Climate Change Effects on Maine Lakes

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Climate Change Effects on Maine Lakes

Outline for this presentation…

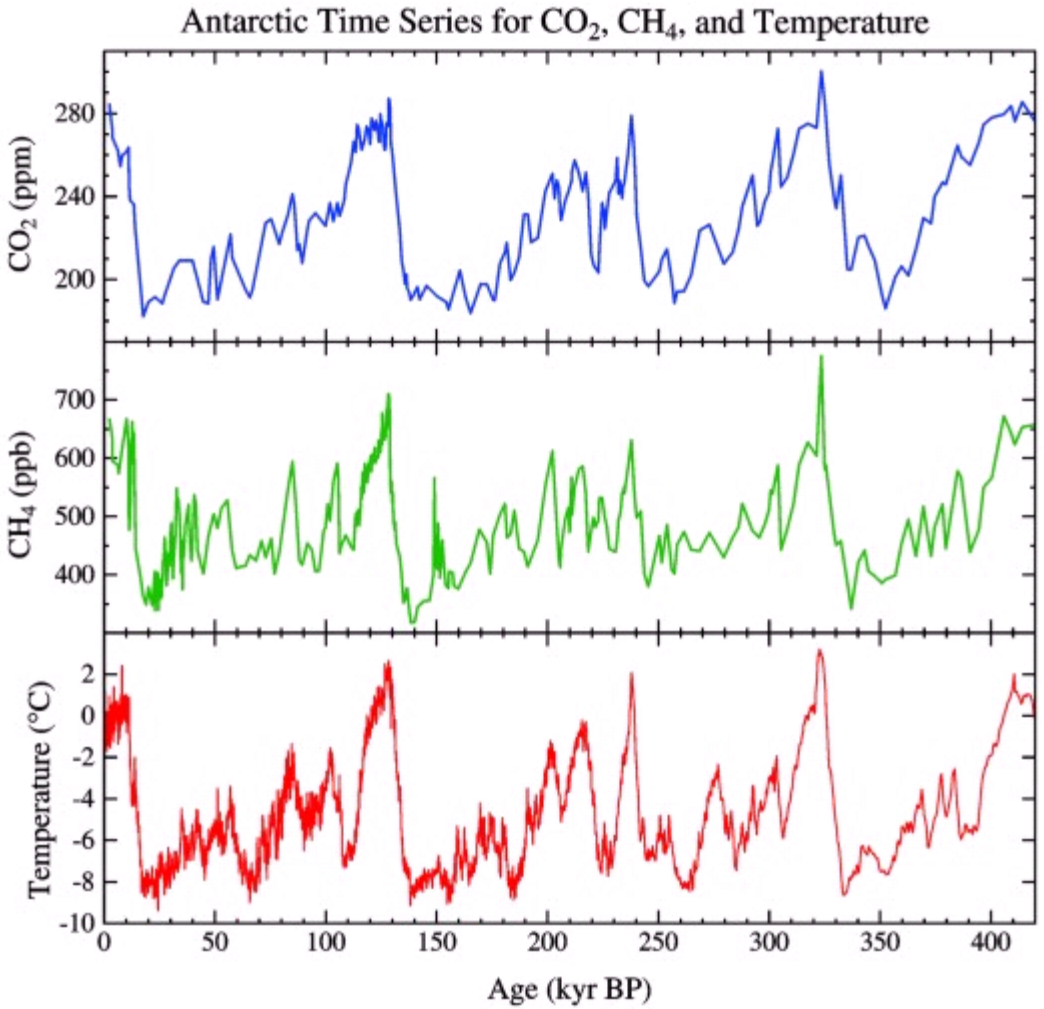
- ✓Background
- •Physical, Chemical & Biological Effects
- •Practical Considerations

Background

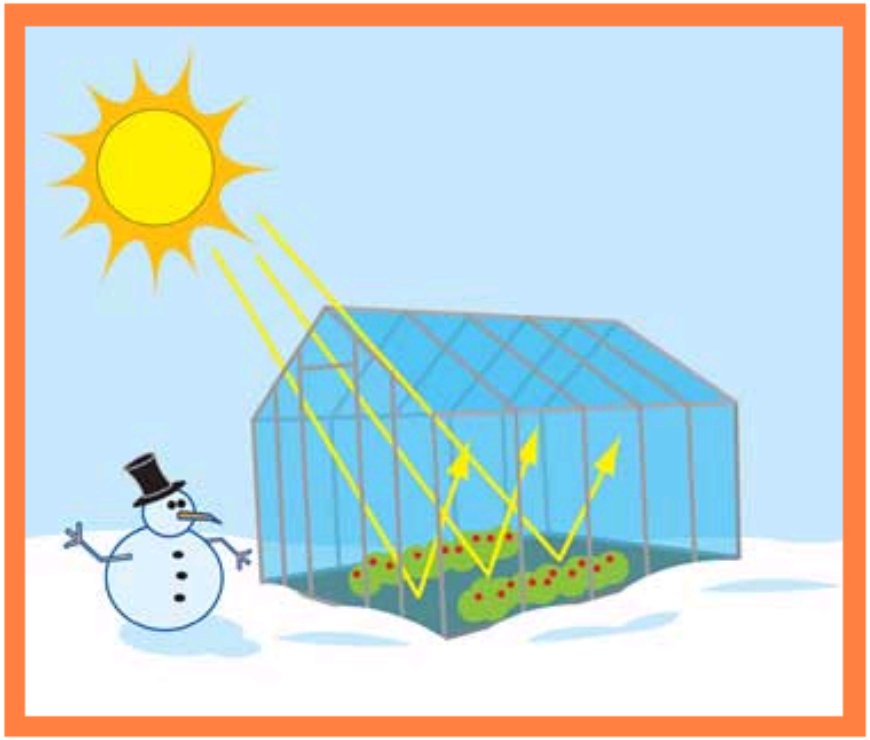
Climate Change has been common over the past 400,000+ years.

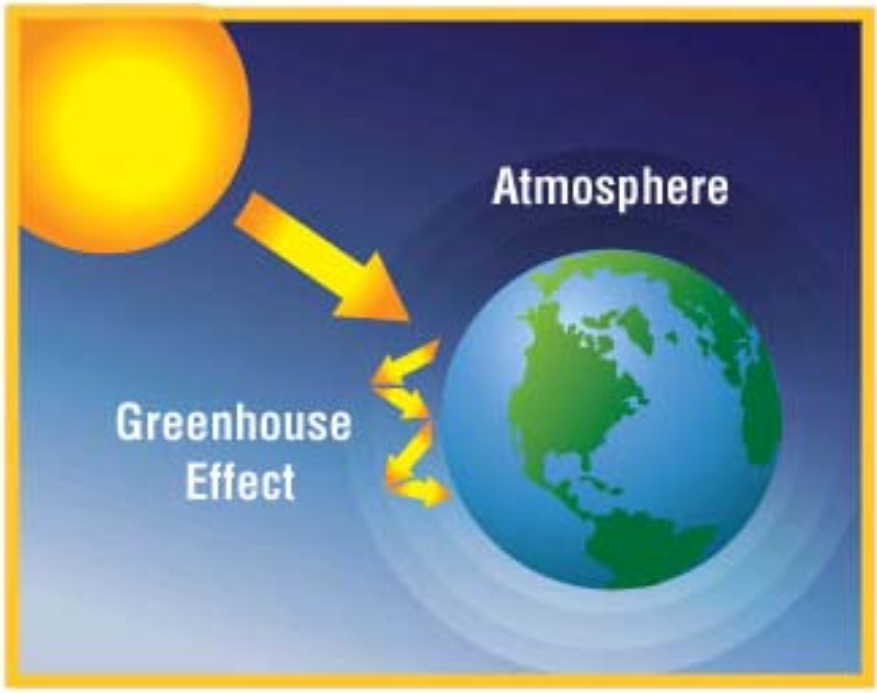
Vostok Antarctic ice core was almost 1.3 miles long (2003).

Air trapped within ice is analyzed for gas composition (in addition to other analytes).

