

BIOL 550 - Waterscape Ecology  
Outline

I Properties of Water

- A. Molecular structure
- B. Liquid nature of water
- C. Density vs. temperature
- D. Specific heat
- E. Viscosity
- F. Surface tension
- G. Solvent properties
- H. Other

II. Introduction to the Waterscape

- A. Global hydrologic cycle
- B. Direct human uses
- C. Ecosystem services
- D. Scientific interest

III. Hydrology

- A. Overview at Watershed Level
- B. Precipitation
  - 1. Spatial and temporal variability
  - 2. Relationship to streamflow
- C. Fate of Precipitation
  - 1. Interception, throughfall, depression storage, and stemflow
  - 2. Evapotranspiration
  - 3. Movement to the channel
    - a. Overland flow vs. interflow vs. groundwater flow
    - b. Infiltration-excess overland flow (IOF)
    - c. Surface storm flow (SSF)
    - d. Saturation-excess overland flow (SOF)
    - e. Baseflow generation
  - 4. Regulators
    - a. infiltration rates
    - b. bedrock permeability
- D. Patterns of Streamflow
  - 1. Headwater catchments
    - a. storm hydrograph
    - b. daily mean flow
    - c. duration curves
  - 2. Larger watersheds
  - 3. Anthropogenic effects
    - a. Land use changes
    - b. Flow augmentation or diversion

- E. Flow velocity
  - 1. Gradient
  - 2. Channel roughness
  - 3. Hydraulic radius

#### IV. Stream Morphology and Physical Structure

- A. Drainage Basin Morphometry
  - 1. Drainage patterns and Stream Order
- B. Channel Morphology
  - 1. Channel sections
  - 2. Longitudinal profile
  - 3. Relation of flow to channel properties
- C. Small Channels
  - 1. Step-pool
- D. Intermediate Channels
  - 1. Pool-riffle-bar
- E. Large Channels
- F. Classification systems (Rosgen)

#### V. Stream Physico-chemistry

- A. Suspended sediment
  - 1. Sources, delivery, and budgets
  - 2. Spatial variation
  - 3. Temporal variation

#### Selected References:

- Church, M. 1992. Channel morphology and typology. Pages 126-143 in P. Calow and G.E. Petts (eds). *The River Handbook*. Volume 1.
- Leopold, L.B. 1994. *A View of the River*. Harvard University Press. 298 pp.
- Smith, D.I. and P. Stopp. 1978. *The River Basin*. Cambridge University Press. 120 pp.
- Walling, D.E. and B.W. Webb. 1992. Water quality. I. Physical characteristics. Pages 48-72 in P. Calow and G.E. Petts (eds). *The River Handbook*. Volume 1.

## B. Solutes

1. Overview
2. Atmospheric inputs
3. Weathering inputs
4. Biological processes
5. Composition of River Waters
  - a. World averages
  - b. Effect of rock type
  - c. Effect of precipitation/aridity
  - d. Temperature
  - e. Land use/human activity
6. Solute vs. sediment transport
7. Spiralling
  - a. Overview
  - b. Phosphorus
  - c. Nitrogen

## C. Temperature

1. Energy budget
2. Temporal patterns
  - a. Annual variation
  - b. Diurnal pattern
3. Spatial factors
  - a. Degree of exposure to solar radiation
  - b. Advection from lakes, groundwater
  - c. Elevation

## D. Dissolved oxygen

1. Overview
2. Sources and sinks
3. Temporal patterns
4. Spatial patterns

Additional references:

The Rivers Handbook: Chapters 3, 4, and 18.

## VI. Stream Food Webs

### A. Overview

1. Sources and sizes of organic matter
2. Types of consumers
  - a. By food type
  - b. By feeding mode
3. Flow processes
4. Longitudinal variation (River continuum concept)

### B. Primary Producers

1. Algae
  - a. Habitats
  - b. Characteristic taxa
  - c. Controlling factors
2. Macrophytes
  - a. Habitats
  - b. Characteristic taxa
  - c. Controlling factors
3. Importance of primary production

### References:

Chapters 9, 10, and 16 in Rivers Handbook.

Hynes, H.B.N. 1970. The Ecology of Running Waters. Toronto University Press.

### C. Consumers

1. Taxonomic composition and life histories
2. Factors affecting life history
  - a. Temperature
  - b. Nutrition
3. Feeding mechanisms
  - a. Grazers and scrapers
  - b. Shredders
  - c. Collectors
  - d. Predators
4. Adaptations to the stream environment
  - a. Morphological
  - b. Behavioral
  - c. Physiological

### D. Energy flow

1. Allochthony vs. Autochthony
2. Comparisons among systems

## VII. Large Rivers

- A. Overview: The flood-pulse concept
- B. Hydrology
- C. The flood plain and the aquatic-terrestrial transition zone (ATTZ)
- C. Exchanges of organic and inorganic material
- D. Biota
- E. Man-made river-floodplains

### Additional references:

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood-pulse concept in river-floodplain systems. Pages 110-127 in D.P. Dodge (ed.) Proceedings of the International Large River Symposium. Canadian Special Publication in Fisheries and Aquatic Sciences 106. (On reserve).

Sparks, R.E., P.B. Bayley, S.L. Kohler, and L.L. Osbourne. 1990. Disturbance and recovery of large floodplain rivers. Environmental Management 14: 699-709. (On reserve).

Cummins, K.W. and M.J. Klug. 1979. Feeding ecology of stream invertebrates. Annual Review of Ecology and Systematics 10: 147-172.

Harmon, M.E. et al. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15: 133-302.

