Proceedings of the Iowa Academy of Science

Volume 78 | Number 3-4 Article 6

1972

Primary Productivity in Lake Red Haw, Lucas County, Iowa

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P. J. KINGSBURY, L. D. CORKUM, and P. D. KRAUSE. Primary Productivity in Lake Red Haw, Lucas County, Iowa. *Proc. Iowa Acad. Sci.*, 78(3-4):48-49, 1972.
SYNOPSIS. Primary production studies were conducted on an 83-acre lake in south central Iowa during the summer of 1970 and winter of 1971. Primary productivity was measured using the light-dark bottle method. Summer values ranged from 2.74 to 6.25 grams of carbon assimilated/m^2/day. This was correlated with water temperature, nitrate nitrogen, ortho phosphates, carbon dioxide, light penetration and plankton populations. Studies were continued during the winter using C^{14} and scintillation counting methods.
INDEX DESCRIPTORS: Primary productivity, carbon 14, scintillation counting, winter, Red Haw.

Total primary productivity is an assessment of the amount of fixed carbon which has been converted into organic material through the action of photosynthesis (Russell-Hunter, 1970). In a lake, the phytoplankton absorbs radiant light energy to build up organic substances, while the heterotrophic organisms gain energy from the utilization of these substances. Productivity is dependent upon the depth to which the sun penetrates and thus the phytoplankton tends to be distributed throughout the trophogenic zone of the lake (Smith, 1966).

The radiant energy assimilated by plants is known as the total photosynthesis or gross primary production. Net production is the amount of organic substance remaining in plant bodies after respiration usage (Ryther, 1956).

Lake Red Haw, an artificial lake established in 1936, has 83 surface acres and is 13 meters in depth. This study was divided into two sections; the first measured monthly productivity values during the summer of 1970 and the second measured weekly values beginning Feb. 14, 1971.

We were interested in determining: 1. seasonal productivity variations, 2. the effect of ice and snow on gross primary production values.

METHODS

For this study we used the light-dark bottle method (Gaarder and Gran, 1927) using a six hour incubation period. During 1970 incubation began at 11:00 AM and utilized an 8 meter water column, during 1971 incubation began at 9:00 AM and utilized a 5 meter water column. All oxygen determinations were made using the azide modification of the Winkler method (Standard Methods, 1971). Light penetration was measured with a Secchi disk and beginning Feb. 14 also with a submarine photometer.

Megard (1969) recommends the use of the following formula to convert data from six hour incubation periods to a 24 hour basis: $p = \frac{2(LB-DB)F}{PQ}$ where:

p = gross photosynthesis (mgm C/1/day)
LB = net increase in oxygen due to photosynthesis in the light bottle
DB = oxygen decrease in the dark bottle
PQ = photosynthetic quotient. A value of 1.2 according to Strickland and Parsons (1968)
F = ratio of molecular weights of carbon and oxygen (0.375)

The measurement for gross photosynthesis for each meter is in mgm C/1 which is equivalent to gm C/m^3. By totaling the values of a column of water, the photosynthetic rate under one square meter of water surface may be determined in gm C/m^2/day (Odum, 1963.)

RESULTS AND DISCUSSIONS

Gross primary productivity values for the entire water column, as shown in table 1, varied from the June high of 6.25 to a low of 3.06 in August. During 1970 two productivity peaks were noted, one in June and the second in September. In May and October, primary productivity values were obtained at all depths sampled with more uniformity present in October. During the four middle months, however, no gross production was noted at the lower depths, in fact in August, no production was evident below three meters.

Thermal stratification was present from May to September, while in October, vertical temperature readings varied by only 0.5°C. Sky conditions and Secchi disk readings varied among the six sampling periods of 1970.

TABLE 1. SECCHI DISK, SKY CONDITIONS AND GROSS PRIMARY PRODUCTIVITY (GM C/M^2/DAY) VALUES FOR THE 1970 SAMPLING PERIOD.

Date	*Secchi Disk* (meters)	*Sky Conditions*	*Gross Productivity*
5/28	3.3	very cloudy	4.86
6/27	0.7	sunny, clear	6.25
7/25	—	sunny, clear	4.40
8/22	1.3	partly cloudy	3.06
9/19	0.9	slightly cloudy	5.69
10/17	1.0	sunny, clear	4.76

Winter (1971) gross primary production ranged from a low of -2.31 on Feb. 21 to a high of 2.84 on Feb. 24. In all

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TABLE 2. SELECTED DATA INDICATING SOME RELATIONSHIPS BETWEEN CLIMATOLOGICAL FACTORS, LIGHT TRANSMISSION AND GROSS PRIMARY PRODUCTION.

Date	Incident Radiation (ft.-cdl.)	Radiation Below Ice (ft.-cdl.)	% Trans.	Secchi Disk	Gross Production (gm C/m²/day)	Weather
2/21/71	983	166	17	0.7	–2.31	40 cm ice, snowing
2/24/71	3,852	95.8	2.5	0.6	2.84	40 cm ice, clear 16 cm snow
2/28/71	1,520	604	40	0.8	1.06	40 cm ice, cloudy 16 cm snow
3/22/71	5,500	3,000	60	1.5	1.01	9 cm ice clear
3/29/71	4,800	4,200	86	1.3	1.31	no ice, clear

cases it was below the values obtained during the summer (1970). The low value obtained Feb. 21 was probably caused by the extreme turbidity of the water. The preceding week was rainy and drainage from the watershed had increased the amount of suspended material. The high reading was obtained Feb. 24, after most of the suspended material had settled out. The 24th was the first clear sunny day in nearly two weeks and this may have influenced the results.

The light-dark bottle method did not work well under winter conditions. In many cases we found production occurring in both light and dark bottles. Dugdale and Wallace (1968) found this occurring in their studies of arctic lakes and were unable to offer a satisfactory explanation; it is also mentioned by Vollenweider (1969) again without explanation. During the winter study a carbon 14 bottle was exposed under conditions identical with those of the light-dark bottles. When the data from the carbon 14 bottles becomes available we hope that the greater sensitivity of the carbon 14 method will allow us to present winter productivity more accurately than is possible with out present data.

Table 2 shows light transmission and primary production under various climatological conditions. March 29, was the first day ice was completely gone and was included for comparison purposes. During Feb. 2.5% to 40% of the incident radiation actually penetrated the ice and snow. The data from Feb. 21 shows that 17% of the incident radiation penetrated through 40 cm of ice, three days later only 2.5% of the incident radiation could penetrate through the same amount of ice covered with 16 cm of snow.

The large differences in light intensity recorded by the submarine photometer are a contrast to the minor variations of the Secchi disk readings. Light intensity under the ice ranged from a low of 95 foot-candles Feb. 24, to a high of 604 foot-candles Feb. 28. We found that on March 29 the 95 foot-candle level occurred at 2.5m and on April 24 it occurred at 4.5m. The 600 foot-candle level was 1.3m March 29 and 2.5m on April 24.

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