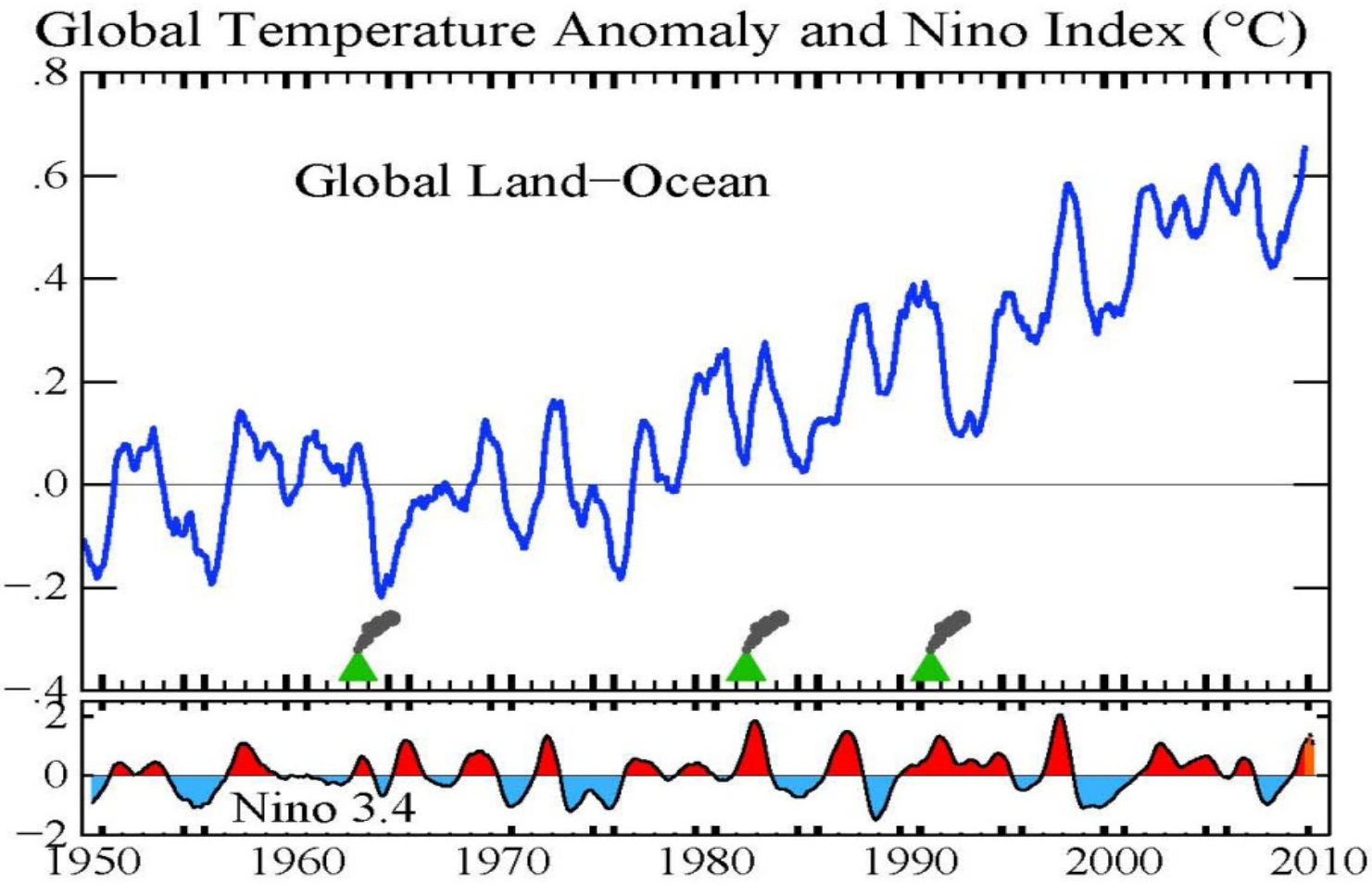


This graph and next few are from Dr. James Hansen, NASA Goddard Institute for Space Studies & Columbia University.

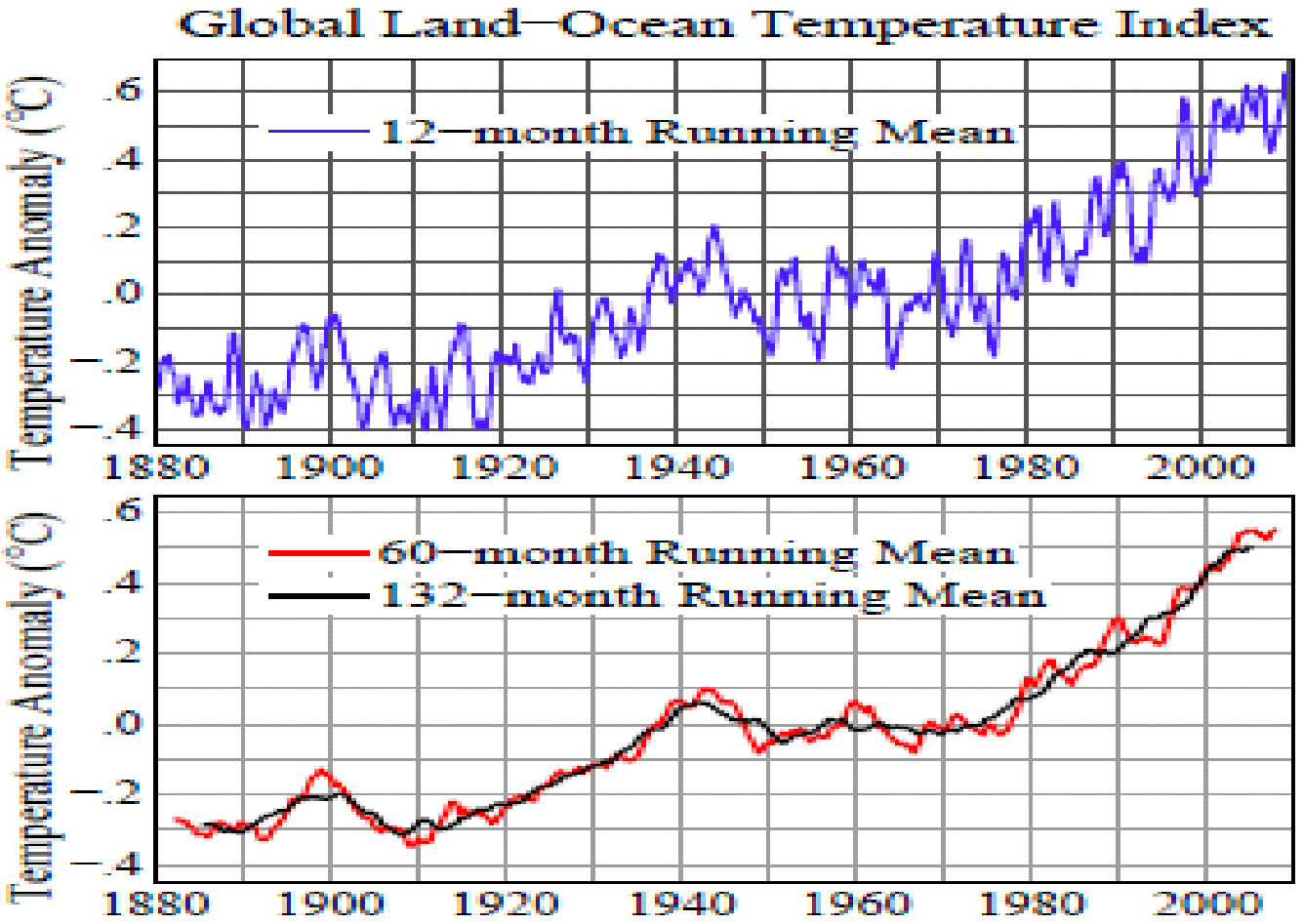




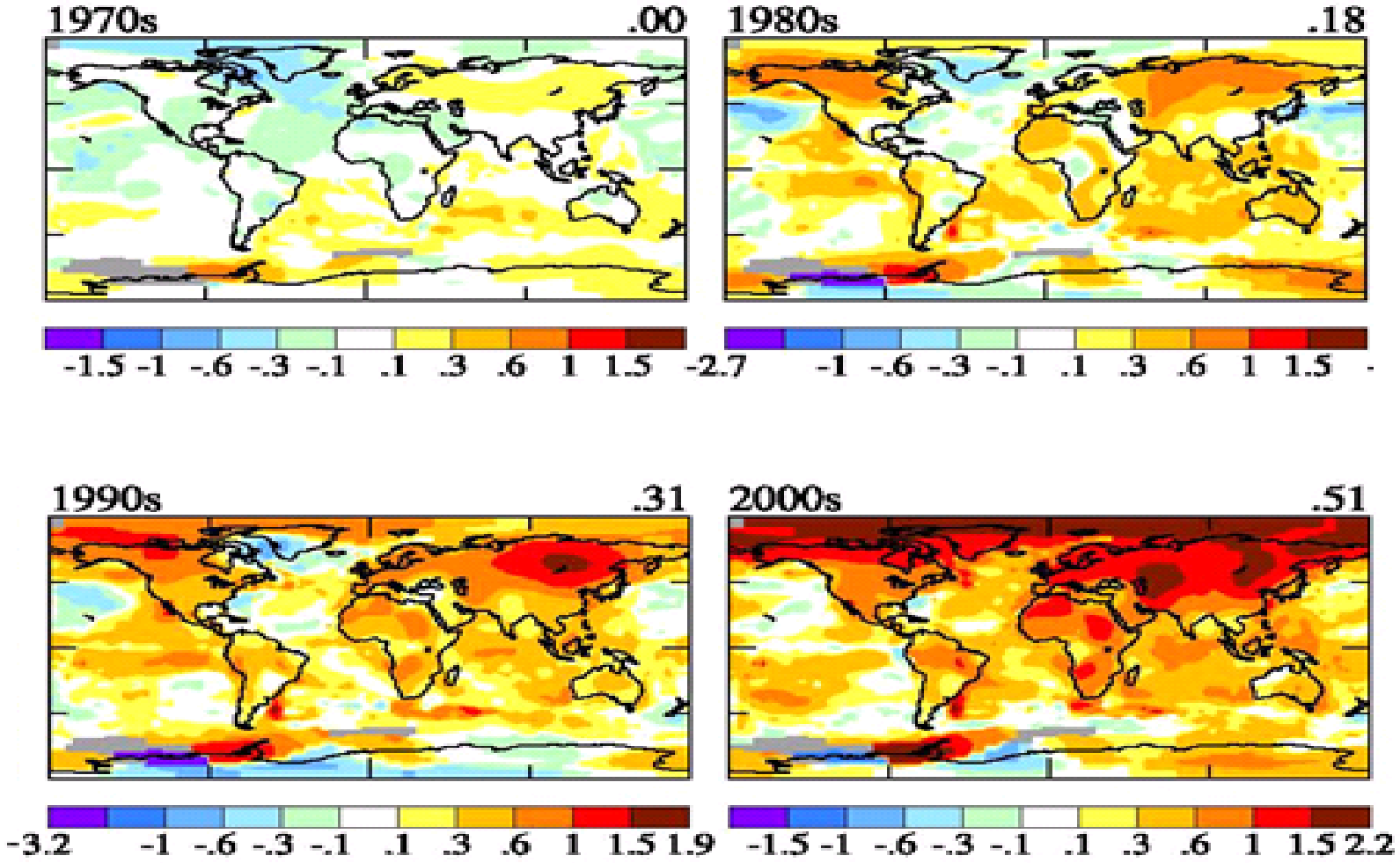
Greenhouse Effect



Blue curve: 12-month running-mean global temperature.
Note correlation with Nino index (red = El Nino, blue = La Nina).
Large volcanoes (green) have a cooling effect for ~2 years.



