

Physical and chemical limnology: temperature gradients

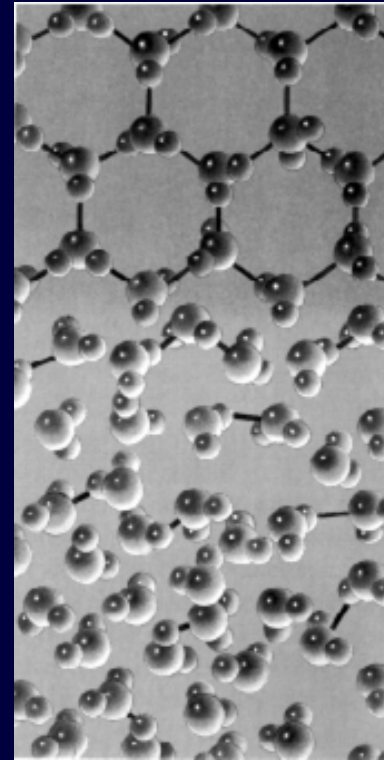
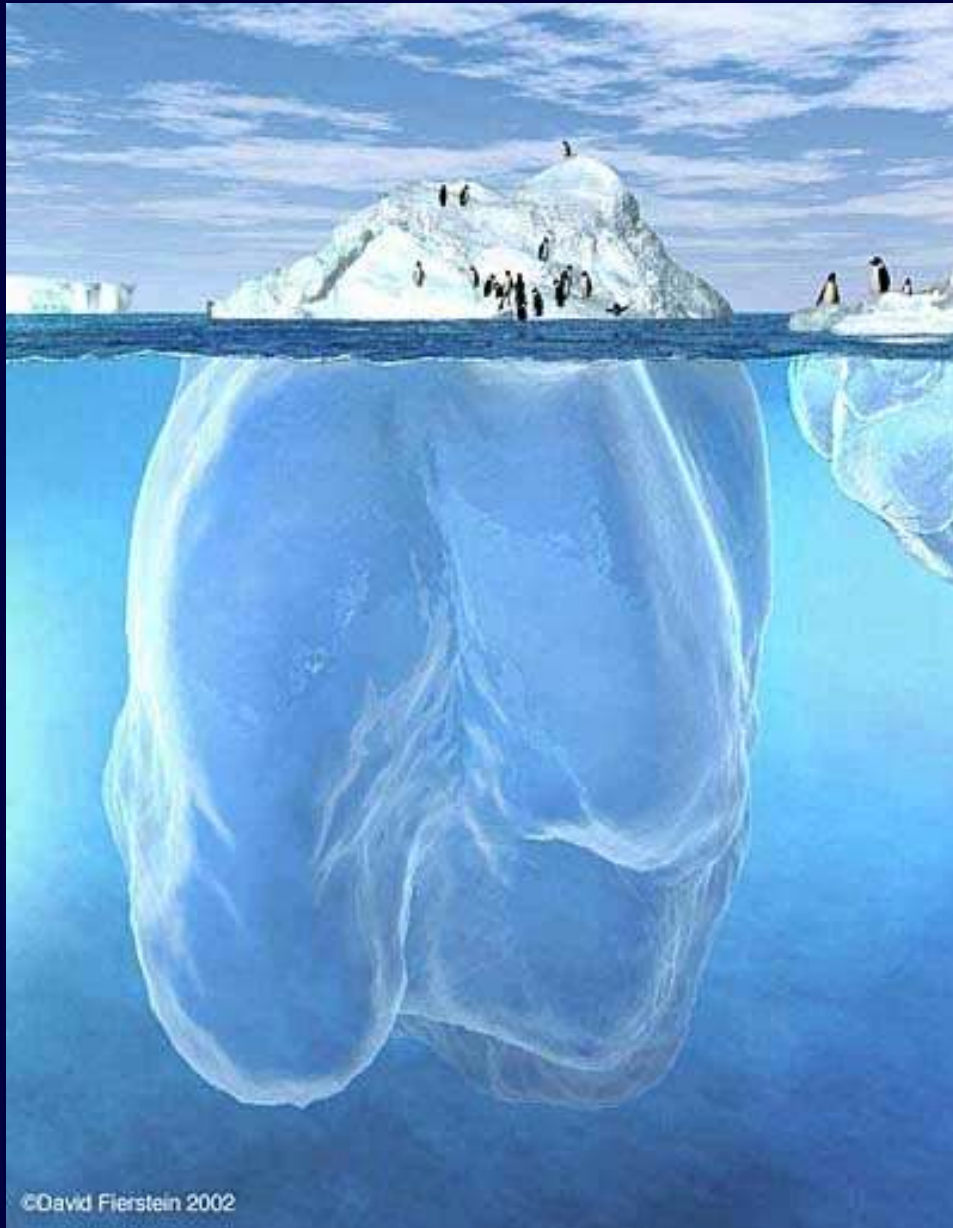
Limnology

Lecture 6

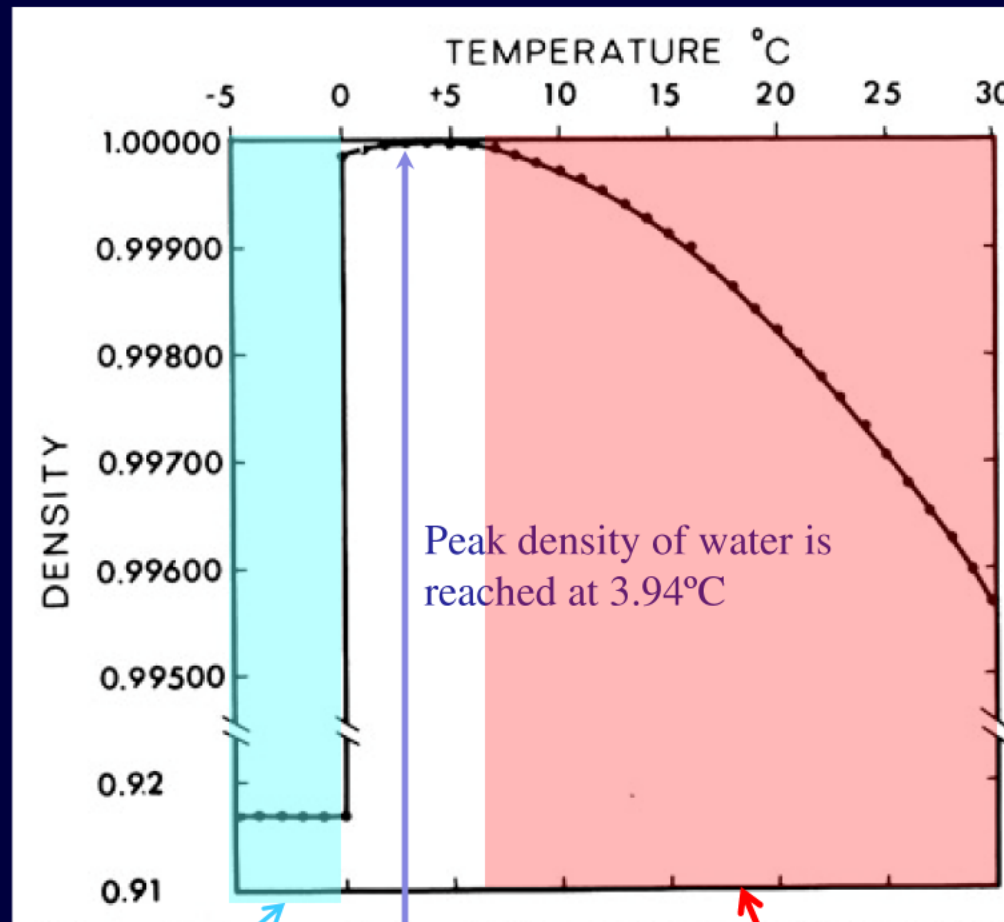
Outline

- Thermal properties of water
- Temperature gradients in lakes
- Mixing patterns and lake classification

