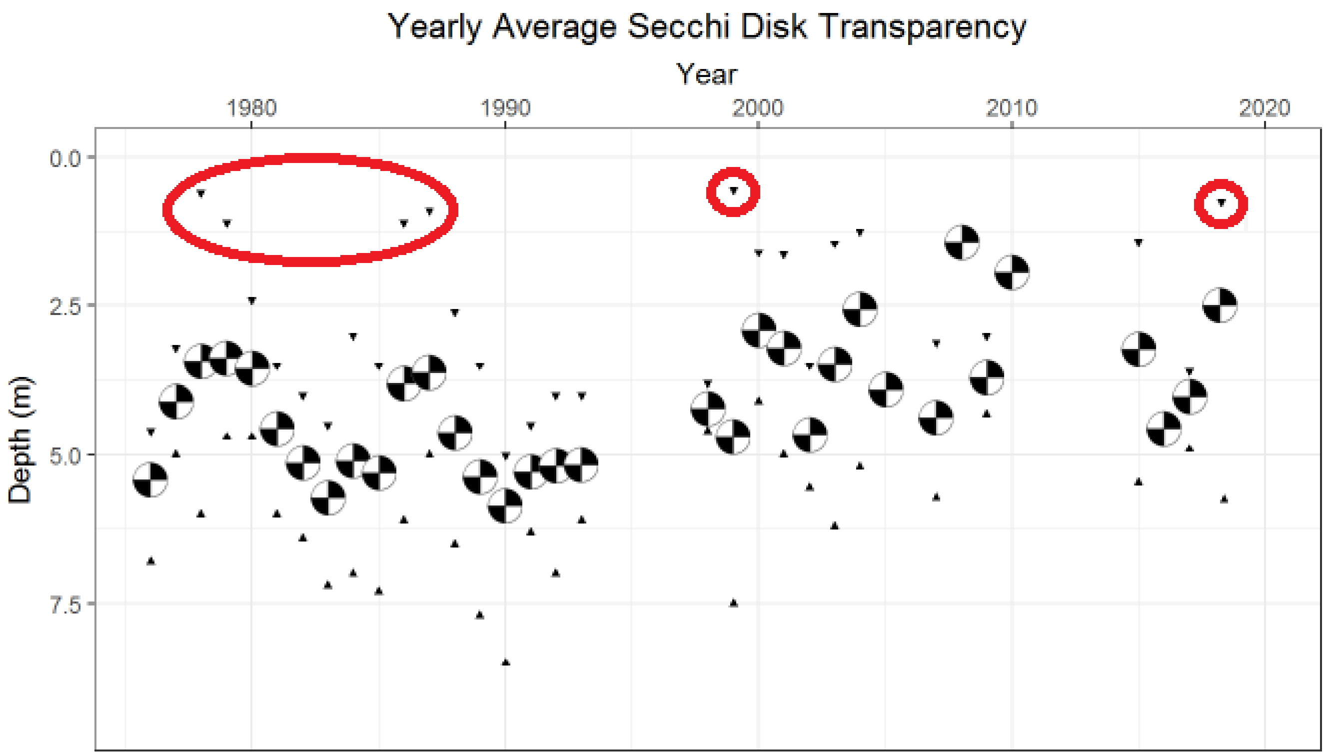


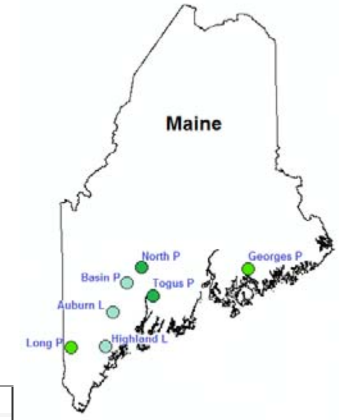


TP: 7 mC = 5
30 mG = 18

TP: 5 mC = 3
18 mG = 10

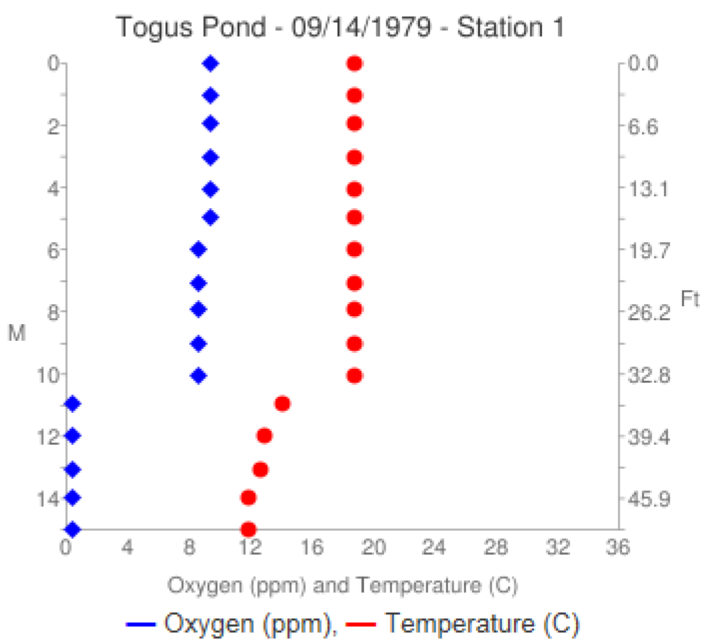
Togus Pond (9931)