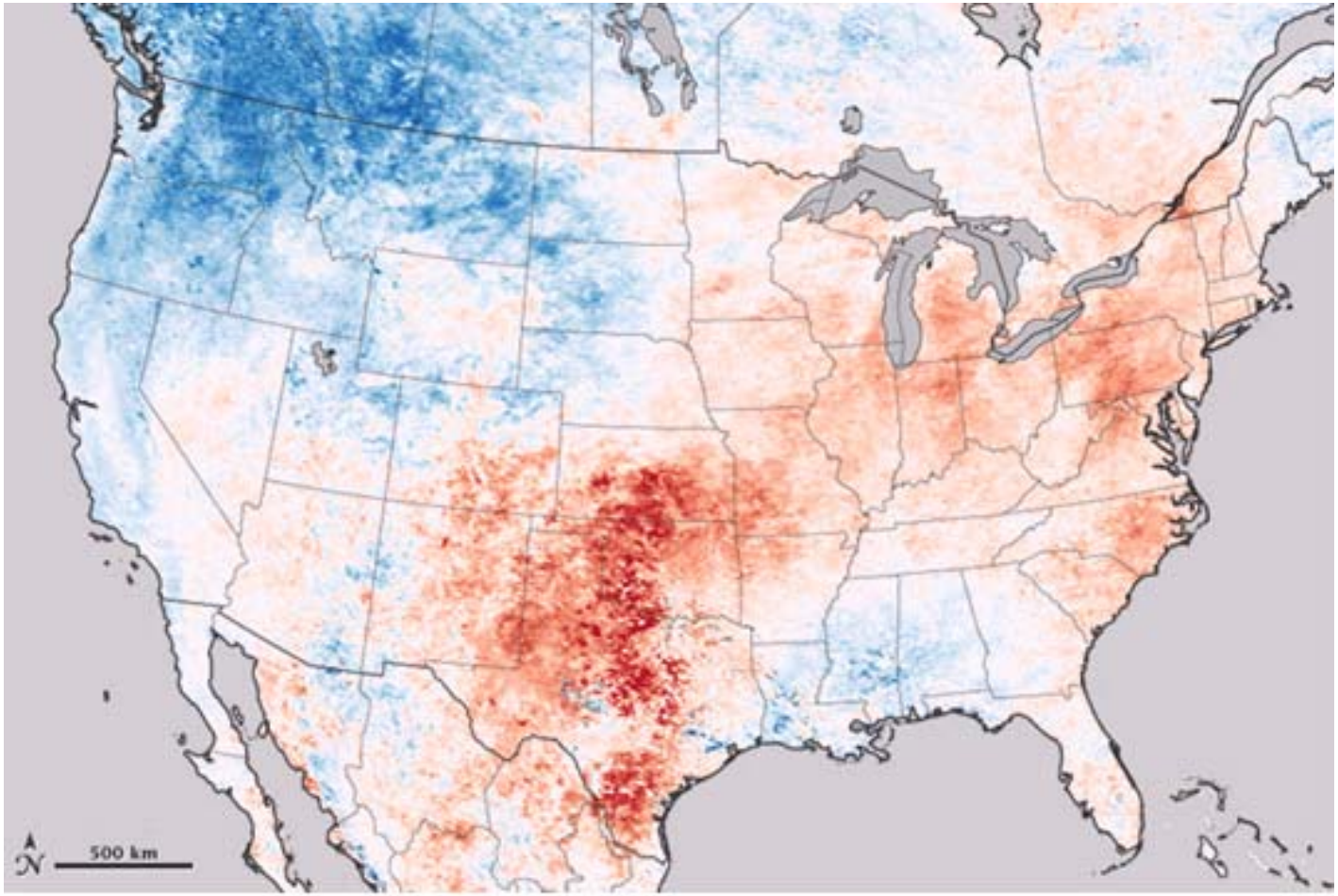
Top: 12-month mean - global temperature is now the warmest in instrumental record. Bottom: 60 & 132-month (5 & 11-year) means minimize tropical and solar variability.



Decadal Surface Temperature Anomalies (°C): 1951-1980 Base Period

Climate change…

- Does not mean that all geographic locations will experience the same direction or magnitude of temperature change.
- With temperature change comes changes in evaporation and addition of water vapor to atmosphere thus precipitation also changes.