The Density Anomaly of Water



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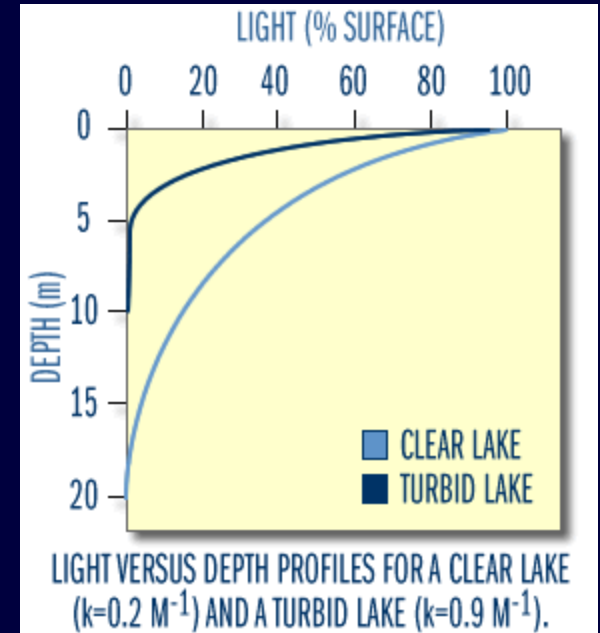
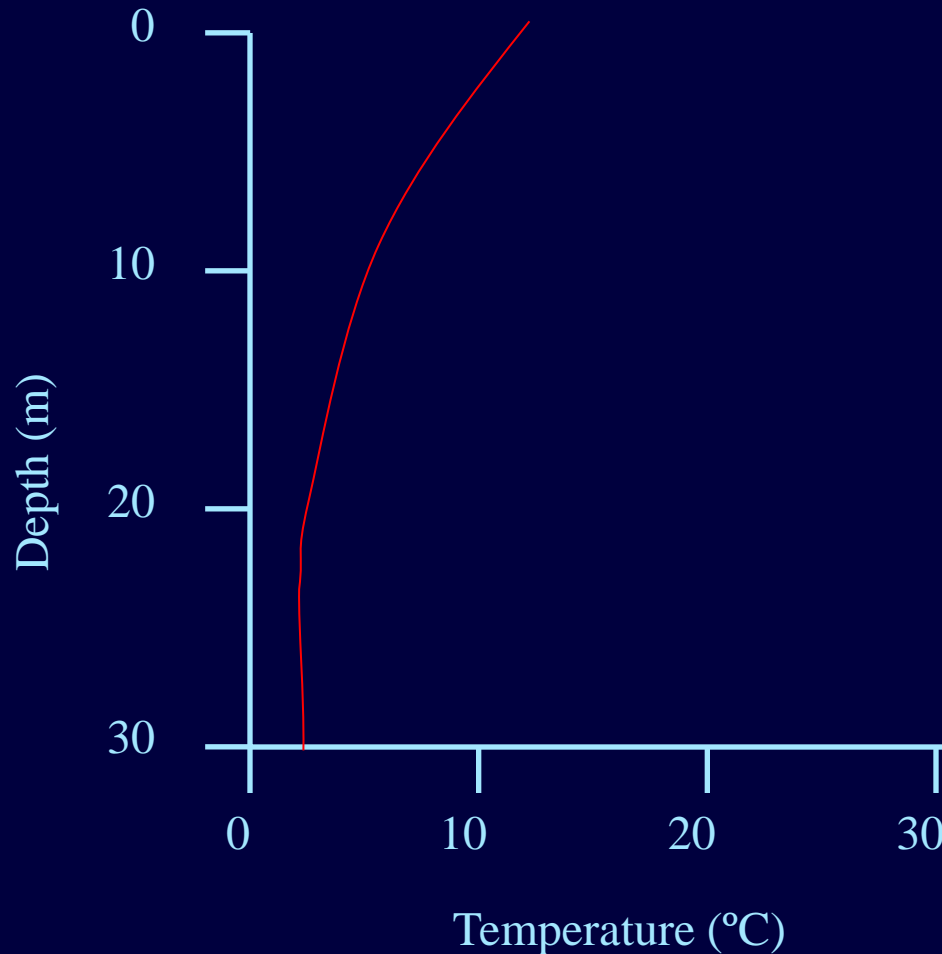
From Wetzel 1983, p.11

