

CEE 577: Surface Water Quality Modeling

Lecture #24

Limnology: More on Stratification

(Chapra, L16)

Lakes

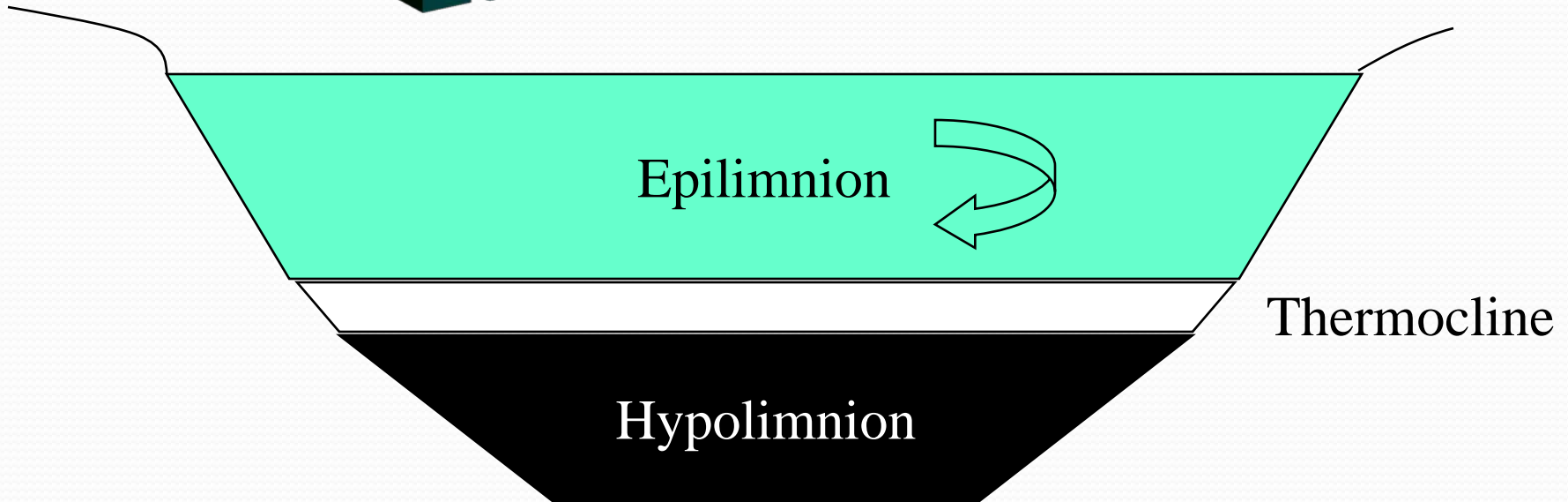
- Concerns in Lakes
 - Eutrophication
 - Toxics
 - Dissolved Oxygen
- Aging of Lakes
 - Oligotrophic
 - Mesotrophic
 - Eutrophic
 - Extinction



