[1]MODULE 2: MORPHOLOGY AND SOME PHYSICOCHEMICAL FEATURES OF STREAM REACHES AND CHANNEL UNITS[1]

Introduction

Stream reaches and channel geomorphic units are hierarchically nested subdivisions of drainage networks that are of smaller spatial scale than the scales of catchment basins and valley segments investigated in the previous laboratory (Frissell et al. 1986, Bisson and Montgomery 1996). Stream biologists often work at these and smaller spatial scales. Channel reaches are stretches of streams whose topographic features and channel geomorphic units are relatively homogeneous and can be distinguished from adjoining reaches (e.g., pool-riffle reaches, see Table 1 in the Landscape Laboratory, Bisson and Montgomery 1996). Within reaches, channel units (also called habitat types) vary in depth, velocity and characteristics of the substrata. Hawkins et al. (1993) classified channel units into several categories shown in Table 1. Features associated with channel units, especially velocity and substrata characteristics, are very important to the biota as we will discuss in future lectures. Thus, channel unit classification is useful for developing an understanding of the distribution and abundance of aquatic plants and animals in patchy stream environments. In this and the next laboratory, we will visit streams of two different stream reach types (pool-riffle and plane-bed, Table 1 in the Landscape laboratory).

Stream organisms are also influenced by the physicochemical features of the water body. Physical features that are important to the biota include temperature and light. Temperature affects the movement of molecules, fluid dynamics, and the saturation constants of dissolved gases in the water (e.g., dissolved oxygen) and is particularly important to the fauna of streams because most of these organisms no internal control of body temperature. Light influences the temperature of the water and primary productivity of the ecosystem through its influence on photosynthesis. The greatest source of heat in freshwater is from solar radiation. This is especially true in streams that are not shaded by a tree canopy. In streams that are densely shaded, transfer of heat from the air and through flows of groundwater may be more important in determining water temperature than solar radiation. Temperatures in streams may vary daily (called the diel temperature flux), especially in streams without canopy cover. Often temperature varies among microhabitats: shaded areas may have lower temperatures than unshaded areas and areas of groundwater entry into the stream may often have more stable temperature than the channel.

There are a myriad of chemical features of water that are important to the biota. The dissolved oxygen concentration is important because of its role in plant and animal metabolism. The inorganic carbon complex (includes such things as dissolved CO_2 and relatives), which regulates the acidity, alkalinity, and pH of most streams, is also important to the biota. Inorganic

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nutrients, such as nitrogen and phosphorus, are also important because of their roles as major cellular components of the biota. These two inorganic nutrients may limit primary production via photosynthesis.

It is the purpose of this module to collect data that will be used to examine the hypothesis that channel units vary in physical and chemical characteristics both within and among stream reaches. Predictions from this hypothesis (e.g., stream velocity differs between pools and riffles) will be formally tested in Module 3. Then in future modules, we will relate differing physical and chemical characteristics with variation in the biota. We will visit one reach during the first week of the laboratory and the other the following week. The first reach will contain two channel units. The second reach will only have one channel unit. We will determine representative channel unit types of reaches, map the channel units, and measure velocity, depth and substrata types. It will be impossible to determine all the physicochemical features of streams in one laboratory; however, we will examine a few select characteristics that are thought to be important to the biota. General reasons for the inclusion of particular characteristics are mentioned in each exercise. We will discuss these characteristics in more depth in lecture. Exercises in this laboratory were drawn from Bisson and Montogomery (1996), Newbury (1996), Gore (1996), Wetzel and Likens (1991), Gordon et al. (1992), Horne and Goldman (1994) and Hauer and Hill (1996).

In this module we will work in groups (3 or 4 students per group). Each group will compile its own data that will be used in the data analysis laboratory. Each person in the group should be sure that they have all the data and that it is correctly recorded. At the end of the data analysis laboratory we will combine data from all groups and these data will be used by each group to write a report (more later).

Exercise 1: Reach type and mapping channel geomorphic units

When you reach the sites to be studied in this exercise, examine a stretch of each stream by walking up and down the banks. Determine the stream reach classification based on the information given in the Landscape laboratory. What kind of channel units are represented in each stream reach? Use Table 1 to determine these.

Draw a map of each channel unit representative of each stream reach. An example map will be provided at the first laboratory. For this laboratory sequential channel units should be chosen (e.g., one riffle and one pool). When doing a "real' scientific study the mapped reach should be long enough to include a full meander amplitude (e.g., two riffles and two pools in a riffle-pool reach). To do basic mapping, stretch a tape along a straight baseline on one bank of the sequential channel units and sketch in the bottom and top of the channel boundaries and major physical features such as boulders, logs, debris, and typical substrata with reference to this tape. Note the boundaries of the stream and the highwater marks. Locate pools, riffles and other local rapidly varying flow conditions and eddy patterns on the map approximately to scale. Note the riparian vegetation and what % of the stream is shaded in each channel unit. Measure the length and width of each channel unit.