Ice floats

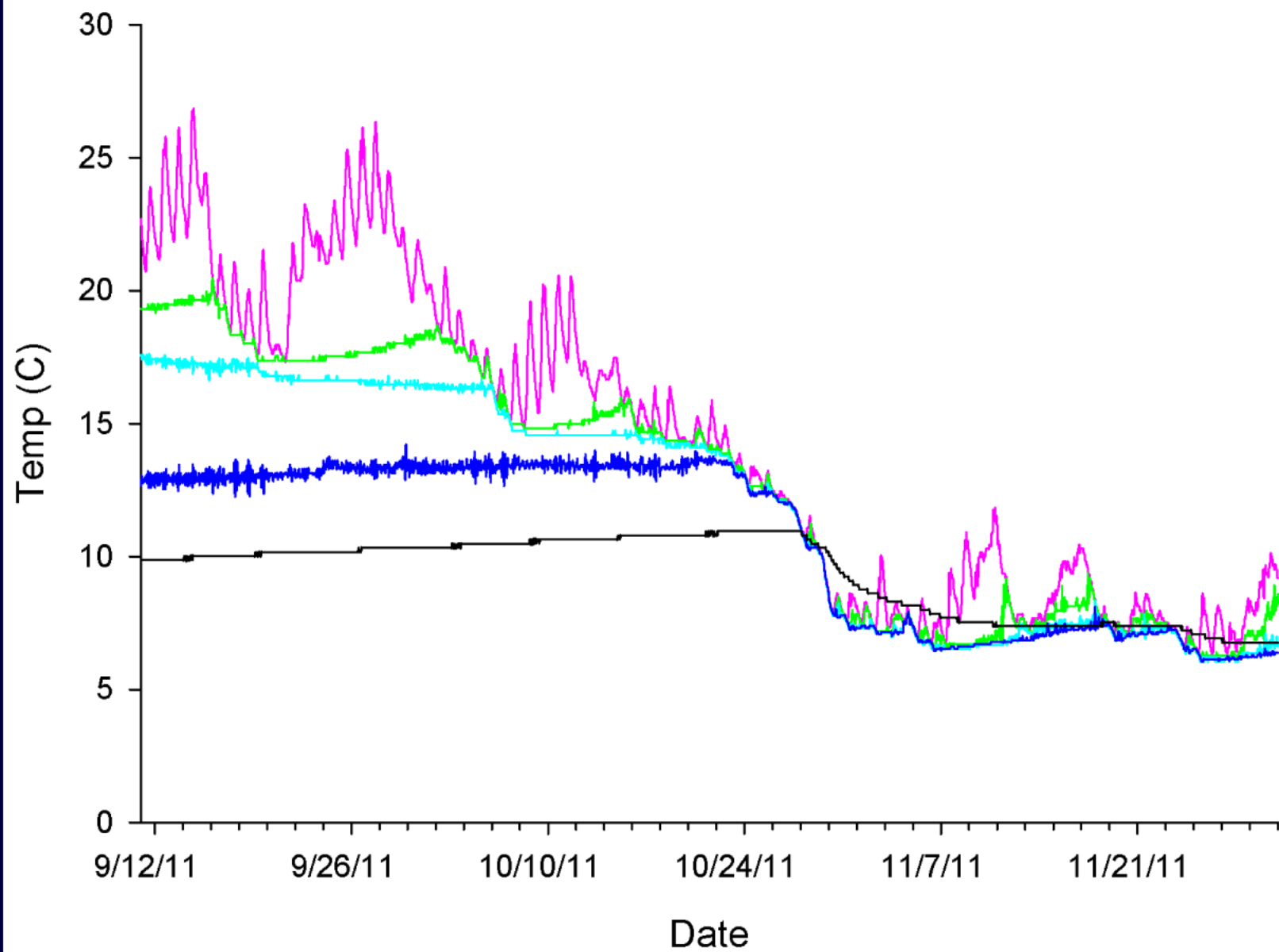
Cool water sinks

Warm water floats

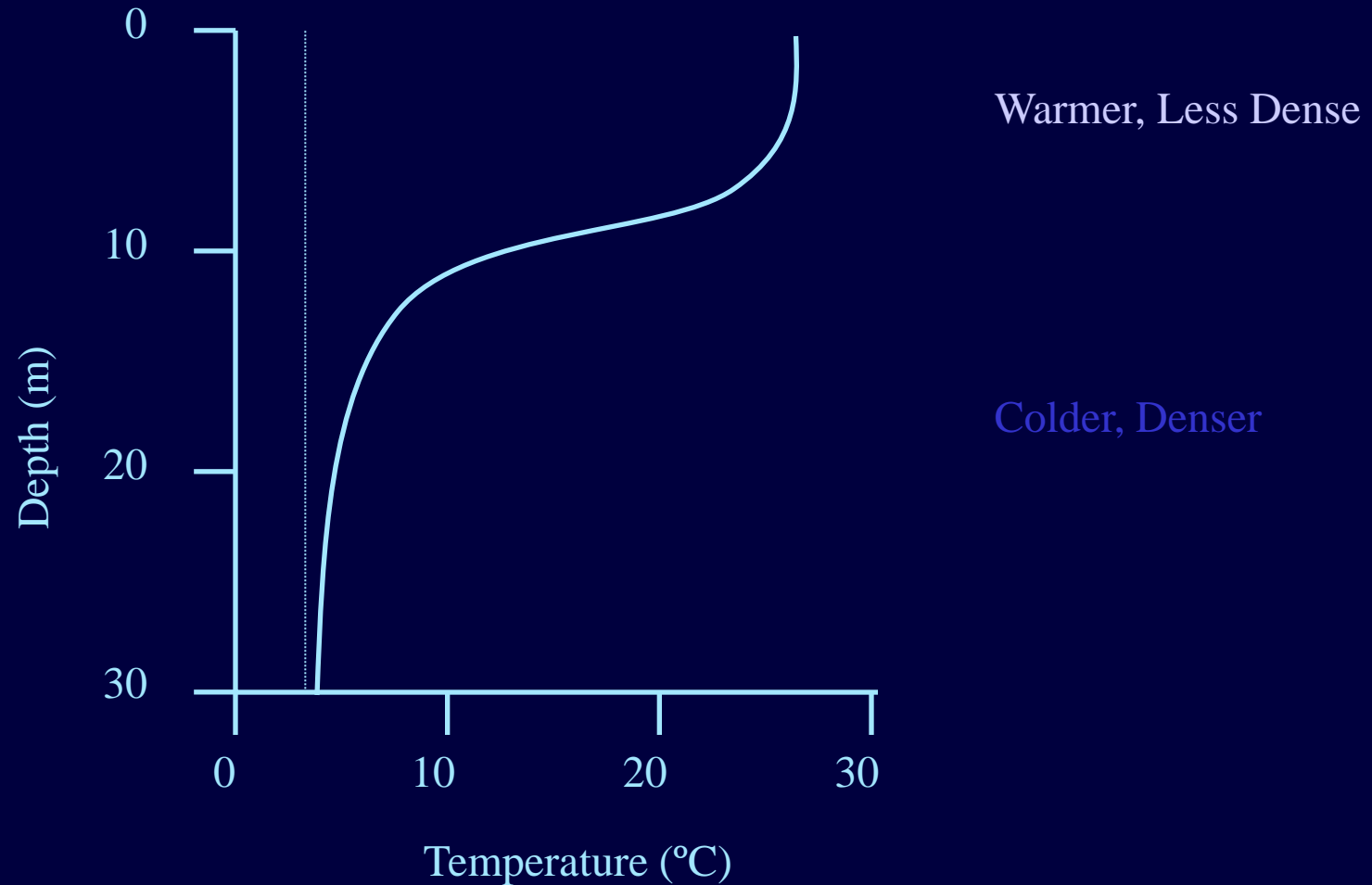
A body of water heated by the sun develops a thermal gradient.



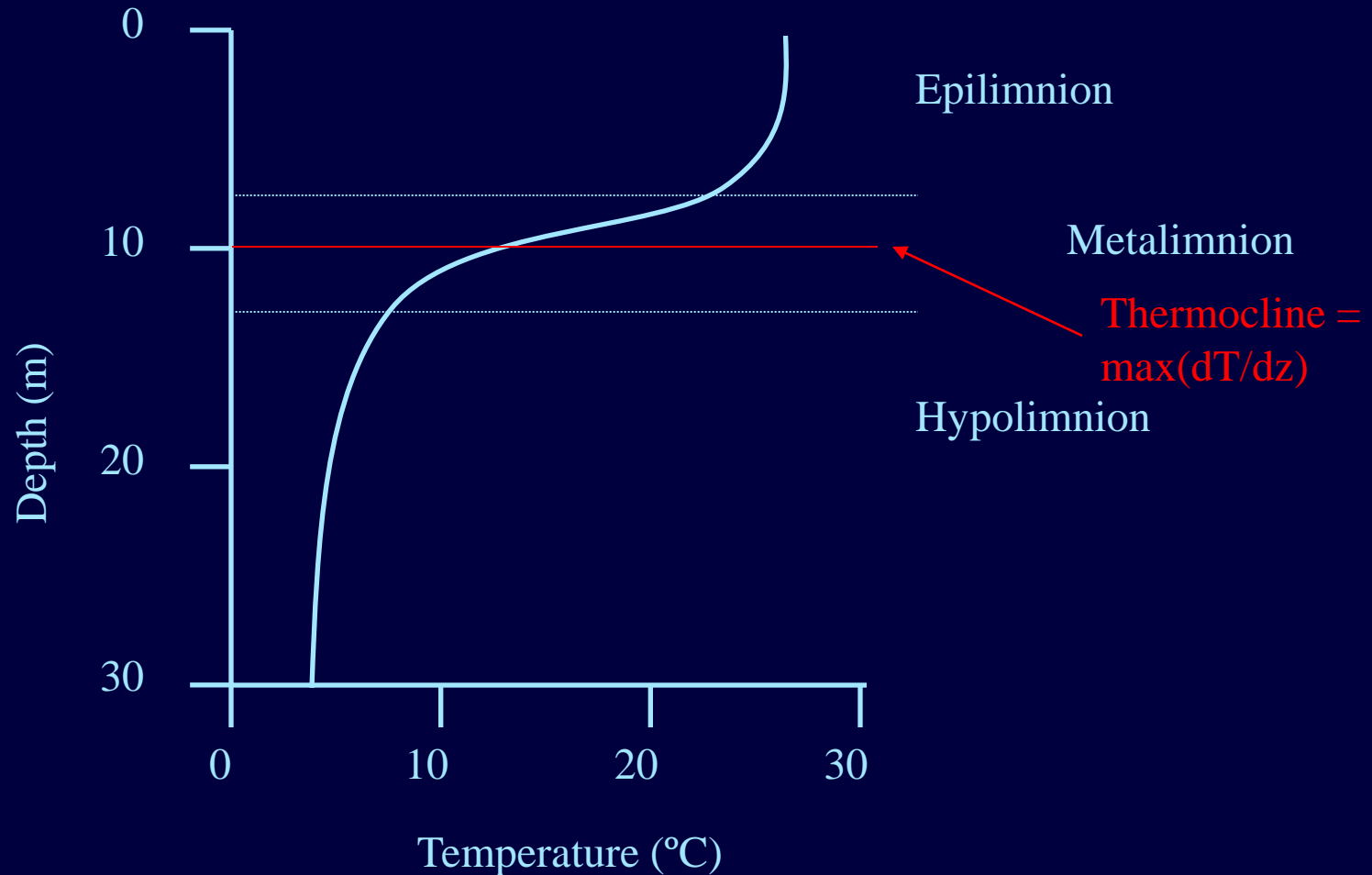
Surface phenomenon
Convection and wind disperse
heat