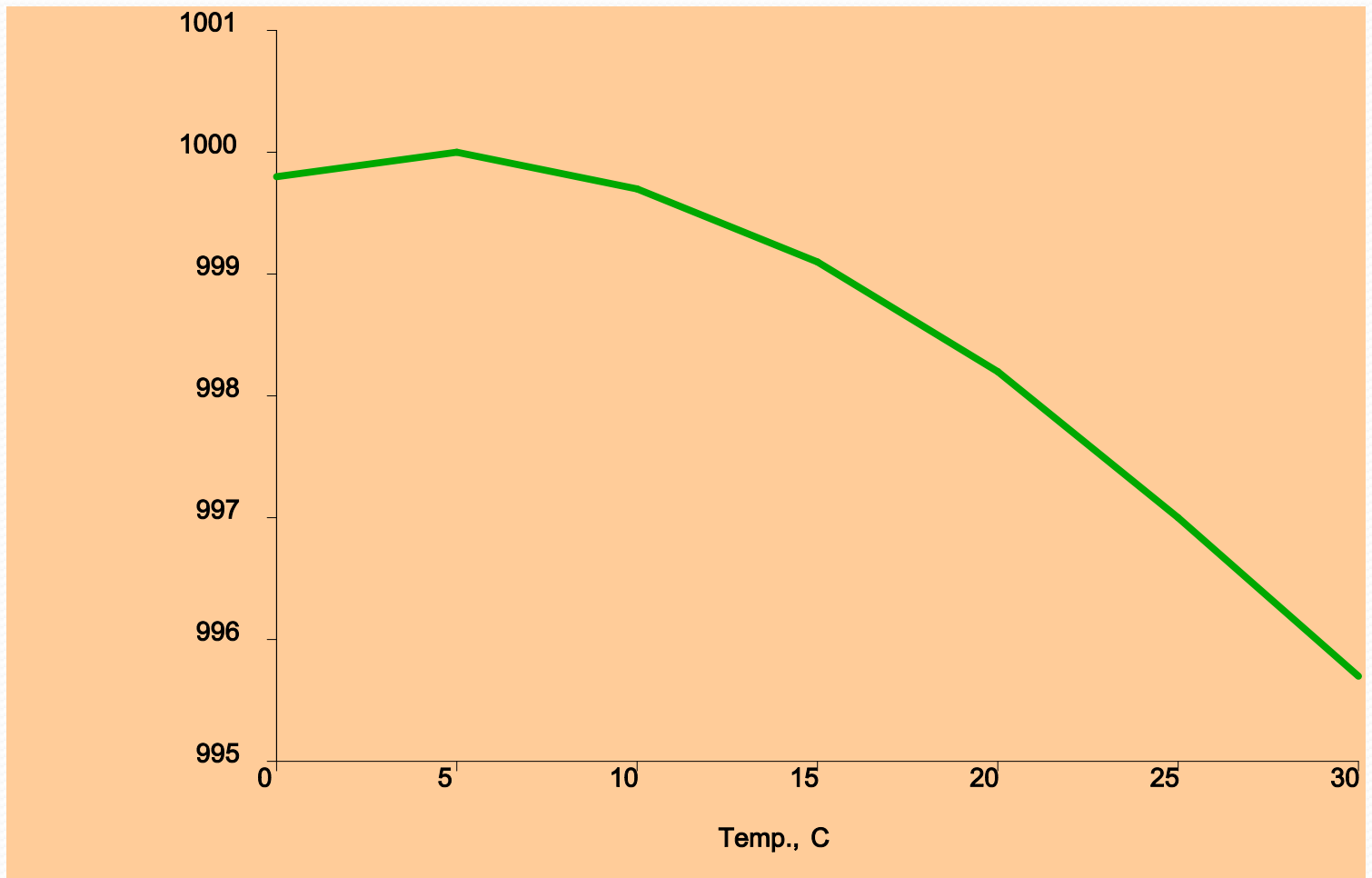
Succession: natural course of events (eutrophication), but can be accelerated by human activities (cultural eutrophication).