Exercise 2: Velocity profiles

Horizontal velocity profile: Chose a cross section in **each channel unit** that is representative of that channel unit in each stream reach. Indicate these cross sections on your map. String the measuring tape across the stream reach perpendicular to the flow and determine the width of the channel unit. At intervals starting from one stream bank, measure the depth of the stream bed (using the rod on the flow meter) and the velocity using the flow meter (m/s). Make 10 measurements and record the data in Data Table 1. We will use an equal number of measurements in each reach to simplify our statistical analyses. In order to calculate stream discharge (which we will do in the analysis laboratory), mean velocity for each section is needed. One way to measure mean velocity is to make velocity measurements at 0.4 D (depth), where D is measured from the stream bottom. The flow meter we are using is attached to a wading rod with a sliding mechanism which allows for depth adjustment. We will show you this when you are using the rod. This method is sufficient in shallow (< 0.5 m streams). There are other ways to measure flow and calculate discharge which give more precise results (Gordon et al. 1992).

Vertical velocity profile: We will do this exercise as a whole class at the end of the laboratory when we are at Rocky Creek. In **each channel unit in Rocky Creek** (which may or may not be the mapped reach), determine the velocity at 5 - 10 increments of depth above the streambed. Record these data in Data Table 2. We will use the vertical velocity profile to calculate shear stress on the stream bottom.

Exercise 3: Composition of the substrata

The substrata of streams is composed of both inorganic (mineral) and organic substrates (e.g., leaves, twigs, logs). The substrata is important to the biota for a number of reasons (e.g., place to live, food source). Both inorganic and organic substrata can be divided into size classes that are important to the biota. Size composition of the inorganic substrata can be measured in many different ways. The most precise way is to take a core of the substrata and then pass the material through consecutively smaller sieves. The material in each sieve is dried and the % composition by weight of each size fraction is determined. The organic substrata can also be defined by size; however, only one size fraction, the coarse particulate organic matter (CPOM, leaves, twigs, bark etc.), can be estimated visually. We will use a modification of the Wolman (1954) pebble count to determine the size composition of the substrata. We will use a simple visual estimation technique to determine the presence of CPOM.

Choose a point along the bank of each channel unit. One person should walk across the unit, heal to toe. At each step this person should reach into the water (in front of the front toe) and pick up the first rock they touch. To keep the sample unbiased you should pick up the rock closest to the same point off the foot each time. After the rock is picked up, the length of the rock perpendicular to its longest dimension should be measured and the data recorded in Data Table . You don't need to record the actual dimension, just put a mark under the correct category (see Table 3). If when you reach down you contact sand or silt (we will not be able to measure the difference in these two categories with this method) record a mark in that column. You should measure at least 30 rocks in each channel. If you need to, chose another transect across the channel unit, but **always from downstream to upstream to avoid disturbing the substrata that you will be measuring**. At each transect record the number of CPOM particles you can see in about a 20 cm square directly in front of your foot. Tally this information in Data Table 3.

Exercise 4: Temperature, dissolved oxygen concentration, conductivity and pH

In this exercise we will study how temperature, dissolved oxygen concentration, conductivity and pH differ between our study reaches. Temperature, dissolved oxygen concentration, conductivity and pH are thought to influence the biota and interact with each other and other characteristics in the following general ways:

Temperature: influences the growth and reproduction of organisms; influences the amount of dissolved oxygen in water and often the amount of oxygen needed by organisms

Dissolved oxygen concentration: oxygen needed for aerobic metabolism; oxygen concentration influences the ability of an organism to obtain oxygen; low oxygen levels can cause metabolic stress and death

Conductivity: measures the amount of current conducted; the amount of current is proportional to the concentration of ions in solution; the specific conductance of water in bicarbonate-dominated streams is closely proportional to the concentrations of major cations (Ca^{+2}, Mg^{+2}, Na^{+}, and K^{+}); these minerals are directly related to alkalinity, impart hardness to the water, and are related to its buffering capacity; these minerals (and others) are important components of many biochemical pathways

pH: a measurement of the hydrogen ion concentration in a solution; low pH indicates acidic conditions; high pH indicates alkaline conditions; extreme values of pH (far away from 7 which is neutral) can be lethal

In this exercise, temperature, dissolved oxygen, conductivity and pH will be measured using a meter (Yellow Spring's Instrument). In practice these features can be measured by many different means. For example, dissolved oxygen can be measured by the Winkler titration method or by using oxygen sensors (our method). pH can be measured by colorimetric or electrometric (pH meter, our method) means. Choose a transect across the stream in **each of the channel units**. In each unit, measure temperature, dissolved oxygen, conductivity and pH at 5 equidistance points across the stream. Record these data in Data Table 4.

