

CEE 577: Surface Water Quality Modeling

Lecture #24

Limnology: More on Stratification
(Chapra, L16)

1

Lakes

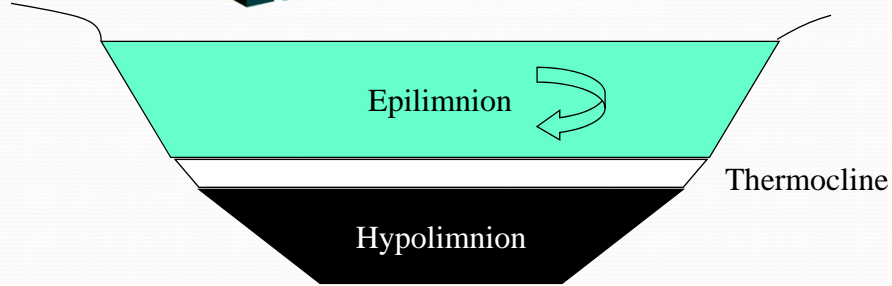
- Concerns in Lakes
 - Eutrophication
 - Toxics
 - Dissolved Oxygen
- Aging of Lakes
 - Oligotrophic
 - Mesotrophic
 - Eutrophic
 - Extinction

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

2

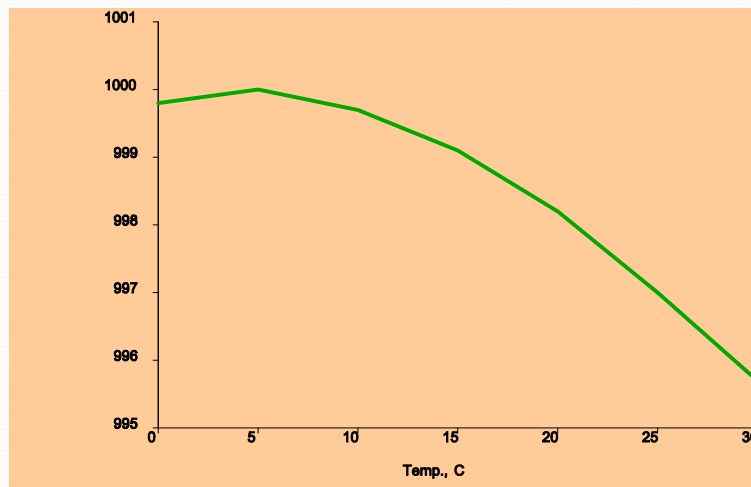
Lakes and Lake Modeling

Lake Stratification



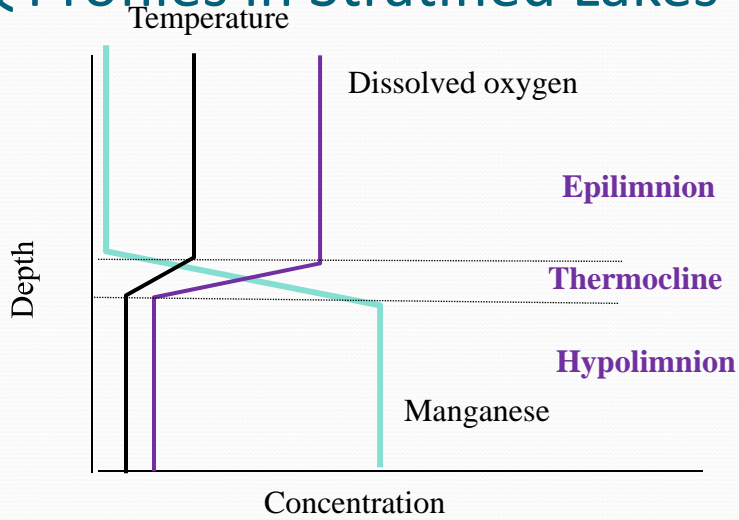
3

Lakes and Lake Modeling (cont.)