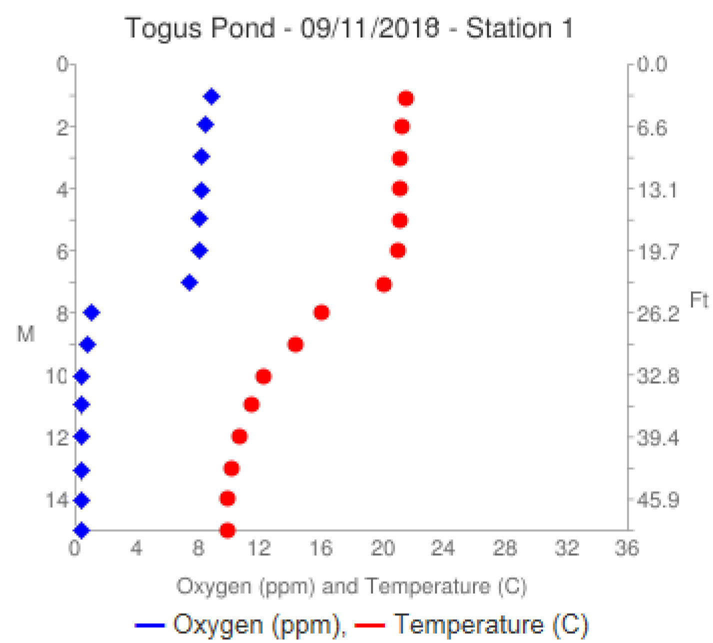




674 acres
49' deep

Togus Pond

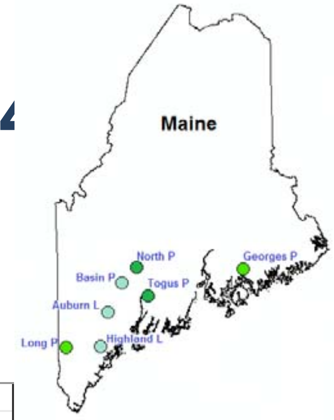


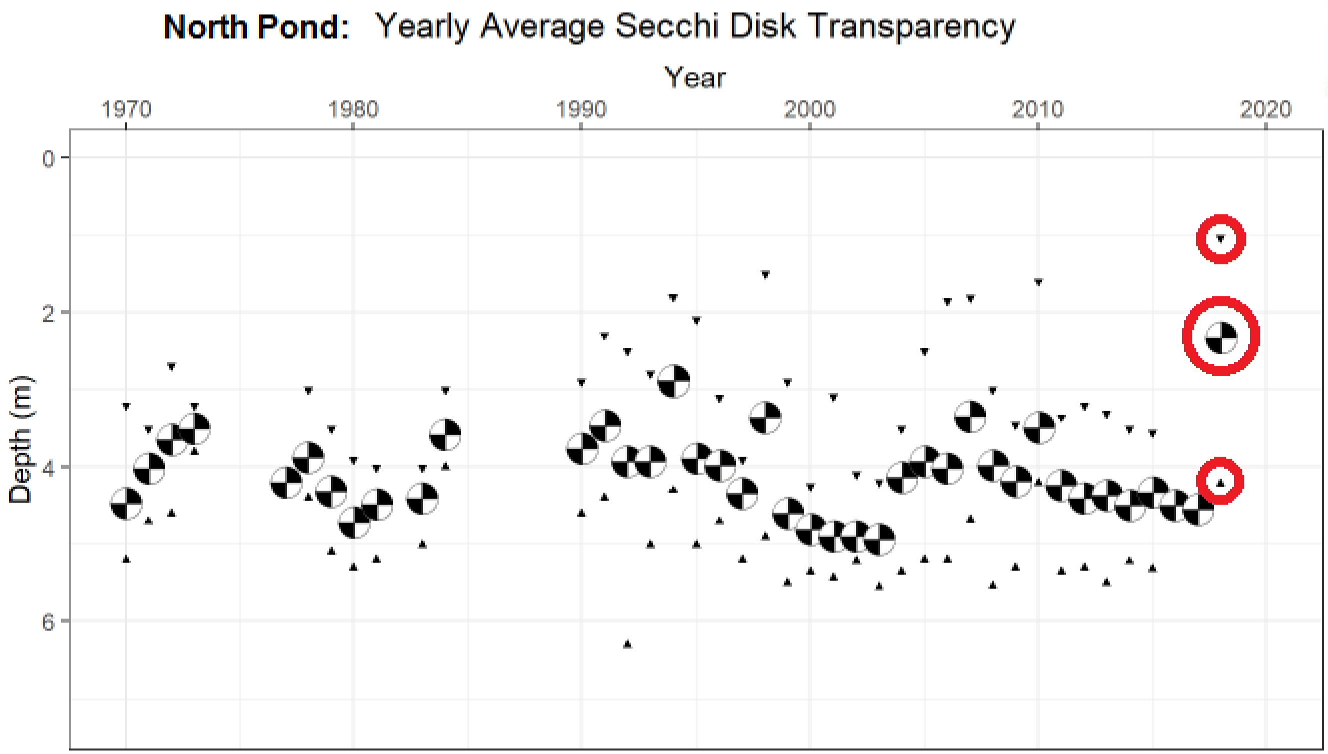


TP: 10 mC ~ 23 ppb
13 mG = 280 ppb

TP: 6 mC = 25 ppb
13 mG = 260 ppb

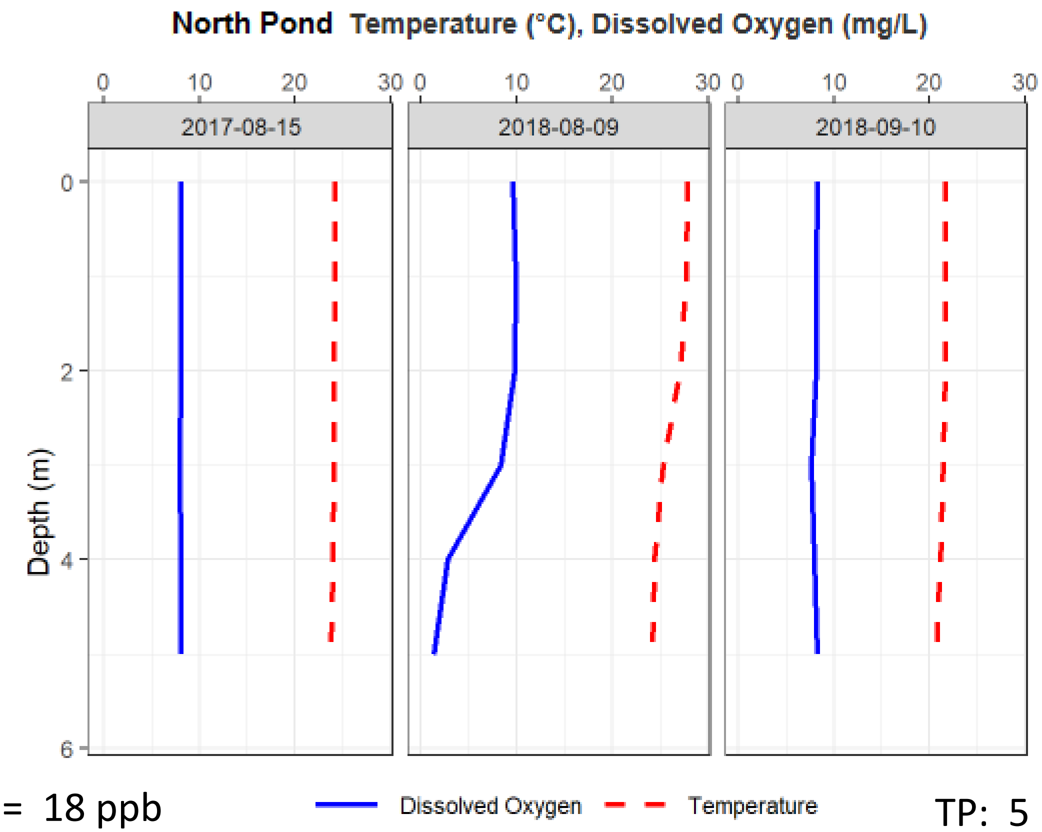
North Pond, Smithfield (534





2531 acres
20’ deep

North Pond, Smithfield



TP: 5 mC = 18 ppb

TP: 5 mC = 32 ppb

TP: 5 mC = 50 ppb

Lake Monitoring Strategies

Frequency of Monitoring

Parameters Monitored

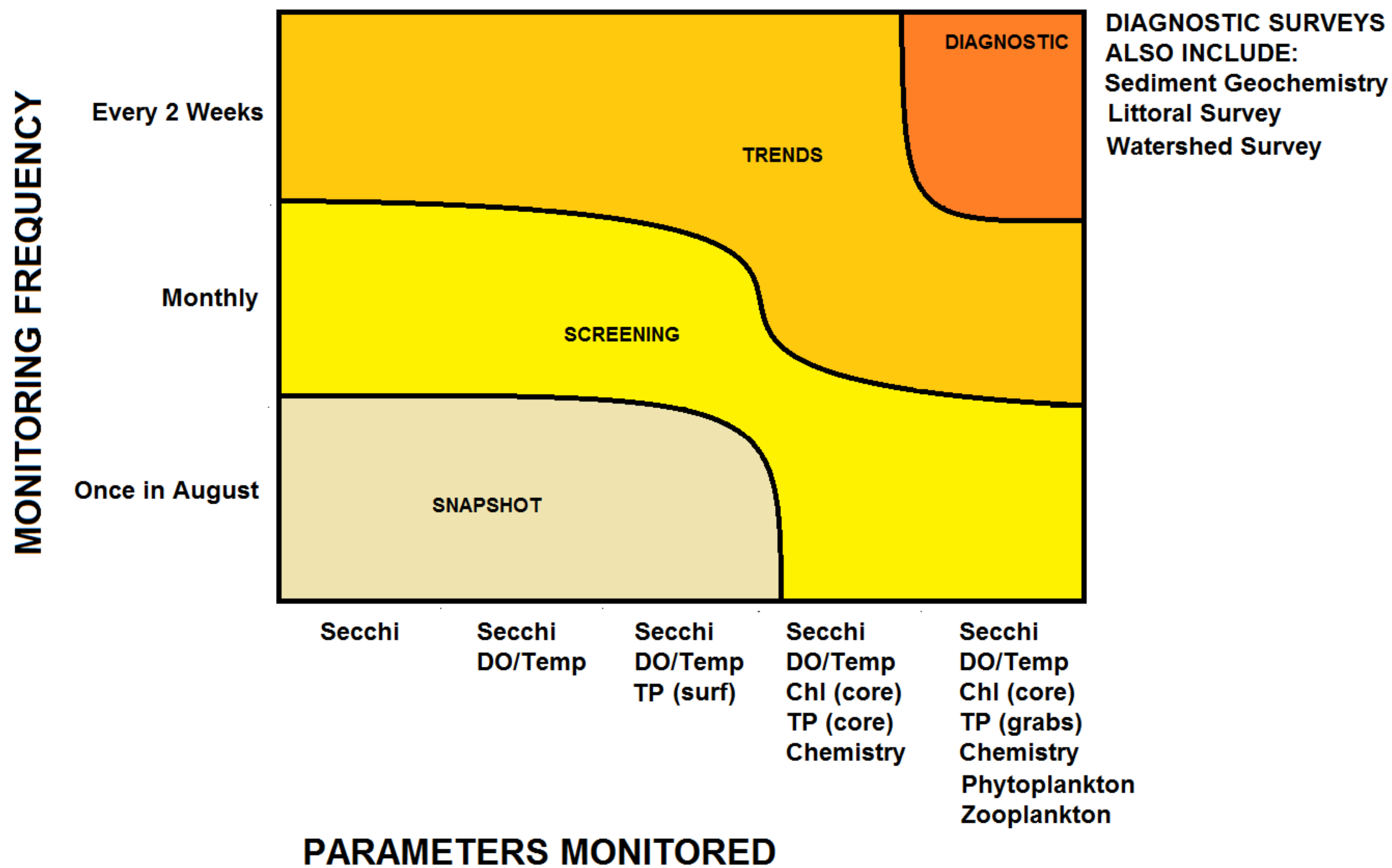
- Snapshot
- Screening