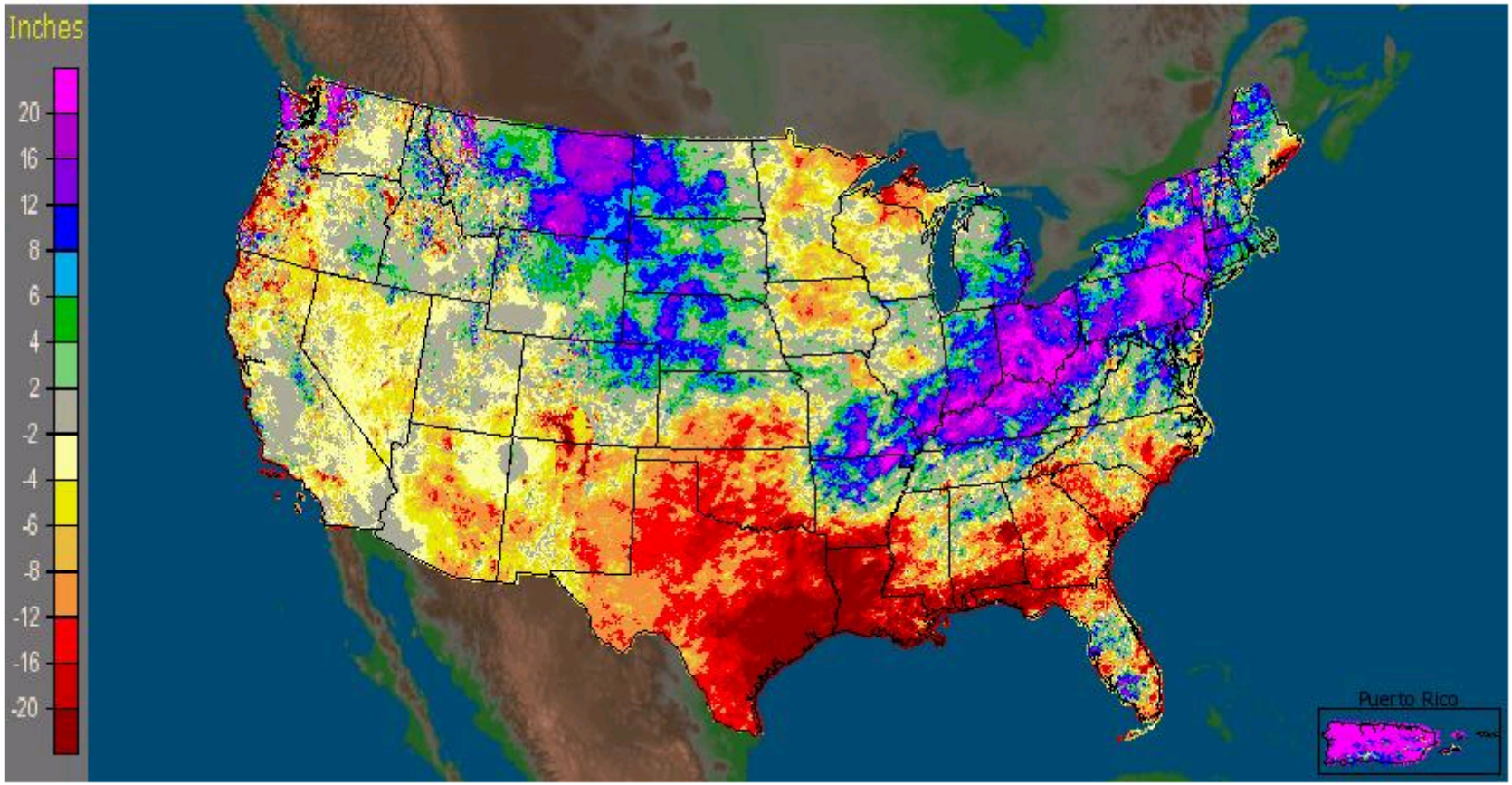


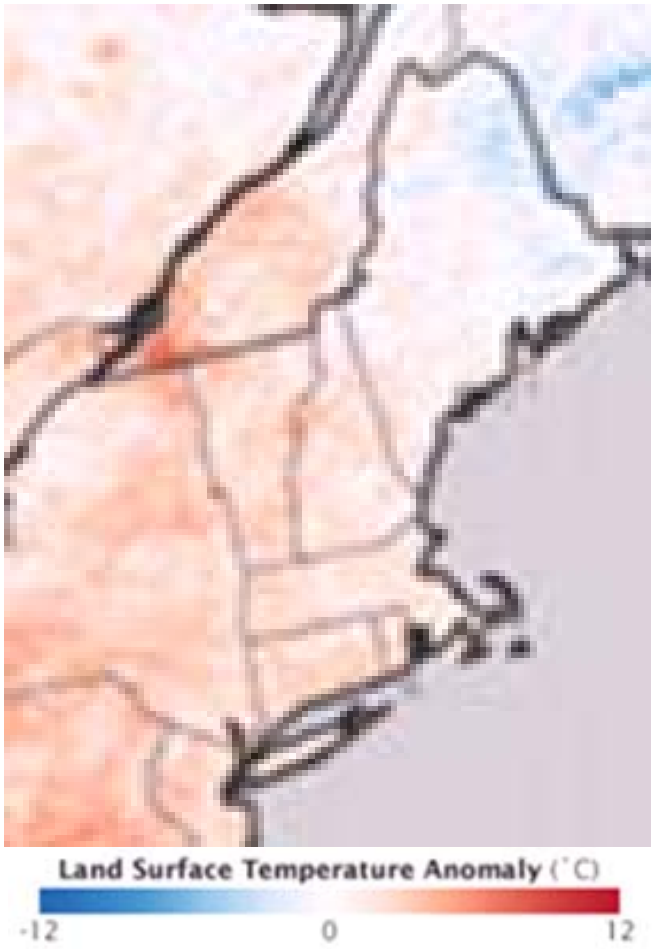
Change of 12C =
change of 21.6 F

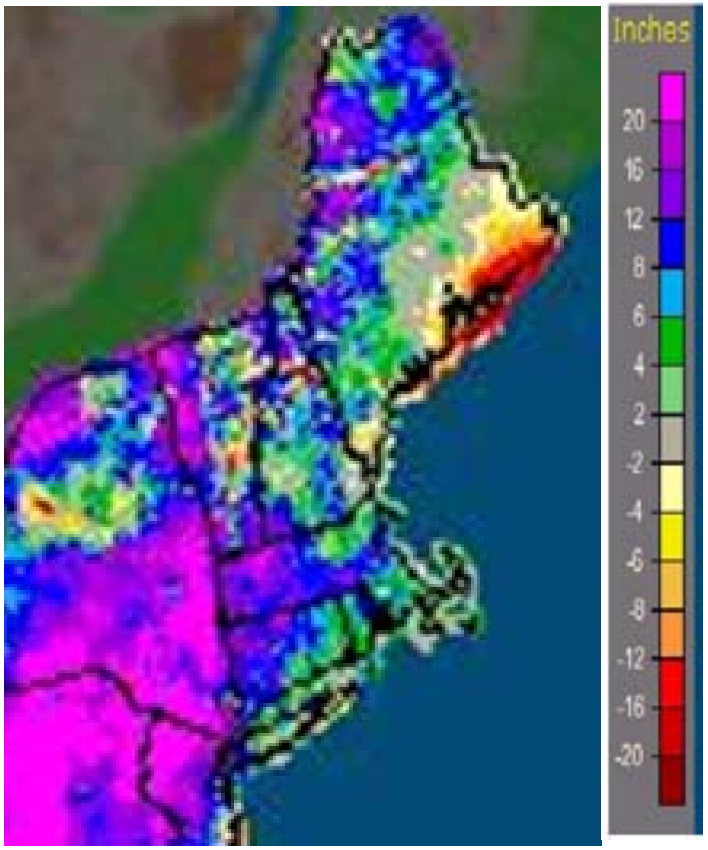
Source: NASA

Temperature departures from average of historic temperatures for the same week.

CONUS + Puerto Rico: Current Year to Date Departure from Normal Precipitation
Valid at 12/1/2011 1200 UTC- Created 12/1/11 23:37 UTC




Land Surface Temperature Anomaly (˚C)
-12
0
12

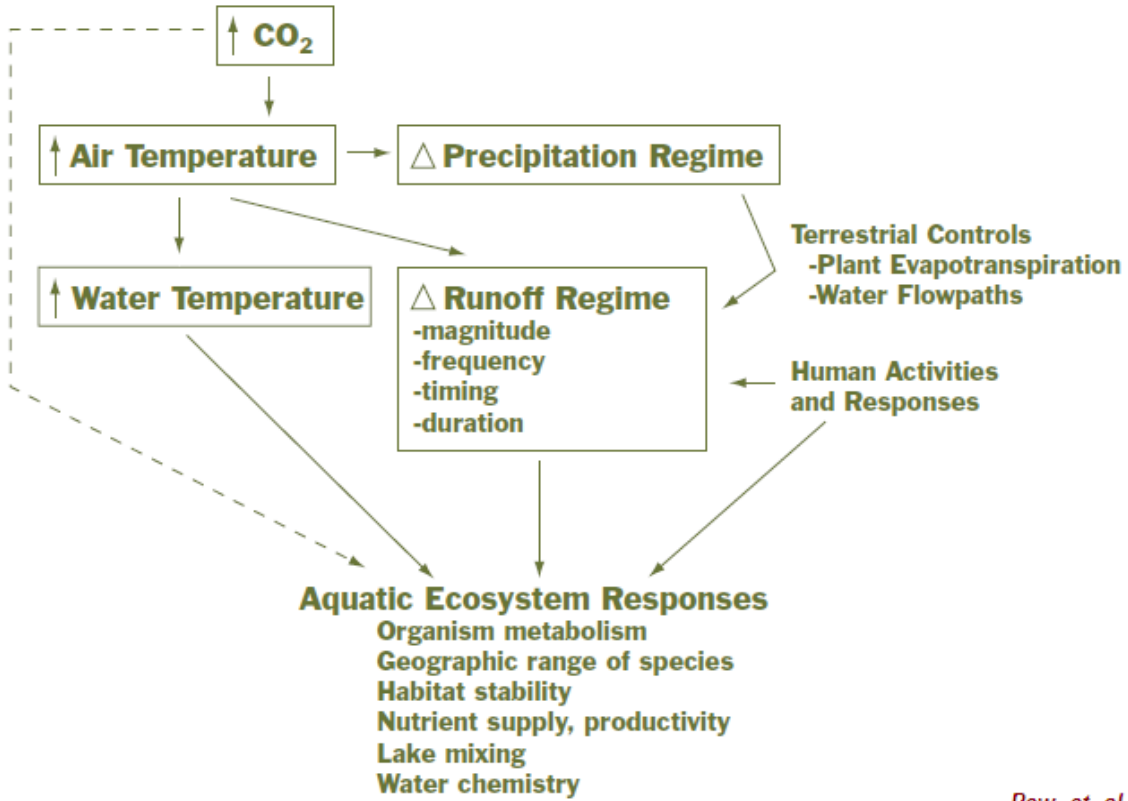

Inches
20
16
12
8
6
4
2
-2
-4
-6
-8
-12
-16
-20

Outline for this presentation…

✓Background
✓Physical, Chemical & Biological Effects
•Practical Considerations

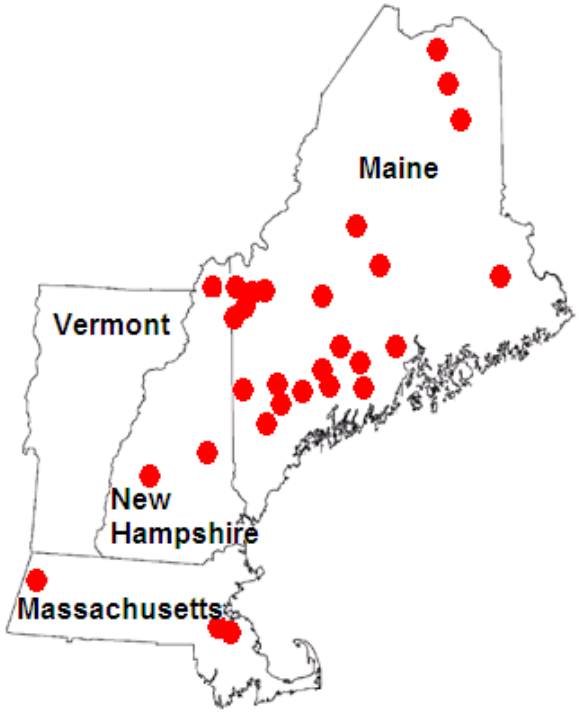
How are these conditions affecting Maine lakes?