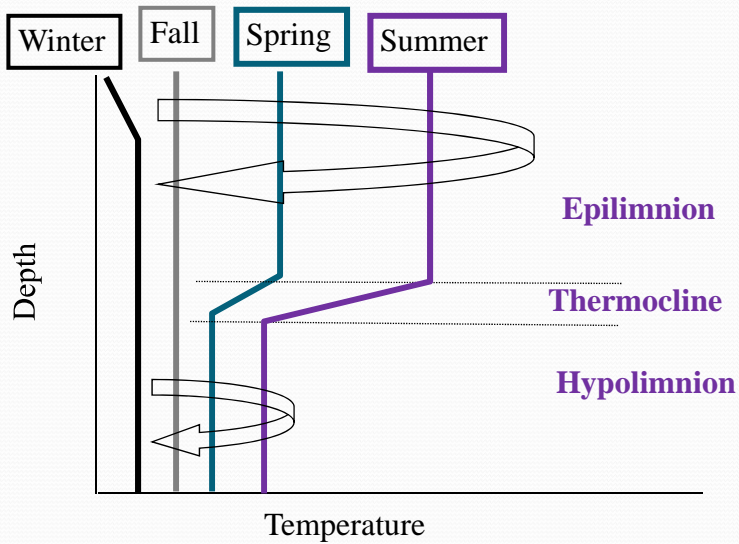
4

WQ Profiles in Stratified Lakes

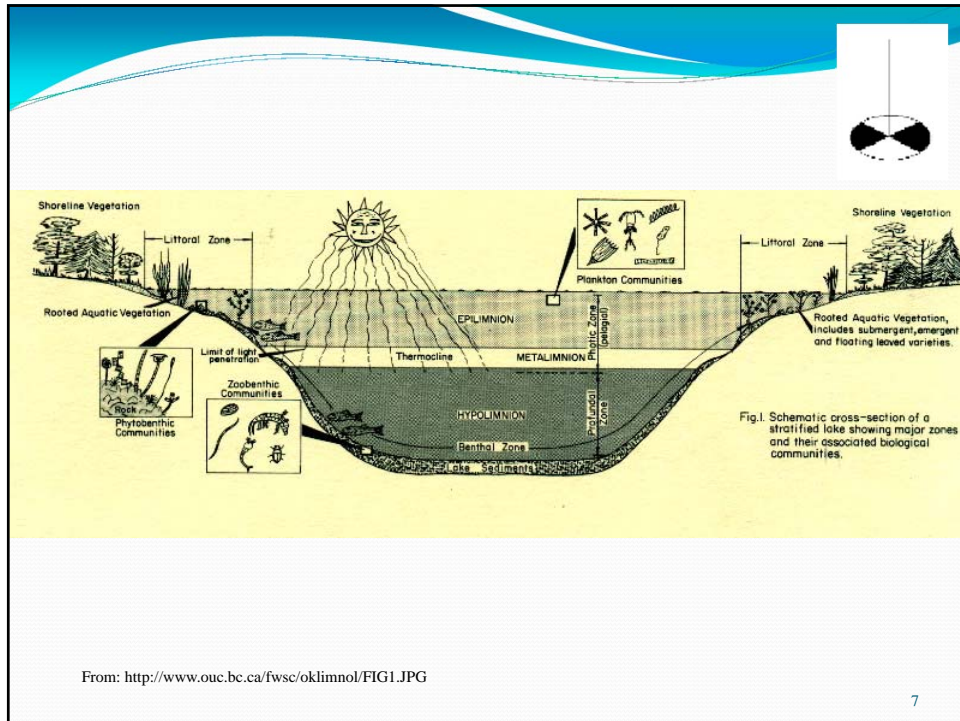


5

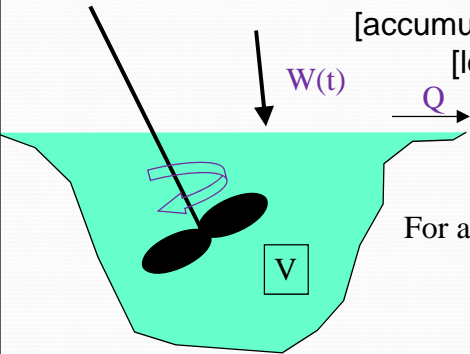
Temp. Profiles in Stratified Lakes



6



Completely mixed lake model



[accumulation] =
[loadings] ± [transport] ± [reactions]

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

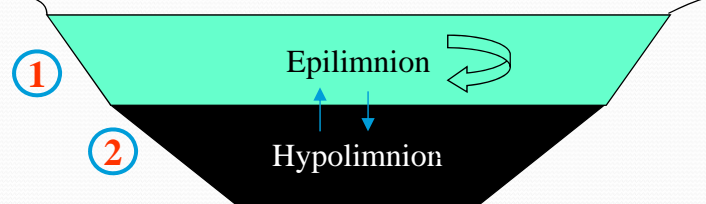
For a 1st order reaction (n=1):

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

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

Steady State Solution: $c = \frac{\bar{W}}{Q + kV}$

Stratified Lake Model



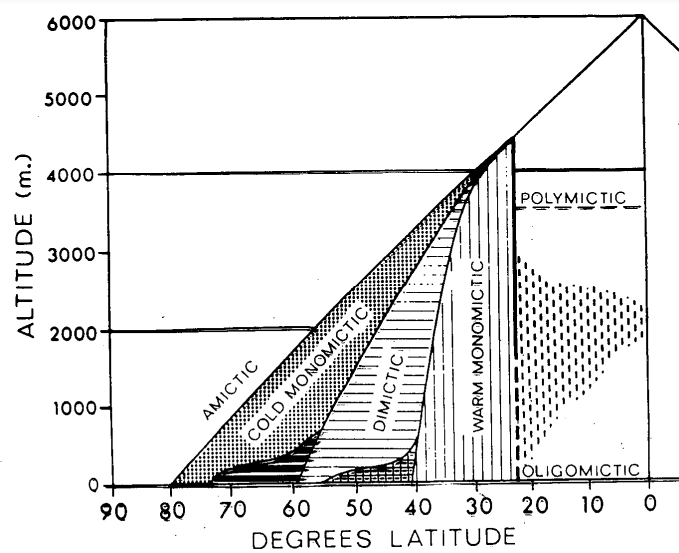
$$V_1 \frac{dc_1}{dt} = W_1 - Qc_1 + E'_{12}(c_2 - c_1) - k_1V_1c_1$$

$$V_2 \frac{dc_2}{dt} = W_2 + E'_{12}(c_1 - c_2) - k_2V_2c_2$$

9

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)

11

- [To next lecture](#)

12