# Longitudinal Variation of Periphyton Productivity in Skeleton Creek, Oklahoma[1]

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The benthic algae or "periphyton" are the major primary producers in many streams. Methods for measuring the productivity of phytoplankton generally are not suitable for periphyton. The standing crop of periphyton can be estimated by scraping natural substrata, but the rate of accumulation is not usually known. Artificial substrata have been used to sample periphyton biomass, but mostly for taxonomic studies or standing crop estimates rather than for productivity estimates (Cooke, 1956; Wetzel, 1964). Placement of artificial substrata in a stream for a single extended time provides a measure of the average rate of biomass accumulation resulting from the process of colonization and ensuing growth of attached periphyton. The rate of accumulation is low in the colonization and lag phase and including this phase in estimating productivity of the well established mat results in a lower value. Accumulation approaches zero at the asymptotic level, thus the longer the exposure period the lower the average rate of growth. Since a single exposure period includes the process of colonization and may include part of the asymptotic level, it does not provide a measurement of the rate of production of a well established mat of periphyton.

Kevern, Wilhm, and Van Dyne (1966) measured biomass accumulation on a series of substrate exposures of increasing duration (e.g., 3, 6, 9, 12 days, etc.) and plotted a growth curve of the standing crop of periphyton. They recognized two components in the growth curve and used a discontinuous linear regression model to distinguish between a colonization and lag phase and an acceleration phase. They stated that the instantaneous growth rate following the colonization and lag phase provided an estimate of the rate of accumulation of the well established periphyton mat. The objective of this study was to determine longitudinal variation in the rate of periphyton growth on Plexiglas plates by using a series of increasing exposure times in an enriched stream.

Skeleton Creek, a permanent stream which originates near Enid, Oklahoma and empties into the Cimarron River 6 miles north of Guthrie, was selected for study. The stream is about 70 miles long and both municipal and oil refinery wastes enter the headwaters. Skeleton Creek was selected for study because it enabled analysis of the periphyton community under various degrees of pollution.

Floating rafts were produced by constructing a 20- × 50-inch rectangle of 1- × 2-inch redwood slats. An additional slat was inserted in the middle of the long axis. A pointed extension with a ¼-inch hardware cloth "cowcatcher" was added to the front to divert debris around the raft. Twelve Plexiglas plates, with an exposed area of 1 $dm^2$ each, were attached with bolts and wing nuts to each of the three slats on the long axis. A pilot study was conducted during September, 1967, in order to

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test the durability of the raft and to provide information on the proper exposure times.

One raft was placed in each of four locations and anchored with cables to both banks along Skeleton Creek on 26 October 1967. An attempt was made to find areas of similar current, depth, and light exposure. Three plates were removed from each of the four rafts on 7, 10, 14, 18, 23, 29, 35, 42, 49, 56, and 63 days after the initial placement. Plates removed on sampling days were specified by selecting numbered cards. One side of each of three plates was used for estimating biomass accumulation.

Temperature exhibited little variation among the four stations. Highest values were recorded in November and the lowest in December. The rafts were placed below riffles and current was similar at the four stations. Turbidities were highest during the early phase of the study and gradually decreased. The pH was consistently above 7 at all stations throughout the study period. Oxygen determinations of daytime grab samples were high at the upper and low station and low at the middle stations. The ranges of physicochemical conditions are presented in Table I.

The data plotted on an ash-free, dry-weight basis approximated the form of a sigmoid curve (Fig. 1). The curves leveled off after approximately 4 weeks at all stations. The data suggested three linear components in the growth curve and the following discontinuous linear regression model was used to analyze the data:

$Y = d(b_1 t) + e\,[a + b_2\,(t - t_i)] + f\,[c + b_3\,(t - t_j)]$ where $Y$ is standing crop, $b_1$ is the slope of the colonization phase, $b_2$ is the slope of the logarithmic phase, $b_3$ is the slope of the asymptotic phase, $t$ is time, $t_i$ is time at the intersection of $b_1$ and $b_2$, $t_j$ is time at the intersection of $b_2$ and $b_3$, $d$, $e$, and $f$ are coefficients determined such that if

$$t < t_i,\ d = 1,\ e = 0,\ f = 0$$

$$t_i < t < t_j,\ e = 1,\ d = 0,\ f = 0$$

$$t > t_j,\ f = 1,\ e = 0,\ d = 0$$

$a$ is the value of $Y$ at time $t_i$, $c$ is the value of $Y$ at time $t_j$.