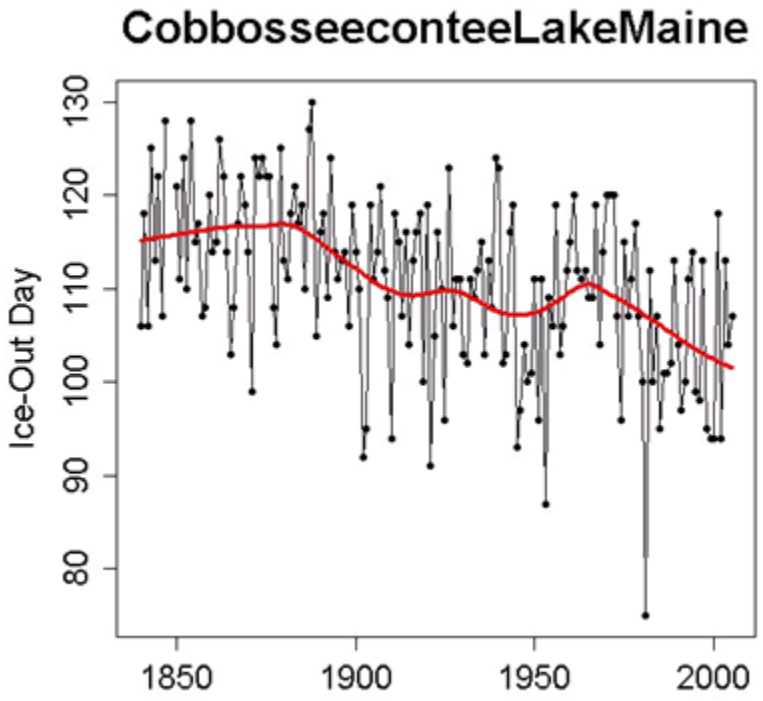
CO_2, Climate, and Ecological Processes



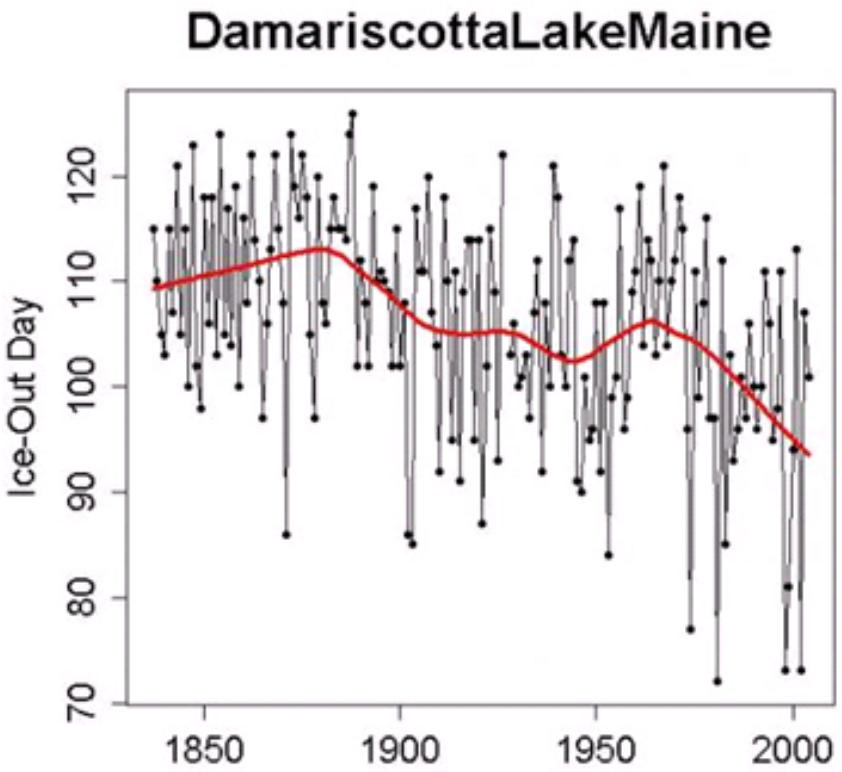
Pew, et. al, 2002

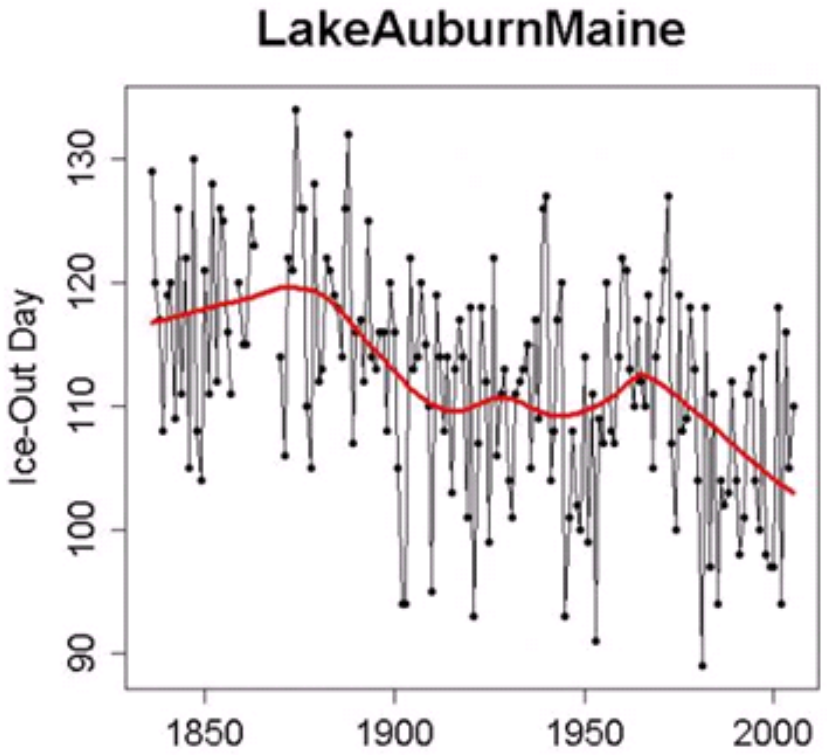
Physical Effects: Ice free period is increasing



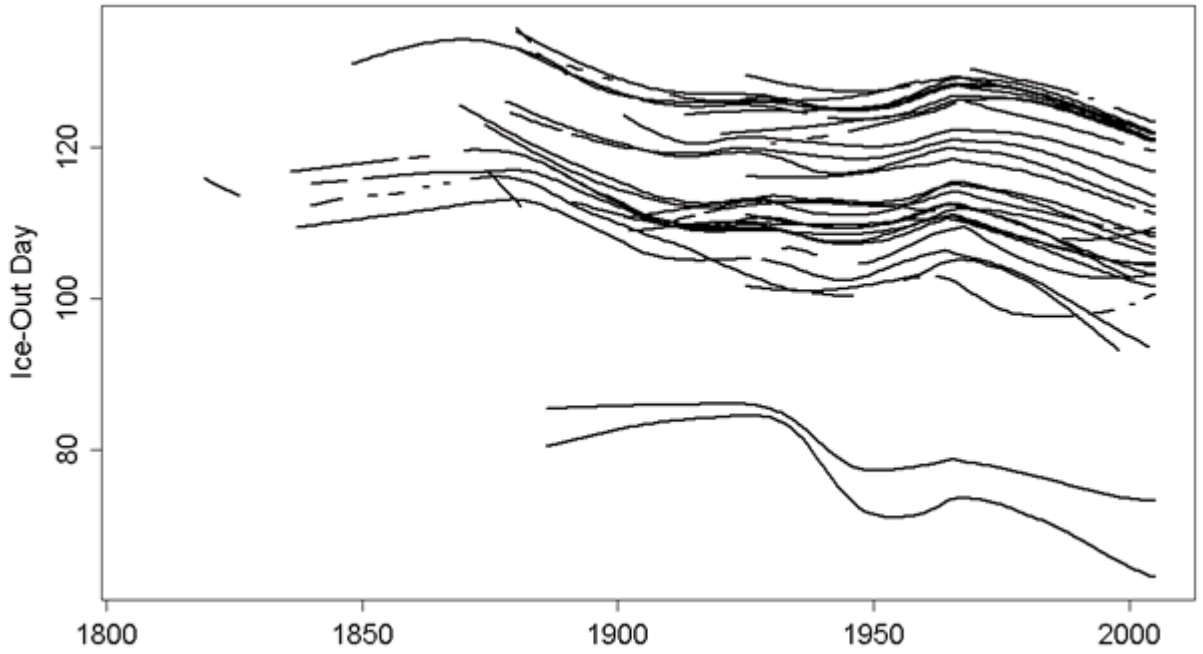


USGS (Hodgkins, James & others, 2002+) compiled ice-out dates from 29 lakes having 64 to 163 years of data.


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

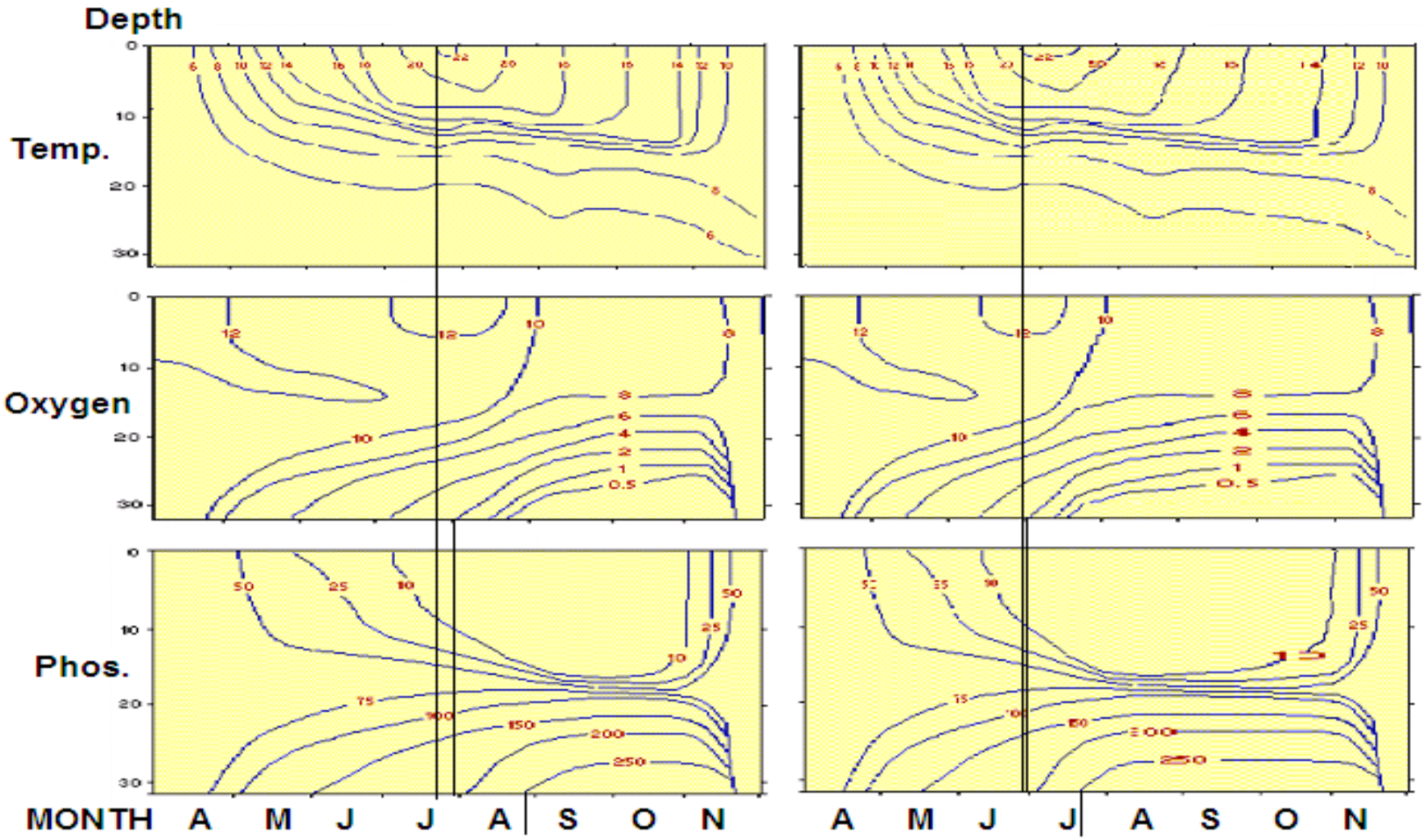
Plot of ice out dates for 29 lakes in New England