Lakes and Lake Modeling

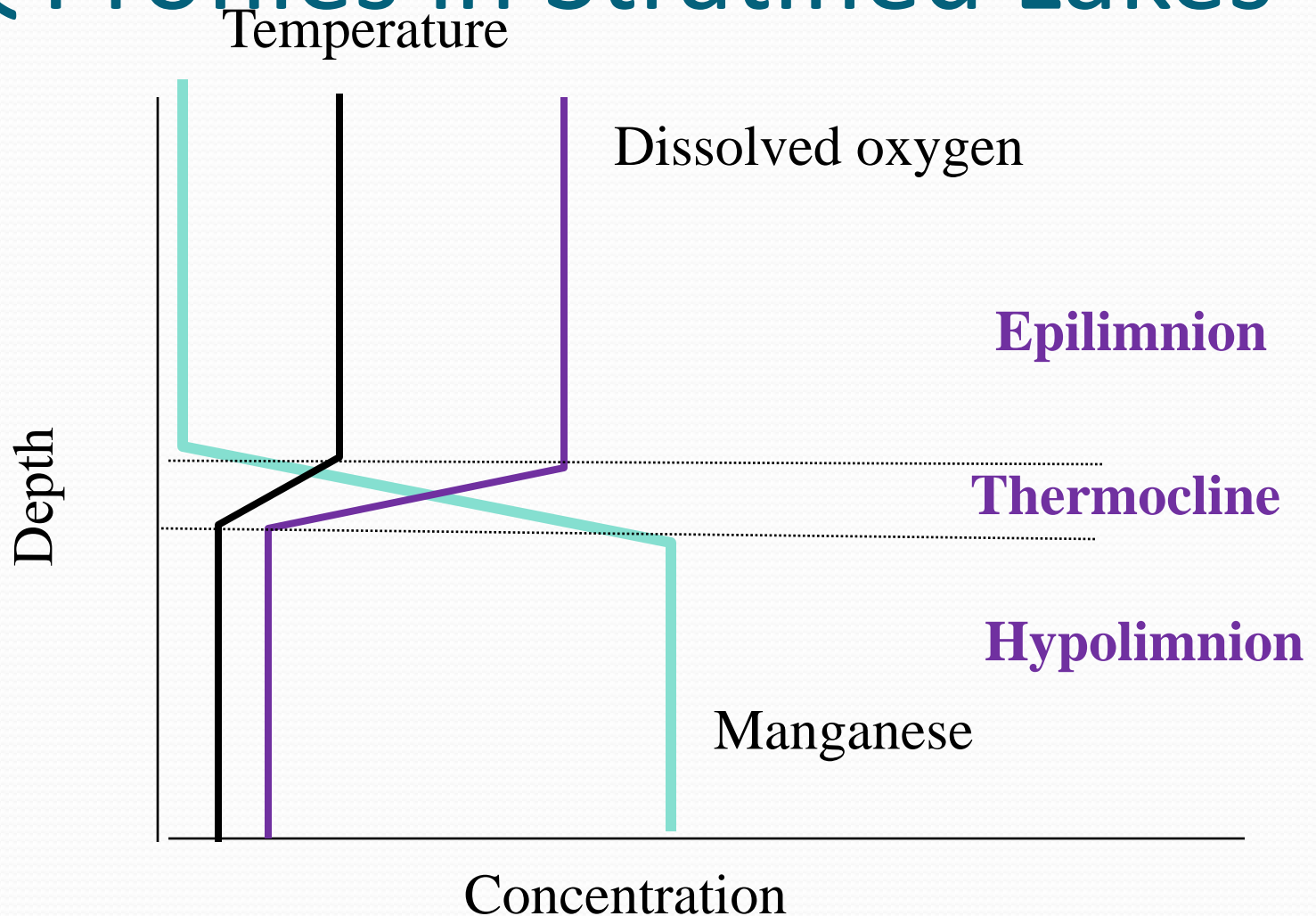
Lake Stratification



