# Turbidity, Compensation Point, and Productivity

**Limiting Factors**

Limiting factors such as precipitation, temperature, and soil nutrients impact the productivity of terrestrial biomes. When any limiting factor is in short supply, productivity is reduced. The same is true for aquatic ecosystems. Light is a limiting factor in freshwater and marine ecosystems. Photosynthetic organisms require enough light to drive photosynthesis, thereby fixing carbon by taking up carbon dioxide dissolved in water and releasing oxygen as a by-product.

**Productivity**

Gross primary productivity (GPP) is the *rate* at which an ecosystem's producers convert solar energy into chemical energy. Net primary productivity (NPP) is the *rate* at which producers use photosynthesis to produce and store chemical energy *minus* the *rate* at which they use some of this stored chemical energy for their own cellular respiration (RL). NPP measures how fast producers can make chemical energy that is stored in their tissues and that is potentially available as energy to consumers in an ecosystem.

**Measuring Productivity**

Consider the equation for photosynthesis:

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$$

It is not possible to measure GPP directly. However, it is possible to measure productivity indirectly by measuring the amount of oxygen released as a by-product of photosynthesis and using a conversion factor to determine the amount of carbon that is fixed. In this case

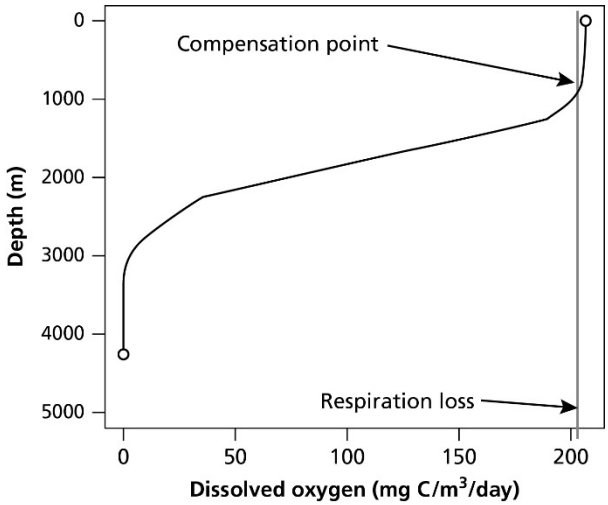
$$1\ mL\ O_2 = 0.536\ mg\ C$$

meaning that for every milligram of oxygen produced, 0.536 milligrams of carbon is fixed as part of an organic molecule. Because a *rate* is being measured, the amount of carbon being fixed is measured over a given amount of time.

**Compensation Point**

The compensation point in a pond or lake is the exact depth in the water column where the rate of photosynthesis is equal to the rate of respiration. Since light is a limiting factor, the depth at which light can penetrate to drive photosynthesis determines the compensation point. Ponds or lakes that are highly productive have deeper light penetration, and those that are less productive have more shallow light penetration. Abiotic factors such as turbidity can impact the amount of light that penetrates a column of water.

A depth profile is a graph that shows how a certain water property changes with depth. The graph is constructed to look like a cross-section of that body of water.




In this example, the property of dissolved oxygen is plotted on the *x*-axis, while depth is plotted on the *y*-axis. The compensation point is where NPP is equal to zero, or where GPP is equal to respiration loss (NPP). In this graph, it is easy to see how far light penetrates this body of water. Above the compensation point, more oxygen is produced than is used for respiration. Below the compensation point, oxygen is used up faster than it is produced, and in the benthic zone, where no light penetrates, oxygen is absent.

**Hemlock Pond**

The following data for dissolved oxygen versus depth was taken by scientists investigating the productivity of Hemlock Pond. To determine gross productivity as the amount of carbon fixed over a certain amount of time, the measured units of mL $O_2$/liter/hour must be converted to mg C/$m^3$/day. Remember that there are 1,000 liters in 1 cubic meter ($m^3$).

Example:

At the surface of the pond, the oxygen measured was 0.2 mL/liter/hour. To convert to mg C/$m^3$/day, begin first with converting the oxygen to the equivalent amount of carbon that is fixed.

$$0.2 \text{ mL } O_2 \text{/liter/hour} \times \frac{0.536 \text{ mg C}}{1 \text{ ml } O_2} = 0.107 \text{ mg C/liter/hour}$$