Statistical analysis of the trend revealed that 17 lakes had significantly earlier ice outs while 12 showed no significant trend.

Effects of Decreased Duration of Ice Cover:

- Earlier warming of shallows
- Longer growing season
- Longer period of stratification
- For dimitic lakes, increased potential for hypolimnetic oxygen loss (duration and extent) during summer stratification (particularly for lakes 6 - 13 m deep), and,
- Increased nutrient cycling from sediments



Data from Weed Lake, British Columbia, Canada

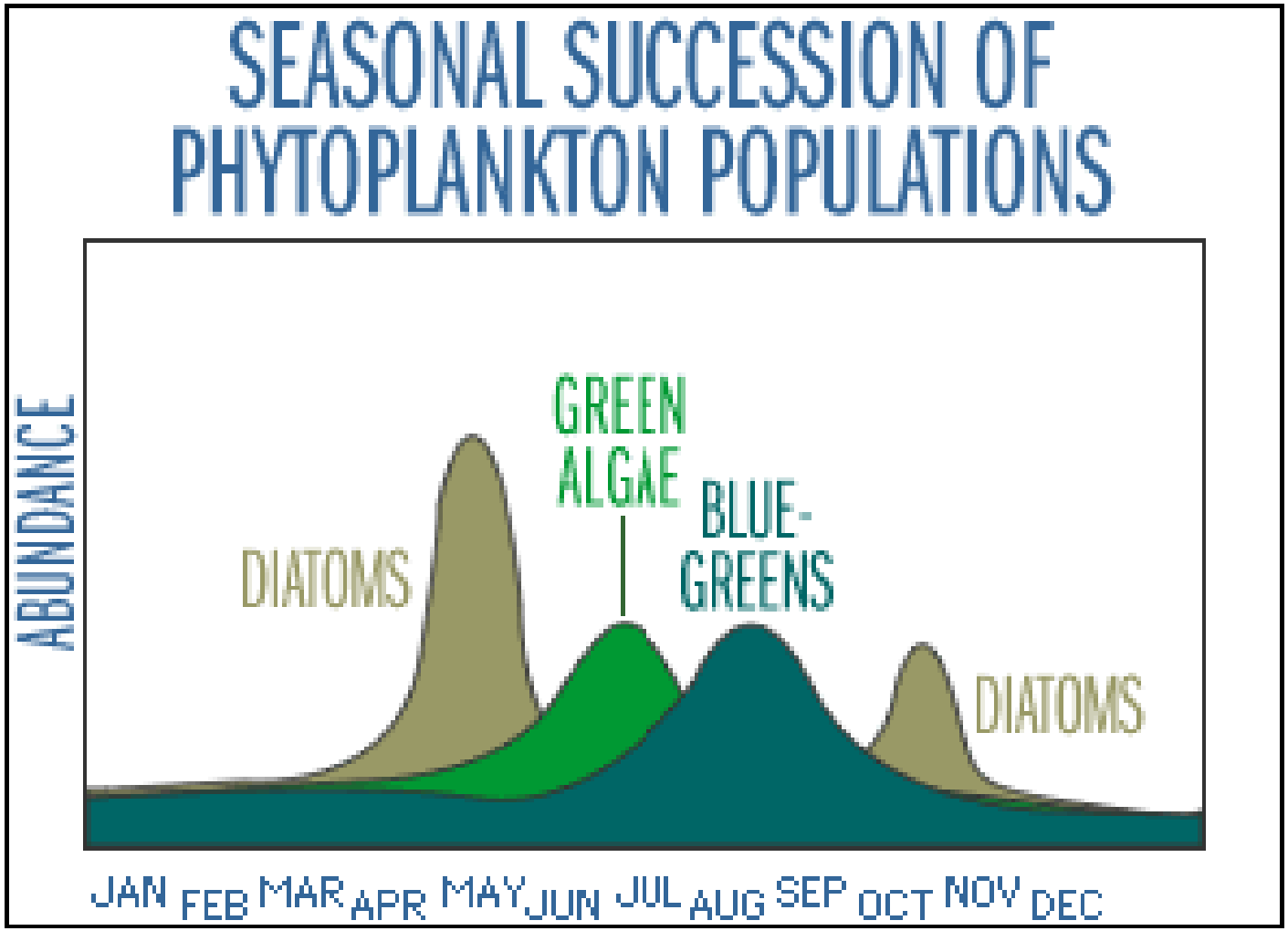
…which leads to…

Species composition changes:

Lake ecosystems depend on 'phenology' or timing of annual biological events

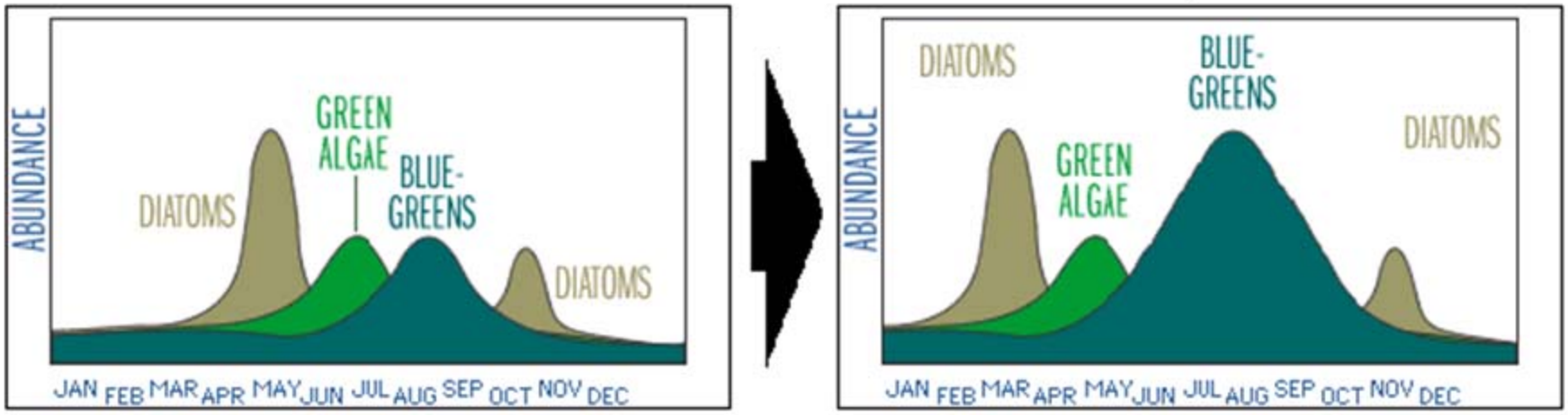
- species level (spawning, production of resting stages, emergence, etc.)
- between species (succession, predator-prey interactions)

Stephen R. Carpenter (1988) concluded that predicting the consequences of climate change in a specific lake required understanding of how species composition in that lake will change.



wateronthweb.com

SEASONAL SUCCESSION OF PHYTOPLANKTON POPULATIONS



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

Metaphyton

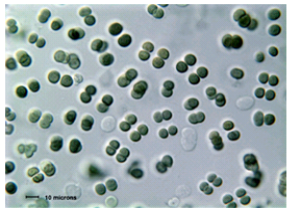
Cyanobacteria

Eucapsis Clements *et* Shantz

Morphology | Ecology | Reproduction

View Movie small med large | Glossary

Eucapsis cells are arranged in perpendicular rows to form cubic three dimensional colonies. Before dividing, each cell is spherical or oval shaped, 1-6 µm wide, and pale or bright blue-green or olive green in color. The cells do not have distinctive gas vesicles. The free-living colonies are microscopic, and sometimes have subcolonies. The colonial mucilage is colorless with indistinct margins.