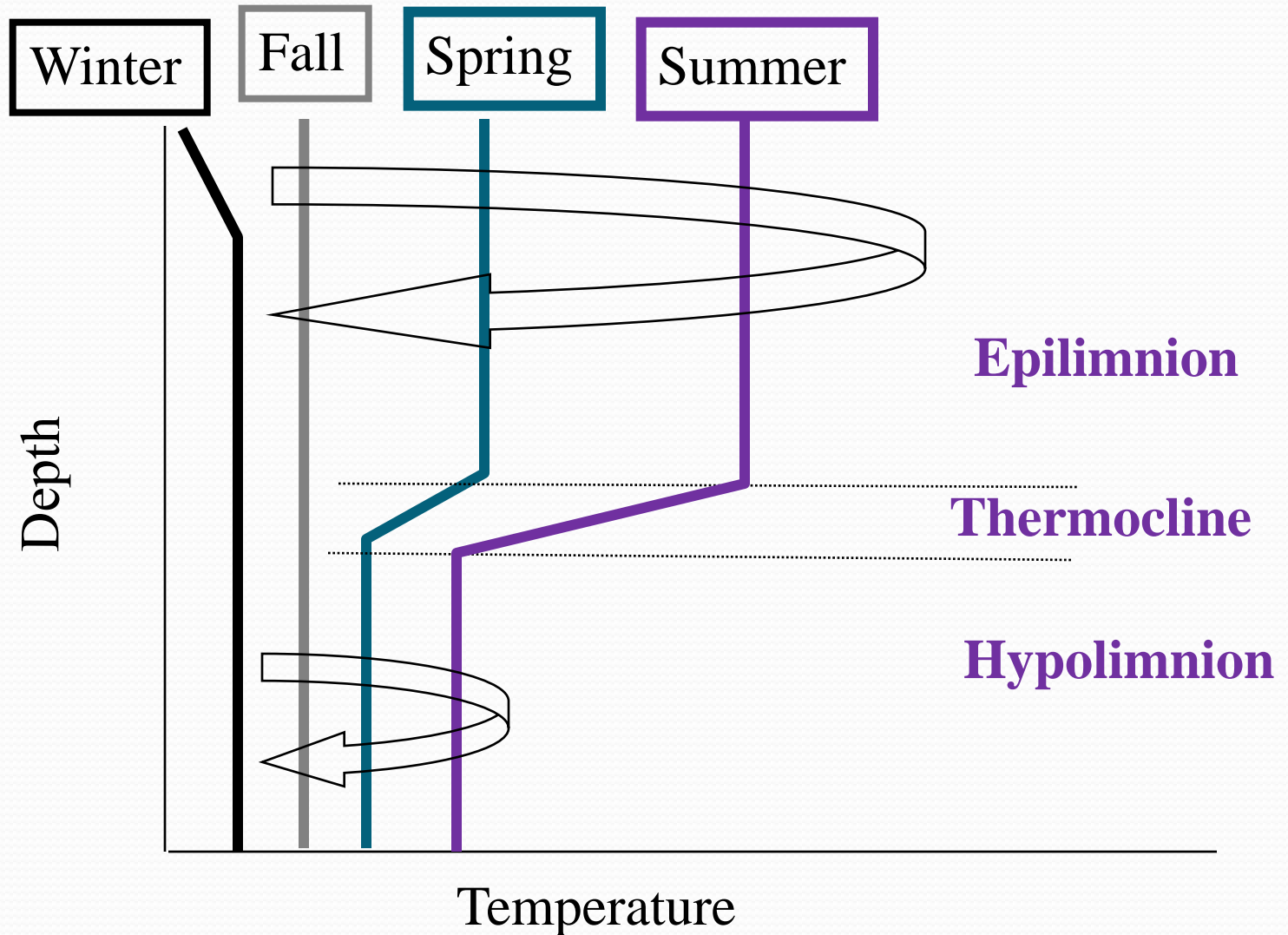
Lakes and Lake Modeling (cont.)