Lake stratification



Thermal gradients and habitat



Dunham pond data

Mixing pattern in dimictic lake

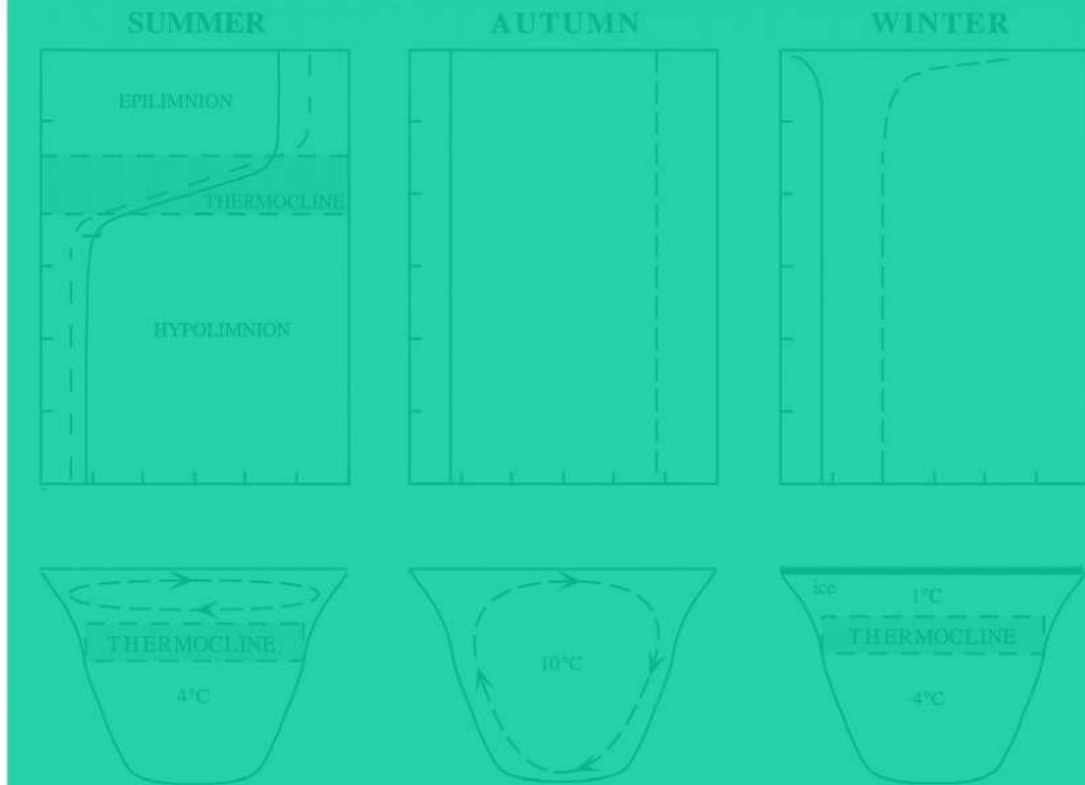
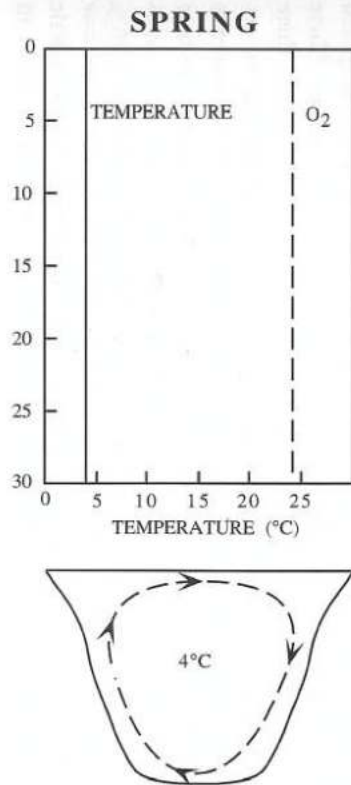


Fig. 2.5 Seasonal circulation of water, as well as depth gradients of temperature (solid line) and oxygen (dashed line) in a temperate lake. During stratification, the water column separates into three different layers with little exchange of water and nutrients. The metalimnion (thermocline) is the layer where temperature changes drastically. The layers above and below the metalimnion are the epilimnion and the hypolimnion, respectively.