Now, convert the liters to cubic meters

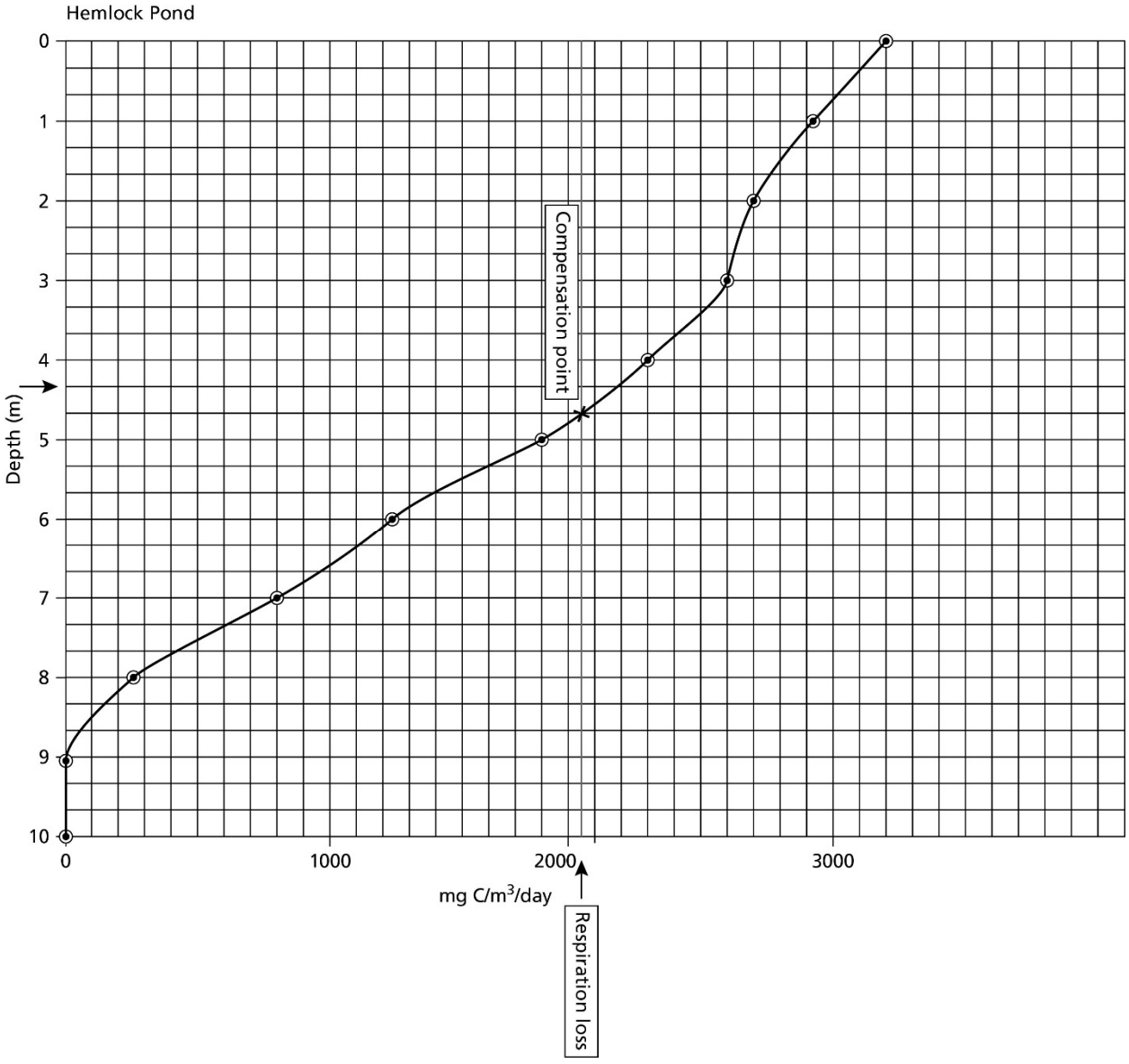
$$0.107 \text{ mg C/liter/hour} \times \frac{1{,}000 \text{ L}}{\text{m}^3} = 107.2 \text{ mg C/m}^3\text{/hour}$$

Finally, because there are 24 hours in a day

$$107.2 \text{ mg C/m}^3\text{/hour} \times 24 \text{ hours} = 2{,}573 \text{ mg C/m}^3\text{/day}$$

| Depth (meters) | Gross Productivity mL $O_2$/liter/hour | Gross Productivity mg C/$m^3$/day |
|---|---|---|
| 0 | 0.25 | 3,216 |
| 1 | 0.23 | 2,959 |
| 2 | 0.21 | 2,701 |
| 3 | 0.20 | 2,573 |
| 4 | 0.18 | 2,315 |
| 5 | 0.15 | 1,930 |
| 6 | 0.09 | 1,157 |
| 7 | 0.06 | 771 |
| 8 | 0.02 | 257 |
| 9 | 0.00 | 0 |
| 10 | 0.00 | 0 |

Respiration loss for Hemlock Pond is 0.16 mL $O_2$/liter/hour. Using the same conversion factors, this is equal to 2,058 mg C/$m^3$/day. This value is plotted as a vertical line originating at this point on the *x*-axis and intersecting the curve.


Hemlock Pond
Depth (m)
0
1
2
3
4
5
6
7
8
9
10
Compensation point
0
1000
2000
3000
mg C/m3/day
Respiration loss