WQ Profiles in Stratified Lakes



Temp. Profiles in Stratified Lakes



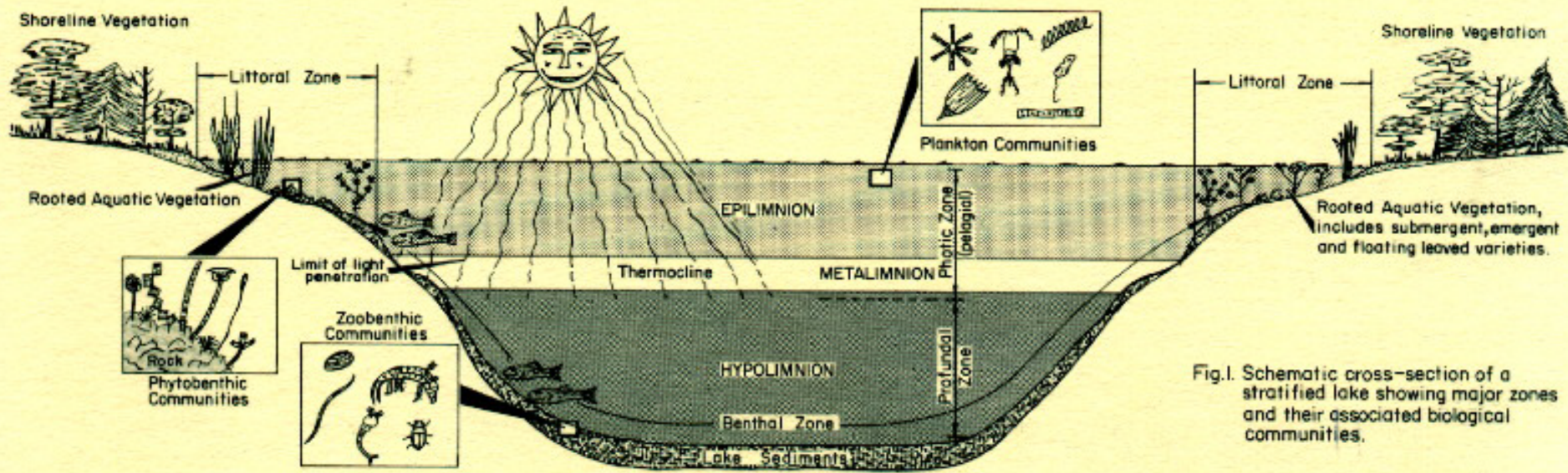
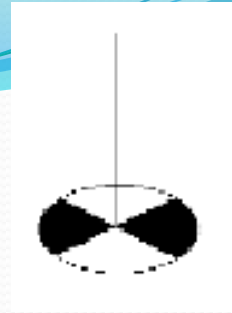
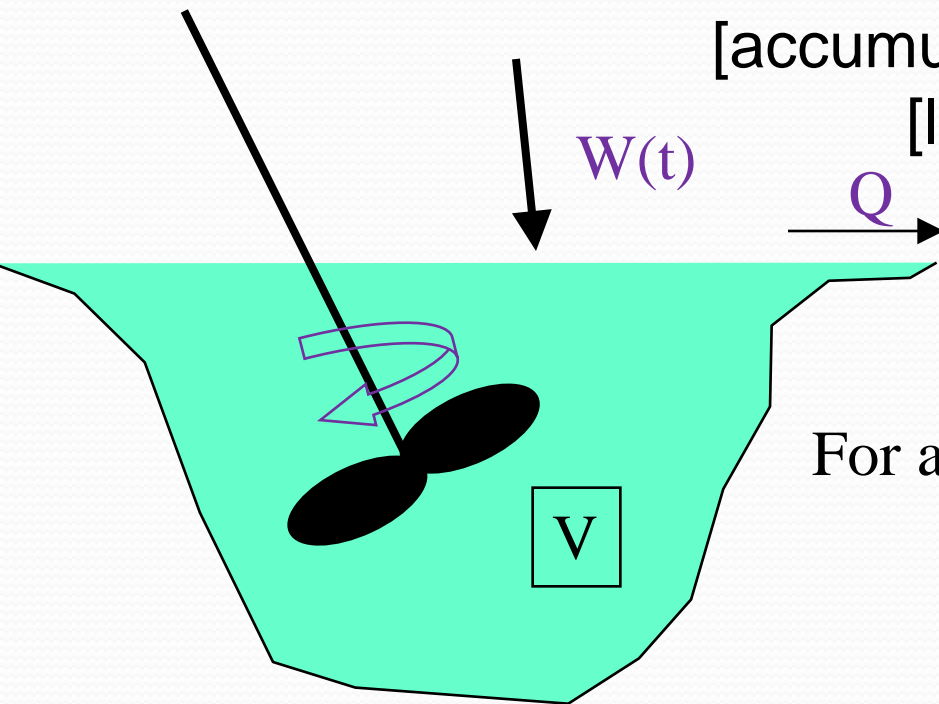


Fig.1. Schematic cross-section of a stratified lake showing major zones and their associated biological communities.