Slope $b_1$ represents initial colonization and the lag phase of growth and was considerably lower than slope $b_2$ at all stations (Table II). Slope $b_2$ approximates the maximum instantaneous growth rate; i.e., at the inflection point of the sigmoid curve. The value of slope $b_2$ decreased with increased distance downstream from the outfall. This was probably influenced by a decrease in available nutrients downstream. An analysis of variance indicated that stations one and two were not significantly ($0.05 < P < 0.1$) different, but that they were significantly greater than stations three and four. Stations three and four were not judged to be significantly different. Slope $b_3$, the asymptotic level, approaches zero as accumulation is balanced by grazing and sloughing. Sloughing occurs with the buildup of the mat and subsequent decay of the underlying layers allowing portions of the mat to float away. Thus, an estimate of the slope following the colonization and lag phase and preceding the asymptotic level provides the best estimate of accumulation of the well established mat.

TABLE I. RANGES OF PHYSICOCHEMICAL CONDITIONS AT COLLECTING STATIONS

| Station | Miles Below Outfall | Current (ft/sec) | Temp. (C) | Oxygen (ppm) | Turbidity (% trans) | pH |
|---|---|---|---|---|---|---|
| 1 | 4 | 0.31-1.3 | 2.0-14.0 | 5.6-18.0 | 17-94 | 7.8-8.4 |
| 2 | 12 | 0.25-0.55 | 2.0-13.0 | 3.8- 8.2 | 66-94 | 7.6-8.2 |
| 3 | 33 | 0.31-1.3 | 2.0-11.0 | 3.2- 8.7 | 4-92 | 7.4-8.0 |
| 4 | 60 | 0.31-1.7 | 2.0-11.0 | 3.7-14.5 | 11-90 | 7.4-8.4 |

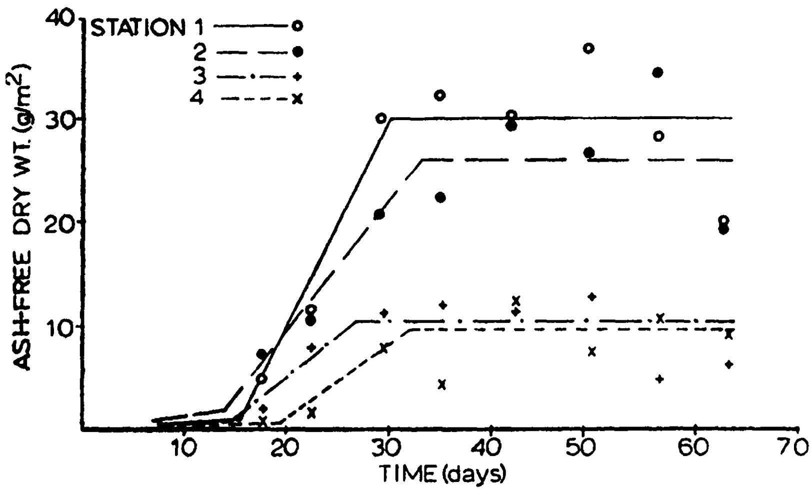


Figure 1. Discontinuous linear regression model fit to growth of periphyton.

TABLE II. SLOPES FOR THE THREE GROWTH PHASES AT FOUR STATIONS IN SKELETON CREEK.

| | Station | | | |
|---|---|---|---|---|
| Slope | 1 | 2 | 3 | 4 |
| $b_1$ | 0.055 | 0.168 | 0.010 | 0.044 |
| $b_2$ | 1.980 | 1.270 | 0.803 | 0.670 |
| $b_3$ | 0.221 | 0.084 | 0.186 | 0.211 |

## LITERATURE CITED

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