Mixing pattern in dimictic lake

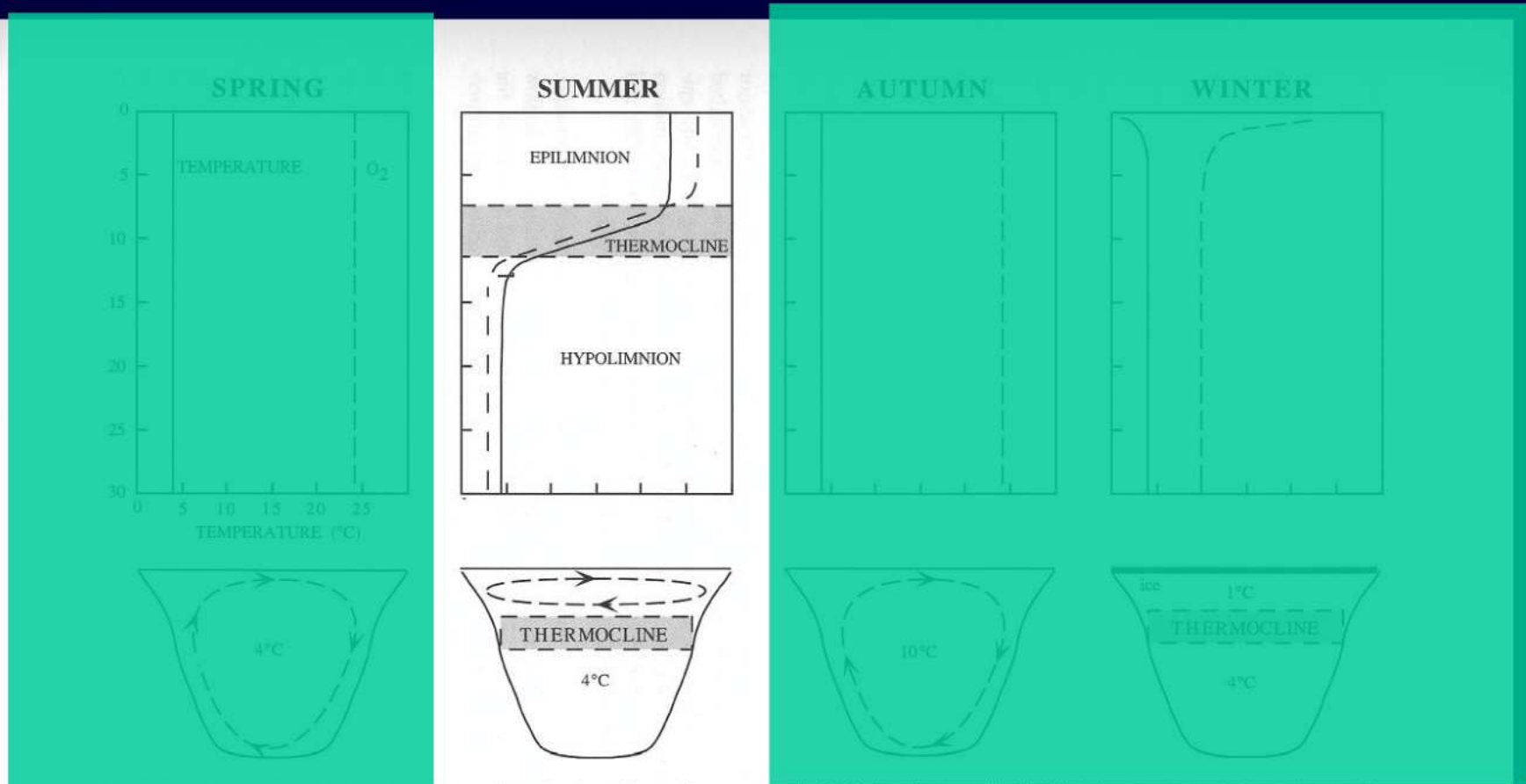


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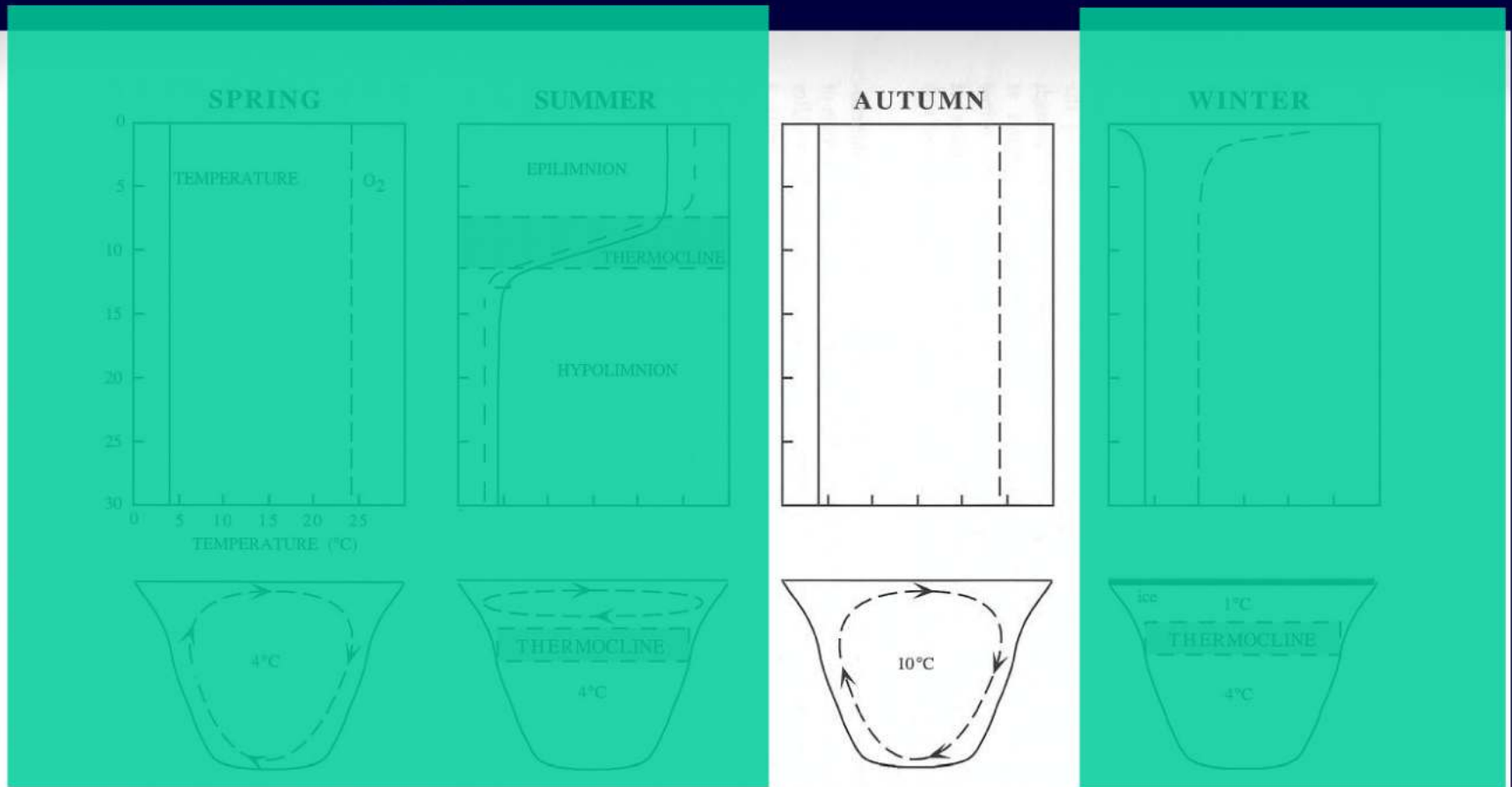