Eucapsis cells divide along three perpendicular planes that vary with successive generations. The new daughter cells usually remain in the place where they formed to add to the colonial structure. Large colonies distintegrate to produce new colonies.

Eight species and several varieties of *Eucapsis* inhabitat the metaphyton of swamps and bogs, acidic peat or salt swamps, and volcanic soils.

In culture, *Eucapsis* may not form its characteristic three-dimensional colonies. These cells have divided and have started to align in a regular arrangement within common mucilage.

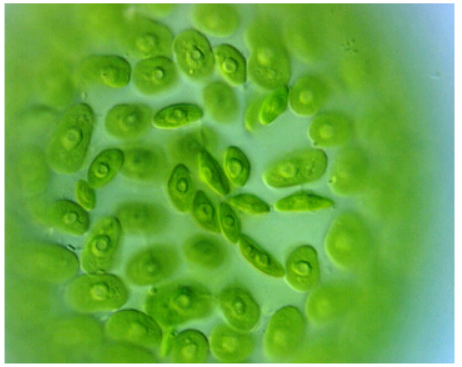
Green Algae

Morphology | Ecology | Reproduction

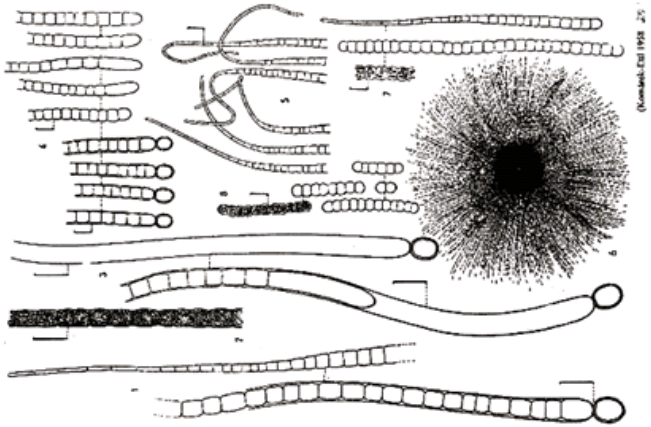
View Movie small med large | Glossary

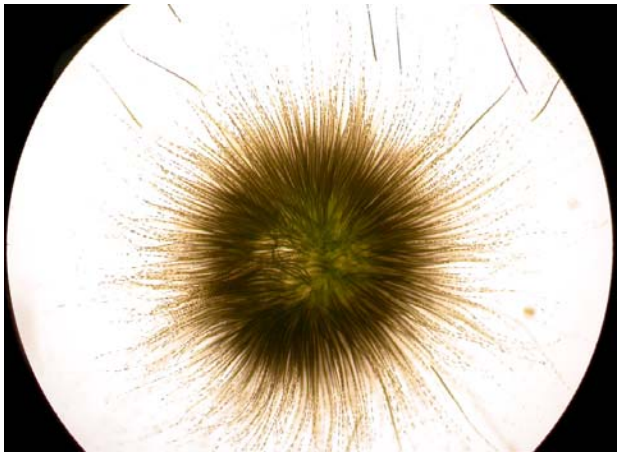
Eremosphaera is associated with desmids in the metaphyton of ponds, lakes, bogs, and ditches, and is most common in softwater, acidic environments. It is found throughout most of the United States, Canada, and the Caribbean.

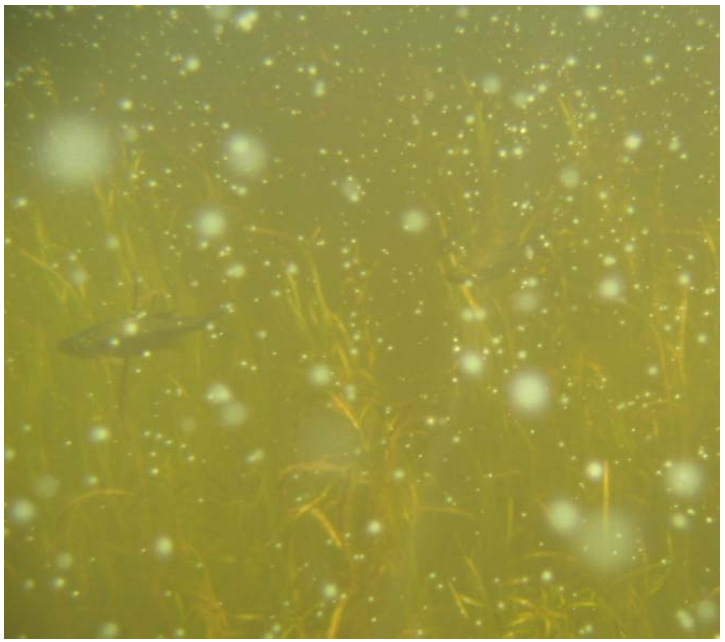
Eremosphaera



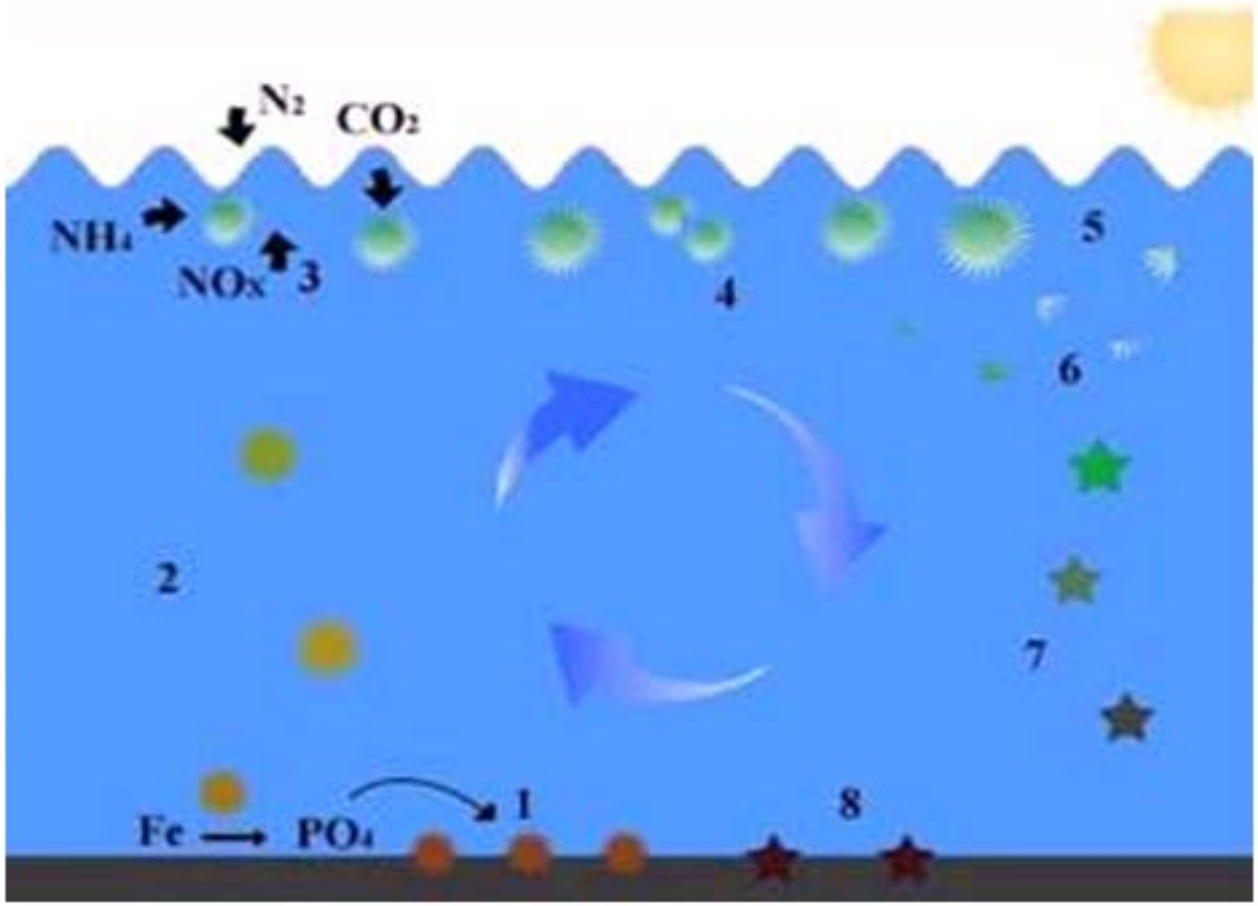
Gloeotrichia echinulata







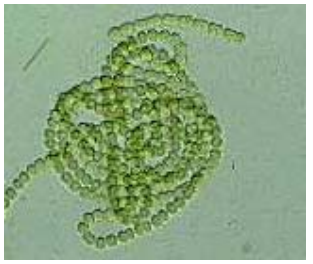
G. echinulata life cycle:

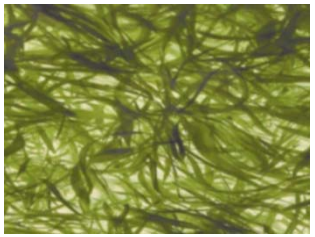


From Colby College website

Increased Algal Productivity:

- Due to Temperature alone if nutrients constant
- Mostly nuisance species - Cyanophytes: Anabaena, Aphanizomenon, Microcystis
- Increased nutrients due to:
  - Nutrient transport from watershed in wet regions
  - Concentration due to decreased flushing in dry regions