## VII. Lake Origins and Morphometry

### A. Lake origins

1. Glacial phenomena
  - a. Direct contact with ice
  - b. Glacial rock basins
  - c. Moraine/outwash dams
  - d. Drift basins
2. Tectonic activity
  - a. Graben, fault-trough, or rift lakes
  - b. Epeirogenesis (overall crustal uplifting)
  - c. Earthquake lakes
  - d. Landslide lakes
3. Volcanic lakes
  - a. Crater lakes
  - b. Lava dams
4. Solution lakes
  - a. Carbonate lakes
  - b. Salt collapse basins
5. Fluvial (river-made) lakes
  - a. Ponding by deltas
  - b. Oxbow lakes
  - c. Pothole lakes
6. Lakes impounded or excavated by organisms
  - a. Human
  - b. Other organisms

### B. Morphology of lakes

1. Surface dimensions
2. Depth-related parameters
3. Hydraulic retention time
4. Comparisons among lakes

## VIII. Light, Heat, and Physical Structure of Lakes

### A. Solar radiation

1. Ambient radiation
  - a. Solar constant
  - b. Spectral distribution
2. Losses of radiant energy
  - a. Atmosphere
  - b. Reflection
  - c. Scattering and Absorption
    1. Beer-Bougher Law
    2. Spectral differences
    3. Measurement
    4. Photic zone determination

### B. Concepts

1. Heat Budget, heat vs. temperature
2. Stratification
3. Mixis

### C. Seasonal stratification and mixing patterns

1. Holomictic
  - a. Dimictic  
(epilimnion, metalimnion, hypolimnion, thermocline)
  - b. Warm monomictic
  - c. Cold monomictic
  - d. Polymictic
  - e. Oligomictic
2. Meromictic
  - a. Profile
  - b. Biogenic
  - c. Ectogenic
  - d. Crenogenic

### D. Other water movements

1. Overview
2. Surface currents (Ekman drift)
3. Langmuir circulation
4. Riverine inflow
5. Vertical eddy diffusion
6. Hypolimnetic currents
7. Seiches
  - a. External
  - b. Internal

## IX. Chemistry of Lakes

### A. Oxygen

1. Sources and sinks
2. Solubility
3. Stratification and vertical distribution

### B. Carbon dioxide, alkalinity, and pH

1. Carbonate-bicarbonate equilibrium
2. Relation between pH and forms of inorganic carbon
3. Alkalinity
4. Effect of photosynthesis and decomposition
5. Stratification and vertical distribution
6. Effect of acid precipitation

### C. Dissolved ions

1. Conductivity vs. Total dissolved solids
2. Dominant anions and cations
3. Hardness

### D. Nitrogen

1. Forms and transformations
2. Stratification and vertical distribution

### E. Phosphorus

1. Forms and transformations
2. Stratification and vertical distribution

### F. Iron

1. Forms and transformations
2. Stratification and vertical distribution

### G. Silicon

## X. Lake Biology: Overview

### A. Habitat Regions

1. Littoral
2. Pelagial
3. Profundal

### B. Biotic Communities

1. Plankton
2. Benthos
3. Periphyton
4. Nekton

## XI. Lake Biology: Plankton

### A. Phytoplankton

1. Characteristics
  - a. Physiological
  - b. Taxonomic
  - c. Morphological
  - d. Adaptations
2. Factors affecting growth
  - a. Light
  - b. Nutrients
  - c. Grazing
  - d. Parasites
  - e. Sedimentation
  - f. Washout
3. Patterns of phytoplankton abundance
  - a. Seasonal
  - b. Horizontal
  - c. Vertical
  - d. Interannual

## B. Zooplankton

1. Characteristics
  - a. Taxonomic
  - b. Life history
  - c. Adaptations (cyclomorphosis, diurnal migration)
2. Factors affecting growth
  - a. Food concentrations
  - b. Temperature
  - c. Filtering rates
3. Patterns of abundance
  - a. Seasonal
  - b. Effects of Predation

## XII. Lake Biology: Profundal Benthos

1. Characteristics
  - a. Taxonomic
  - b. Life History
  - c. Adaptations
2. Patterns of Abundance
  - a. Seasonal
  - b. Lake Trophy

### XIII. Lake Biology: Littoral Zone

#### A. Macrophytes

1. Characteristics
  - a. General morphology
  - b. Taxonomy
  - c. Adaptions
2. Factors affecting growth
  - a. Low oxygen in root zone
  - b. Inorganic carbon supply
  - c. Depth: light and pressure
  - d. Nutrients
  - e. Temperature
  - f. Sediment quality and stability
3. Patterns of abundance and productivity
  - a. Seasonal
  - b. Productivity determination
  - c. Spatial

#### B. Periphyton

1. Characteristics
  - a. General morphology
  - b. Taxonomy
  - c. Adaptations
2. Factors affecting growth
  - a. Substrate type and availability
  - b. Light
  - c. Nutrients
  - d. Temperature
  - e. Grazing
3. Patterns of abundance and productivity
  - a. Seasonal
  - b. Productivity determination
  - c. Spatial

#### C. Littoral invertebrates

1. Characteristics
  - a. Taxonomy
  - b. Feeding strategies
  - b. Adaptations
2. Factors affecting growth
  - a. Temperature
  - b. Food availability
  - c. Substrate type and availability
3. Patterns of abundance and productivity
  - a. Seasonal
  - b. Spatial

#### XIV. Fish

##### A. Characteristics

1. Taxonomic
2. Trophic
3. Life History

##### B. Factors Affecting Growth

1. Temperature
2. Food Supplies

##### C. Patterns of Abundance and Productivity

1. Resource and habitat partitioning
2. Bottom-up and top-down controls
3. Variation in reproductive success