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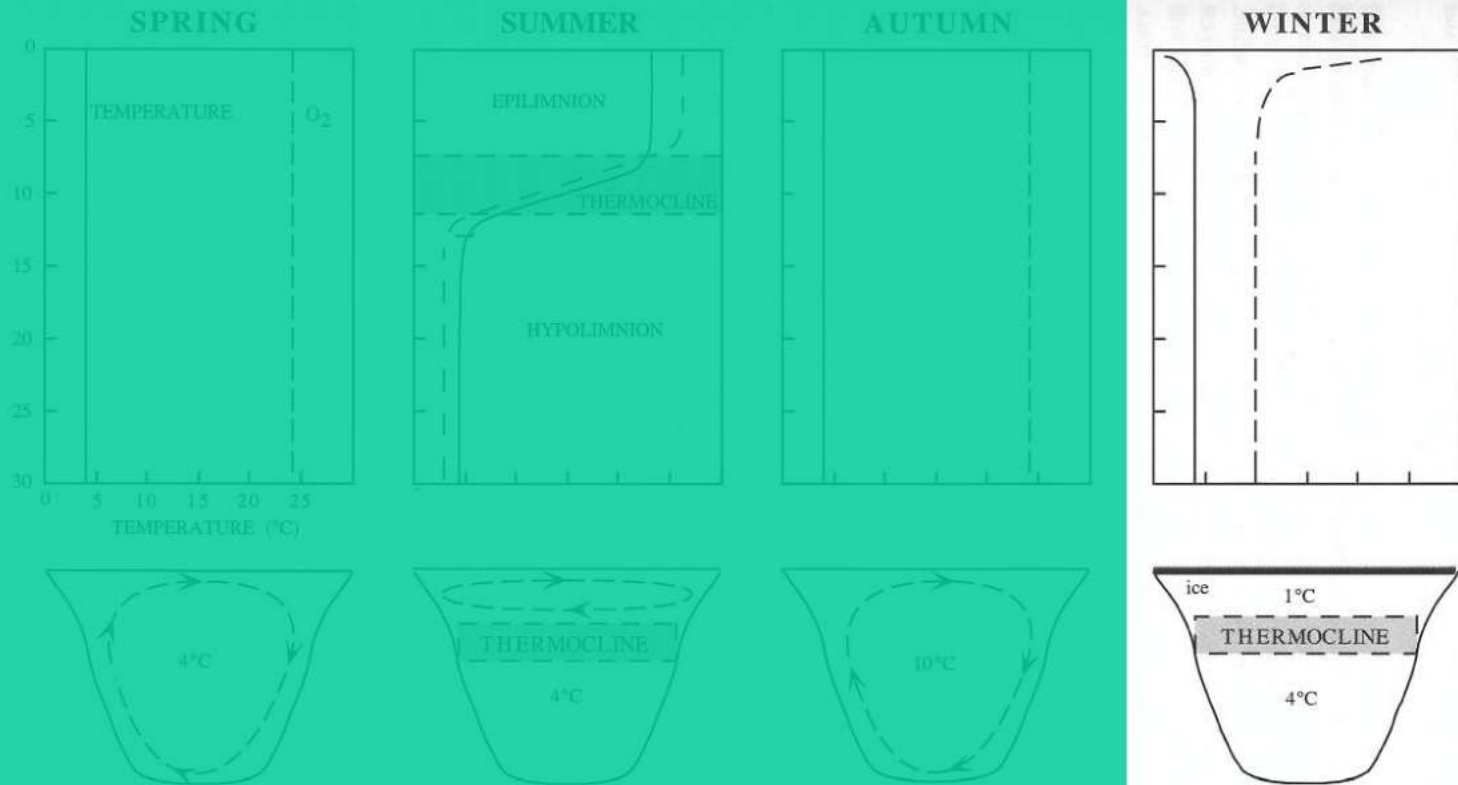
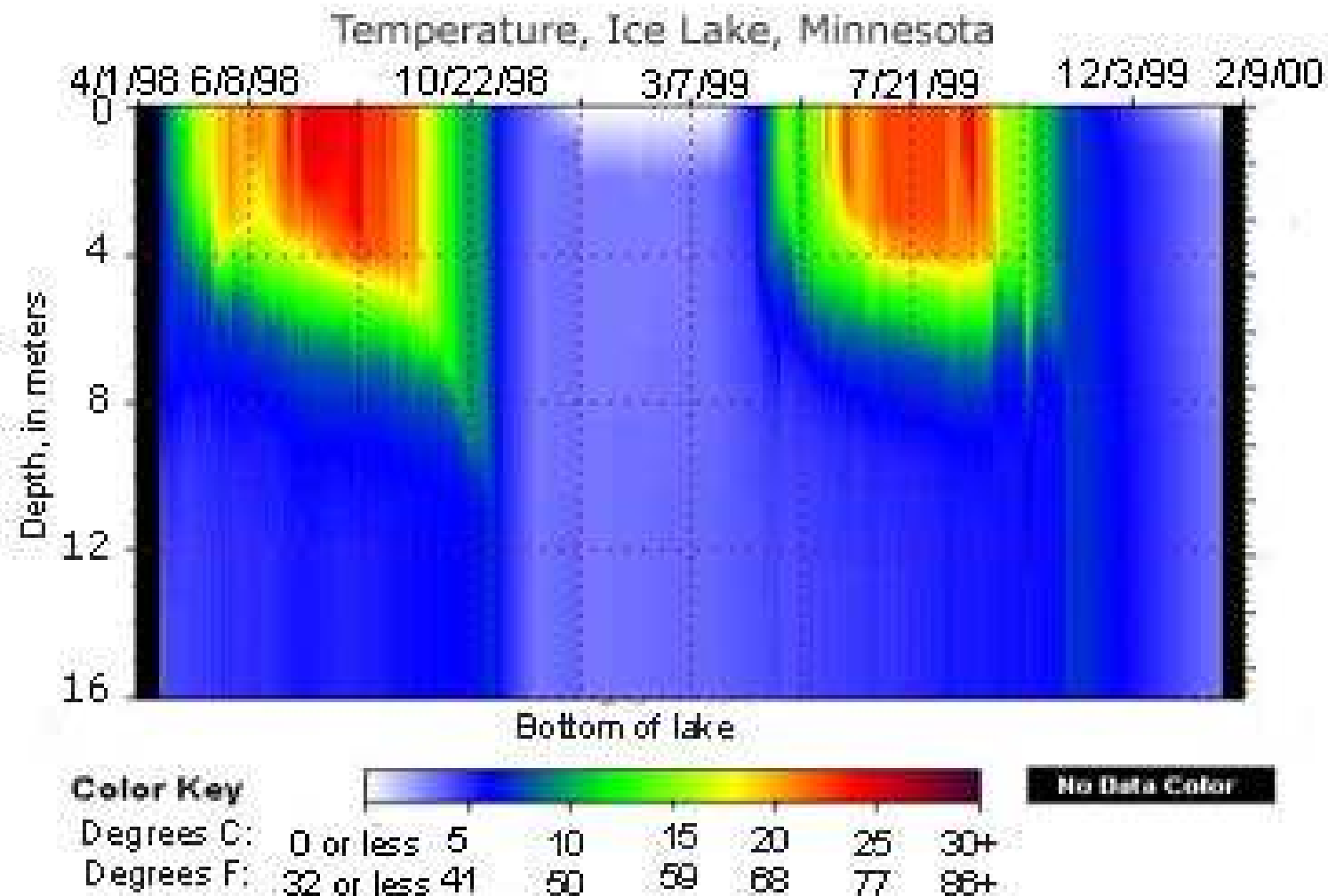


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Inverse stratification



Source: "Water on the Web",
www.mathematik.uni-kassel.de/~didaktik/DataSharing/WOW/DataAnalysis.html

Probability of mixing

- Depth
- Topography
- Solutes
- Size (fetch) – distance over which wind travels

Increases mixing



Western Brook Pond, Newfoundland

Seiche: standing wave in enclosed water body

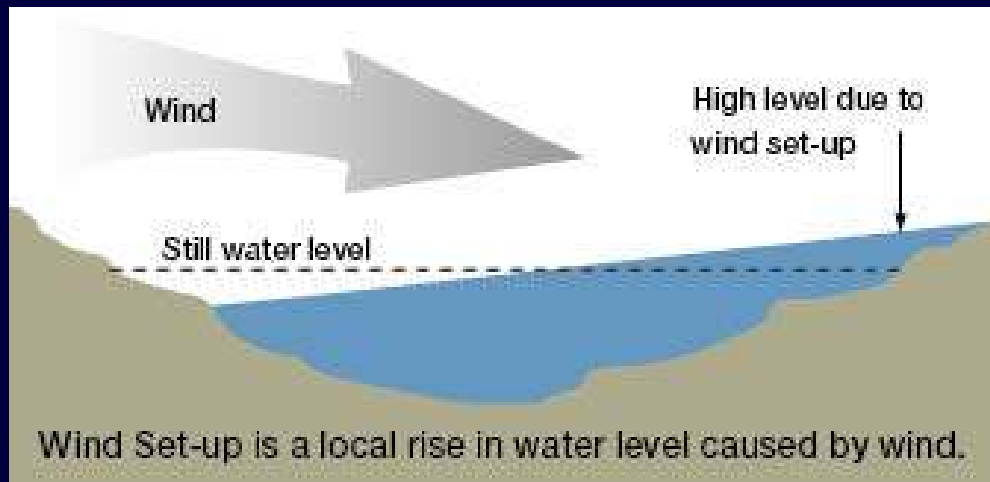
Wind pushes water to one side

Sloshes back and forth when wind abates

Implications:

Larger lakes have larger, more frequent seiches

Bends thermocline down, causes some mixing



Lake Erie winter seiche



VIDEO



Mixing patterns in lakes

- Dimictic = mix twice a year
- Amictic = no mixing
 - Permanently frozen
- Polymictic = mix frequently, even daily
 - Warm - tropical or shallow ($< 3\text{m}$) lakes with wind exposure
 - Cold – shallow temperate lakes
 - Cold means it freezes

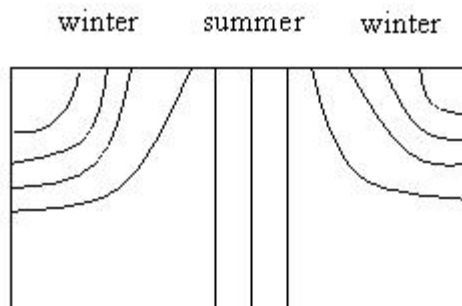
Other mixing patterns in lakes

Monomictic = mixing once a year

Cold – polar lakes do not reach above 4 C

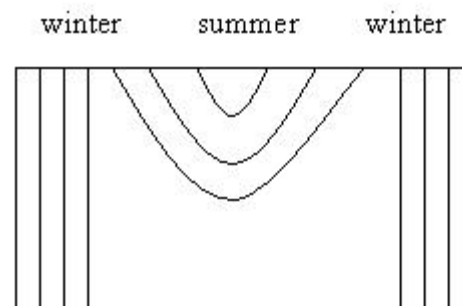
Warm – large lake does not freeze, mixes in winter

Monomictic lakes



Cold monomictic

Inversely stratified most of year
Do not stratify in summer
Usually high latitude or altitude
Oneida Lake



Warm monomictic

Stratified during summer
Mix all winter – no ice
Often in S. U.S. or in Pacific Northwest
Cayuga and Seneca Lakes

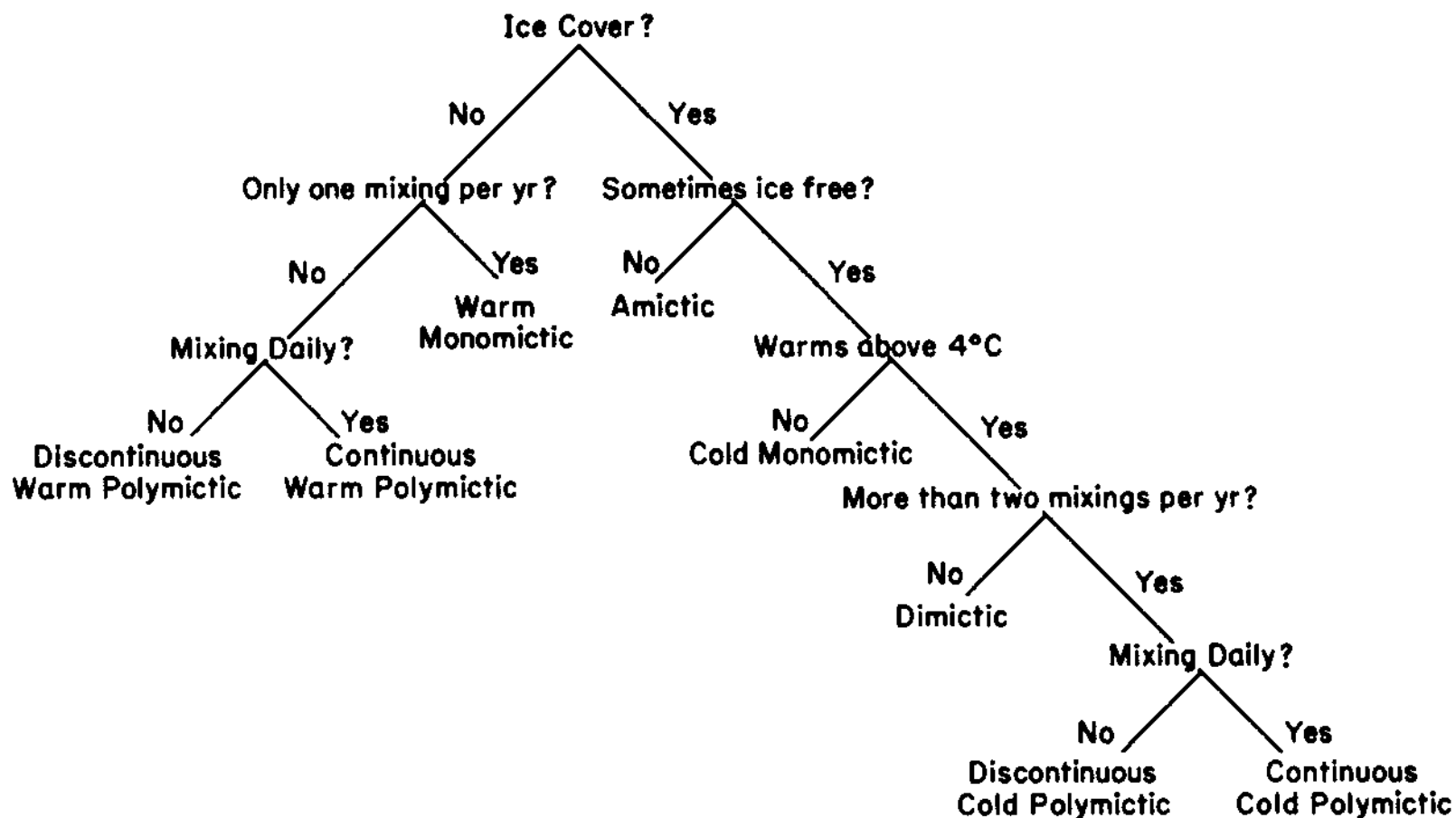
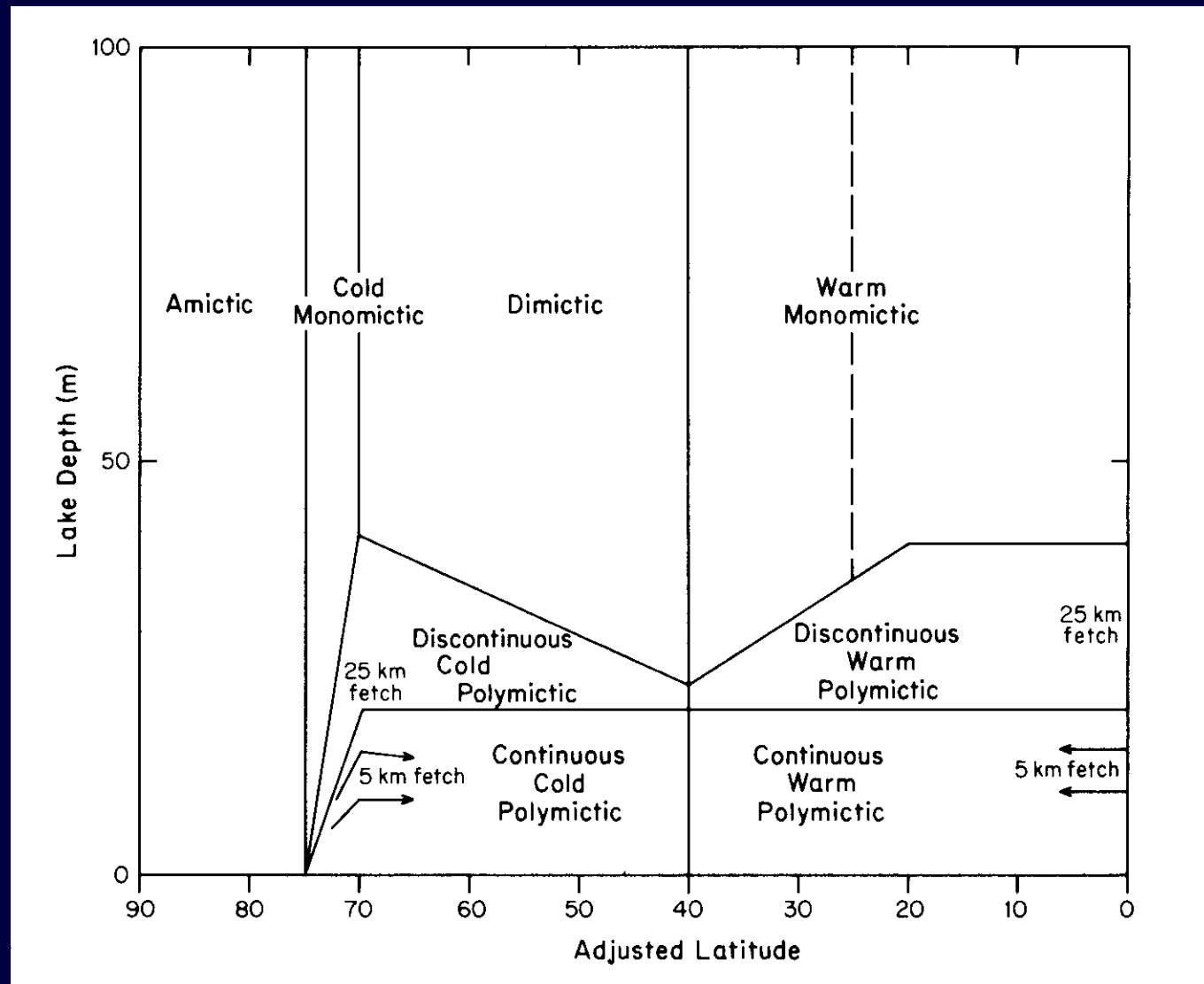
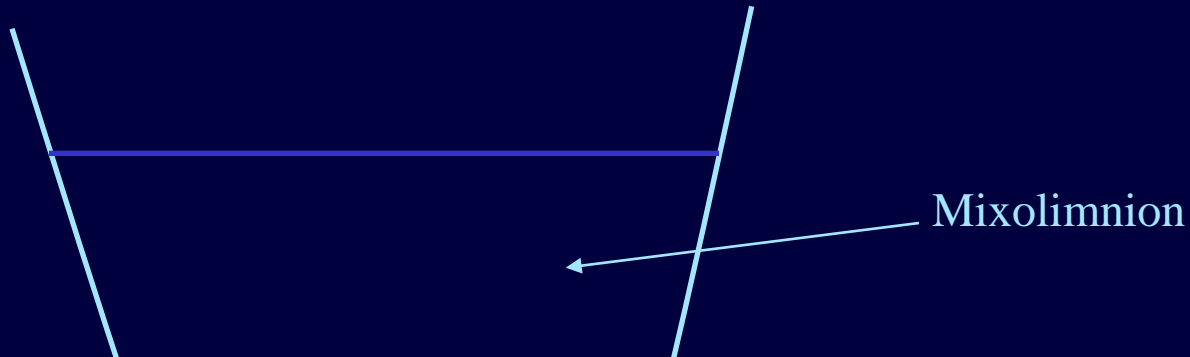