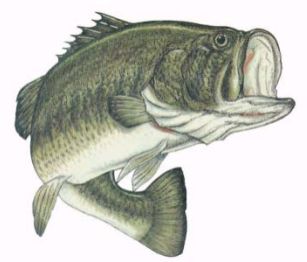




Altered fish composition:

- Elimination of coldwater (CW) species due to increased hypolimnetic anoxia in moderately deep lakes

- CW fish enhancement in very deep lakes as oxygenated hypolimnetic water warms slightly

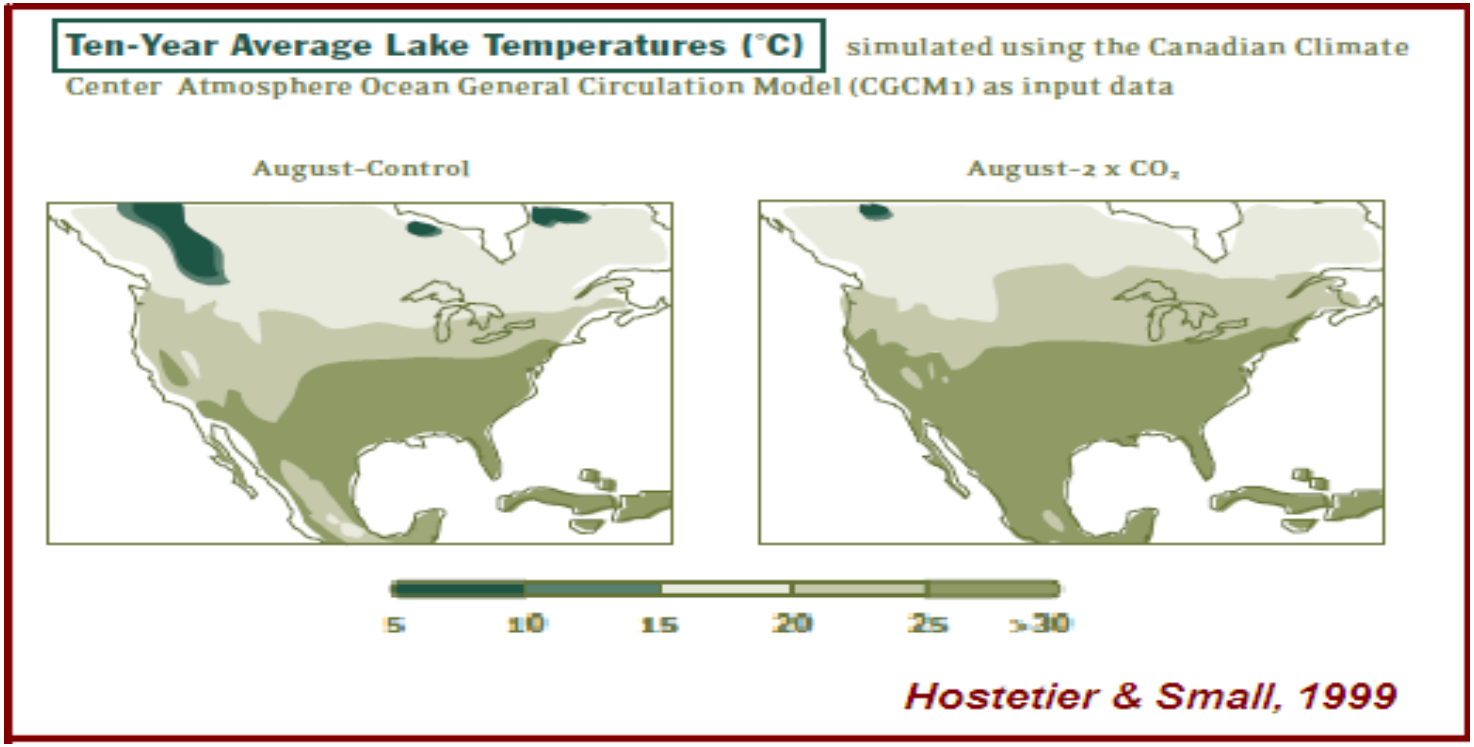


- Increase warmwater (WW) species survival in small shallow lakes subject to winter fish kills due to decreased duration of ice cover

Pew report cites results from Stefan et al's simulation of a doubling of CO2 on 27 lake types across the US as compared to pre-1980 conditions:

- CW habitat reduced by 54%
- Coolwater fish habitat reduced by 30%
- Shallow (4m) and medium depth (13m) lakes most affected
- WW fish habitat increases in 100% of lake types

Species ranges for WW fish are likely to expand; CW fish ranges likely to decrease due to temp & decreased precipitation:



Trophic Cascade:

Reduction or elimination of large predatory fish will result in an increase in smaller planktivorous fish.

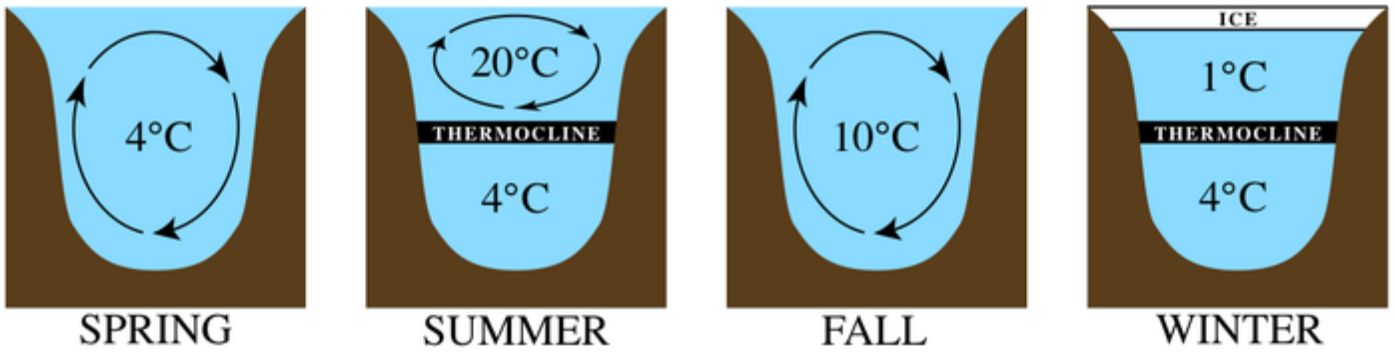
In turn, this will decrease zooplankton populations.

Reduced zooplankton will allow proliferation of algae.

Increase in algae will decrease transparency and could lead to algal blooms.

Increased Color / DOC

- Lakes range from clear to tea colored
- Color/DOC – decaying vegetation
- Wetlands export color / DOC
- Longer growing season results in a longer decaying season

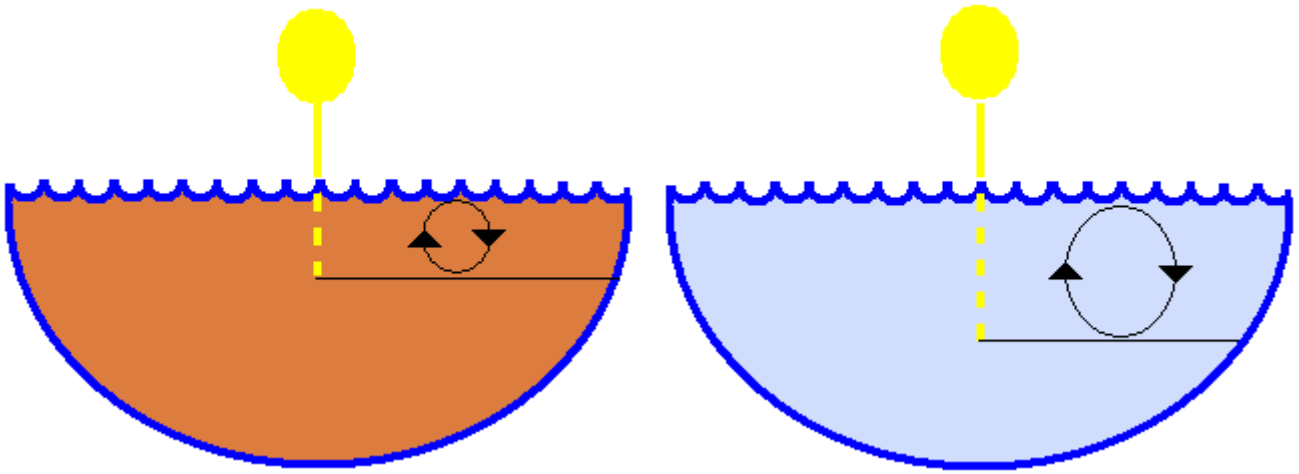


Mixing Pattern in Dimictic Lake

qwiki.com

Color / DOC influences lake stratification

- Sunlight warms water
- Sunlight penetration depth is a prime factor in stratification depth
- Sunlight reaches shallower depth in lakes with high color / DOC
- Stratification depth influences plankton species



Algal mobility depends on:

- Flagella
- Gas vacuoles
- Wind

Thus, species changes can influence higher trophic levels

Precipitation Changes

- Less precipitation – shrinking lakes (saltier)
- More precipitation
  - More stormwater runoff & more nutrients
  - Higher water levels & flooding
  - More shoreline erosion & more nutrients
  - New groundwater seeps

New groundwater seeps:

Photo from Tunk Lake, early July 2012

Photo by Nicholas Bacon

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Practical Considerations

- Culverts
  - Clean culverts may prevent a washout
  - Increase size of replacement culverts
- Erosion Controls
  - Shoreline / Shoreland
  - Adjacent streams

Practical Considerations

- To swim or not
- To drink or not
- Safety
  - Docks
  -


www.maine.gov/dep