- Trend determination
- Diagnostic

    Sediment Geochemistry

    Watershed Survey

    Littoral Survey

Lake Monitoring Strategies



Strategies by Parameter

Snapshot
Screening
Trends
Diagnostic

	August	Monthly	Every 2 Weeks	Every 5-10 Years
Secchi Transparency	x	x	x	
Temp/Dissolved Oxygen Profiles	x	x	x	
Surface Total Phosphorus	x	x	x	
Total Phosphorus Epilimnetic Core	x	x	x	
Total Phosphorus Profile Grabs	x	x	x	
Chlorophyll - Epilimnetic Core	x	x	x	
Chemistry	x	x	x	
Phytoplankton	x	x	x	
Zooplankton	x	x	x	
Littoral Survey				x
Sediment Geochemistry				x
Watershed Survey				x

Additional Considerations

- Strategies are based on objectives
- DEP tracks trends & blooms (DEP objectives)
- The more data, the better – to a point
- The more parameters, the better
- Baseline data establishes ‘normal’ for a lake
- It all costs money (do as much as is needed to accomplish objectives)

Building Resilience

- Document what is normal for your lake
- Watch for invasive species
- Participate in Lake Smart
- Get the younger generation involved
- Clean your culverts
- Fix erosion problems (may need permits)
- Bring all this to the entire watershed!

Credits

- NOAA National Centers for Environmental Information, State of the Climate: Global Climate Report for June 2019, published online July 2019, retrieved on July 22, 2019 from https://www.ncdc.noaa.gov/sotc/global/201906
- *JENGA®* is a registered trademark *owned* by Pokonobe Associates
- Slide 13 image from: https://www.theemotionmachine.com/how-to-tell-a-story-through-your-presentation/

Contact:

Linda Bacon
207-441-0462 (Cell)
linda.c.bacon@maine.gov

www.maine.gov/dep