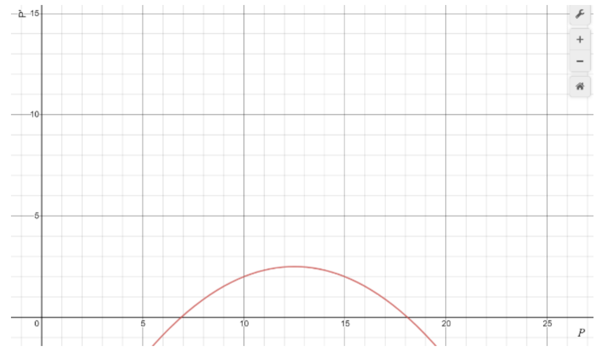
In tackling this problem, we began by altering our model equation to incorporate harvesting, k. Subtracting k from the population growth portion of the equation means that it can only be defined with positive values. If k could be negative values, then we would no longer be removing fish from the population but adding fish and that does not make sense in the context of a harvesting variable. That being said, k in this equation is a constant, unaffected by the dependent variable, P. This means that as k grows larger, it shifts the graph down [see below].

$$\frac{dP}{dt} = 2P(1 - \frac{P}{25}) - k$$

Population Rate of Change v. Population [k-value of 0]



Population Rate of Change v. Population [k-value of 10]

Since our model equation is a rate of change function, the points at which P' ($\frac{dP}{dt}$) is equal to zero are the points at which the population is not changing. In the examples provided, if there is no harvesting occurring, ergo a k-value of 0, the model is equal to zero when P is equal to zero and when P is equal to 25. This means that if the population of fish in the hatchery is zero or twenty-five thousand, then the population will not change until fishes are added or removed.

Continuing with the example of a k-value of 0, if the population were to be somewhere in between zero and twenty-five thousand then the population would increase until it reaches a population of twenty-five thousand. We know this because between P=0 and P=25, the rate of change function lies above the P-axis, meaning its positive and a positive rate of change means growth. Since we know that the population cannot change on its own at P=25, that means that once the population grows to that amount, it will stop.

If the population were to be over twenty-five thousand (P>25), we can see that our model lies below the P-axis, meaning a negative rate of change which would mean that the population would decrease. Again, since we know that the population cannot change on its own when it is equal to twenty-five thousand, once it reaches that value it will stop.

Recall from before, as the harvesting rate grows, our model is shifted down. Additionally, note that our model is just a downward facing parabola. Using this information, we can see that as we increase the harvesting rate, the points at which our population stops growing approach each other and given a high enough harvesting rate, will vanish entirely. This can be visualized using our other example graph for a k-value of 10. Increasing k to 10 resulted in more of the model to lie underneath the P-axis, meaning fewer population sizes that could survive that harvest rate. If you continue to raise k beyond this, there will eventually be a k-value at which the two unchanging populations will be equal. Any k-value higher than that and the model equation will lie entirely under the P-axis meaning a negative rate of change no matter the population size, which would result in eventual depletion of the fish in the hatchery.