FIG. 1. The revised classification.



Meromixis

Meromictic = deep waters never mix, salt layer



Chemolimnion (pycno- or halocline)

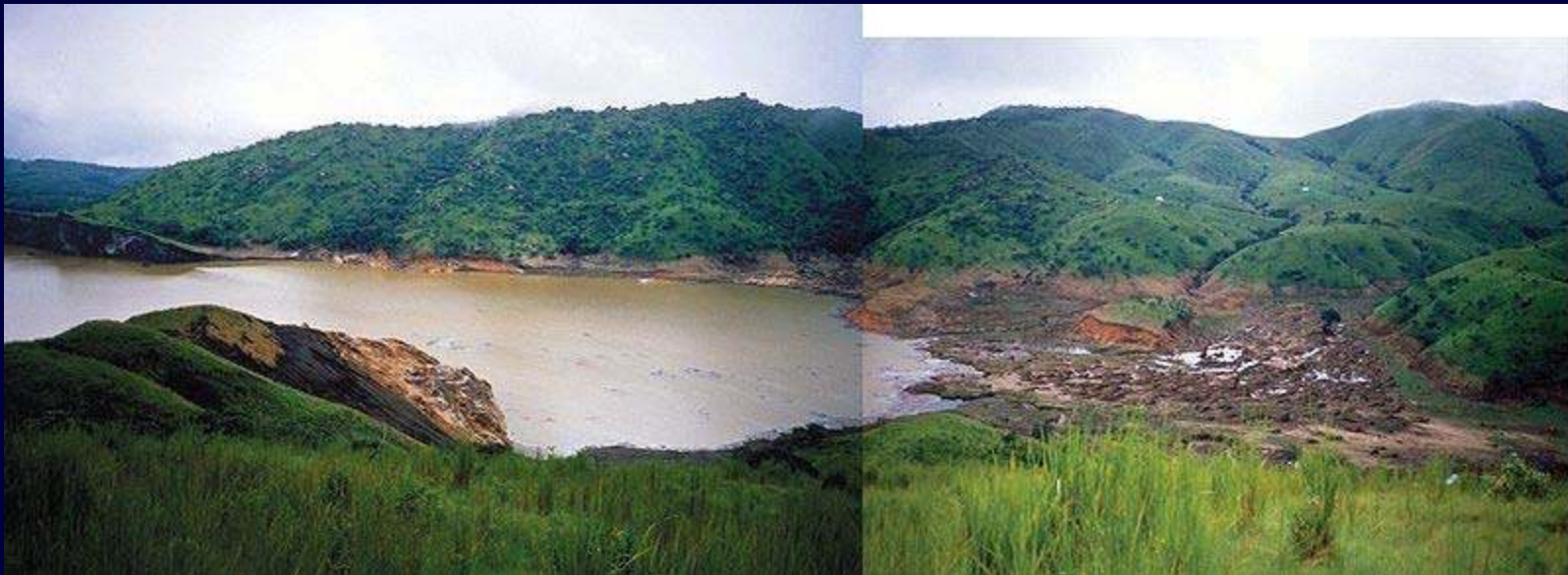
Monimolimnion



UNREGISTERED

Killer meromictic lake: Lake Nyos

- Volcanic crater, 200 m deep
- magma leaks CO₂
- > 1 liter CO₂ per liter of hypolimnion



Lake Nyos: Hypolimnetic Inequilibrium

- 1986 CO₂ release caused by earthquake
 - 1700 people killed by cloud
 - Degassing program put in place

Degassing of
Hypolimnion