Completely mixed lake model



[accumulation] =
[loadings] \pm [transport] \pm [reactions]

$$V \frac{dc}{dt} = W(t) - Qc - kVc^n$$

For a 1st order reaction ($n=1$):

$$\frac{dc}{dt} + \alpha c = \frac{W(t)}{V}$$

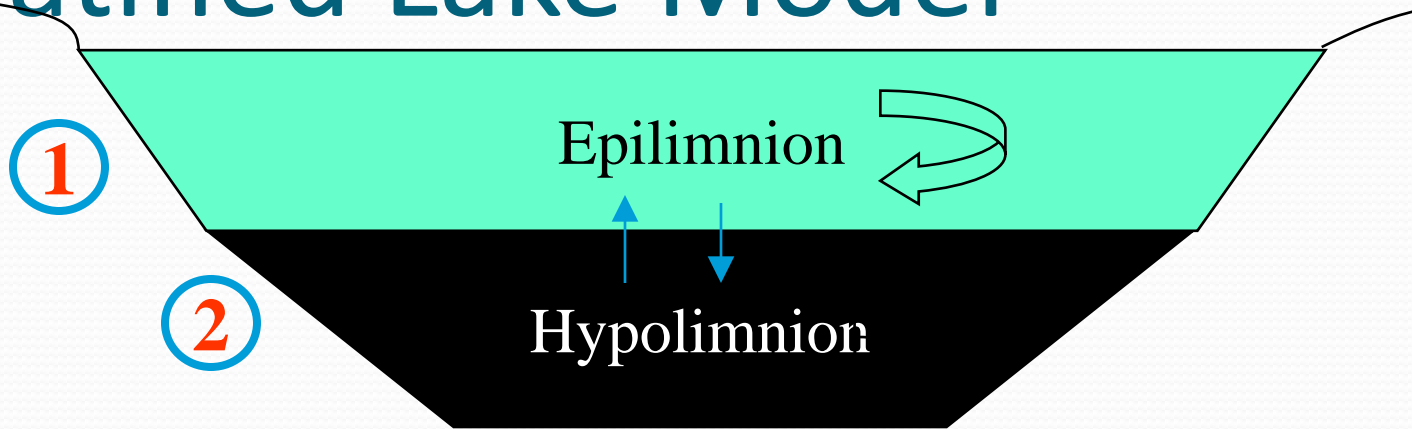
Where:

$$\alpha = \frac{Q}{V} + k$$

Steady State Solution:

$$c = \frac{\bar{W}}{Q + kV}$$

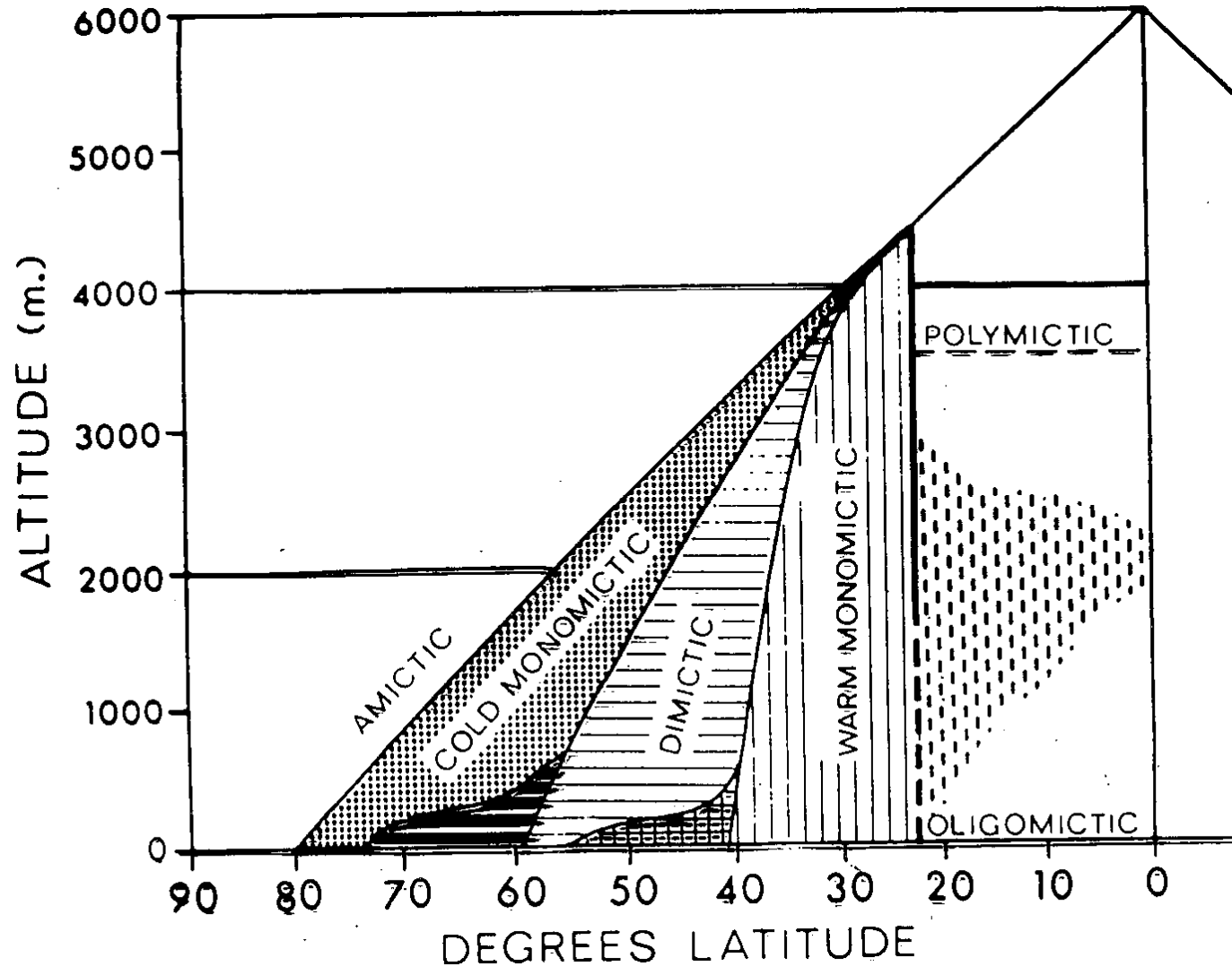
Stratified Lake Model



$$V_1 \frac{dc_1}{dt} = W_1 - Qc_1 + E'_{12}(c_2 - c_1) - k_1 V_1 c_1$$
$$V_2 \frac{dc_2}{dt} = W_2 + E'_{12}(c_1 - c_2) - k_2 V_2 c_2$$

Thermal Lake Types vs Latitude

- From Limnology, by Wetzel



Lake Types

- **Amictic**: lakes permanently covered with ice
- **Cold Monomictic**: temperature is always $<4^{\circ}\text{C}$, mixes only in summer, when $T \sim 4^{\circ}\text{C}$
- **Dimictic**: circulates freely twice a year, temperature ranges above and below 4°C
- **Warm Monomictic**: temperature is always $>4^{\circ}\text{C}$. Mixes only in winter
- **Oligomictic**: warm lakes (usually tropical) with rare and irregular mixing
- **Polymictic**: frequent or continuous circulation (possibly even diurnal)

- To next lecture