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Table 1. Description of channel units from Hawkins et al. (1993). Level 1 classifications (I, II.....), Level 2 classifications (A, B.....), Level 3 classifications (1, 2, 3....)

1. **Fast Water**
   a. **Turbulent--**Layers of fluid break up into "globs" which mix with other globs in chaotic collection of eddies and swirls. [Actually most flow in streams is turbulent.] Here we use the term generically to describe fast water that has some "white-water" showing; Level 3 categories listed below are in order of reach gradient (except sheet, which can have a variable gradient).
      i. **Falls**--vertical drops of water spanning a flow obstruction; commonly found in bedrock, cascade and step-pool stream reaches.
      ii. **Cascades**--highly turbulent series of short falls and small scour basins; prominent features of bedrock and cascade reaches.
      iii. **Chute--**narrow, steep slots in bedrock.
      iv. **Rapids**--moderately steep but possess a planar longitudinal profile; dominant in plane-bed streams.
      v. **Riffles--**most common type in low gradient alluvial channels; found in plane-bed, pool-riffle, regime, and braided reaches
   b. Non-turbulent--No "white-water" showing.
      i. **Sheet**--shallow water flows uniformly over smooth bedrock; found in bedrock, cascade, or step-pool reaches.
      ii. **Run**--fast water, shallow gradient, typically deeper than riffles
2. **Slow Water**
   a. **Scour pools**--pools created by scour that forms a depression in stream bed.
      i. **Eddy**--scouring action behind large flow obstructions along the edge of the stream; often associated with woody debris & found in all alluvial reach types.
      ii. **Trench**--located in tightly constrained bedrock, reaches.
      iii. **Mid-channel--**deep areas formed by flow constrictions that focus scour along the main axis of flow; common in cascade, step-pool, and pool-riffle reaches
      iv. **Convergence**--pool where two streams of similar size meet; common in any alluvial stream reach.
      v. **Lateral**--scouring action lateral or under flow obstructions near the edge of the stream; common in step-pool, pool-riffle, regime, and braided reaches; form naturally in meander bends.
      vi. **Plunge--**scour from the vertical fall; most abundant in steep headwaters.
   b. **Dammed pools**; impoundment of water upstream of a flow obstruction.
      i. **Debris**--debris impounds water
      ii. **Beaver**--beaver impound water
      iii. **Landslide**--landslide impounds water
      iv. **Backwater**--not connected to main channel at low flow.
      v. **Abandoned channel--**no surface water connection to main channel.

Table 2. The classification of mineral substrates by particle size, according to the Wentworth Scale. Modified from Allan 1995.

Size category	**Particle diameter (mm)**	**Phi value**
Boulder	> 256	< -8
Cobble	64 - 256	-7, -6
Pebble	16 - 64	-5, -4
Gravel	2 - 16	-3, -2, -1
Sand	0.063 - 2	4, 3, 2, 1, 0
Silt	< 0.063	> 5

Data Table 1A--Horizontal profile
Rocky Creek

Date:

Description of the Channel Units present:

Unit Type		Channel Unit 1		Channel Unit 2	
Description of channel unit					
	Distance from bank (m)	Velocity (m/s)	Depth (m)	Velocity (m/s)	Depth (m)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

Data Table 1B--Horizontal profile
Bear Creek

Date:

Description of the Channel Units present:

Unit Type		**Channel Unit 1**	
Description of channel unit			
	Distance from bank (m)	Velocity (m/s)	Depth (m)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

DATA TABLE 2--Vertical Profile

Date:

Description: (as in Data Tables 1A and 1B)

	Rocky Creek			
	Channel Unit 1		**Channel Unit 2**	
Description of unit				
Number	Distance from bottom (m)	Velocity (m/s)	Distance from bottom (m)	Velocity (m/s)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

DATA TABLE 3--Substrata composition

Date:

Description: (as in Data Tables 1A & B)

		Rocky Creek		**Bear Creek**
		Channel Unit 1	**Channel Unit 2**	**Channel Unit 1**
Size category	**Particle diameter (mm)**	Description:	Description:	Description:
Boulder	> 256			
Cobble	64 - 256			
Pebble	16 - 64			
Gravel	2 - 16			
Sand and Silt	< 2			
CPOM				

DATA TABLE 4--Physicochemical conditions

Date:

Description: (as in Data Tables 1 A & B)

	Rocky Creek								**Bear Creek**			
	Channel Unit 1				**Channel Unit 2**				**Channel Unit 1**			
	Temp (°C)	Cond. (mhos)	DO (mg/l)	pH	Temp (°C)	Cond (mhos)	DO (mg/l)	pH	Temp (°C)	Cond. (mhos)	DO (mg/l)	pH
1												
2												
3												
4												
5												

Assignments:

The only assignment for the laboratory is for each group to turn in all completed data sheets at the end of the laboratory with the names of the people in each group indicated.