**QR GOALS#1:** (Knowledge and Conceptual Understanding): From a given real life data set of population (such as graphs, tables or charts), create the corresponding model of first order differential equation (such as modeling fish harvesting, logistic population growth or heat transfer etc.). Students will be able to extract relevant information to construct the differential equation modeling the given problem. Students will be able to solve the constructed differential equation.

**CORRESPONDING QR LESSON:**

Please look at the table below. This table shows the population, in thousands, of harbor seals in the Wadden Sea over the years 1997 to 2012.

| **Year** | **Seal Population (Thousands)** | **Year** | **Seal Population (Thousands)** |
| --- | --- | --- | --- |
| 1997 | 3.493 | 2005 | 19.590 |
| 1998 | 5.282 | 2006 | 21.955 |
| 1999 | 6.357 | 2007 | 22.862 |
| 2000 | 9.201 | 2008 | 23.869 |
| 2001 | 11.224 | 2009 | 24.243 |
| 2002 | 12.964 | 2010 | 24.344 |
| 2003 | 16.226 | 2011 | 24.919 |
| 2004 | 18.137 | 2012 | 25.108 |

Answer the following questions:

1. Calculate the rate of growth for each year starting from 1997. Looking at these rate of growth, do you think this population data may satisfy a logistic population growth? Why or why not?
2. Find a logistic population model which will fit the given data set? Use the help of a graphing calculator as needed.

**QR GOALS#2:** (Thinking and Other Skills): After finding the solution of the differential equation (from above), students will be able to explain/analyze how accurate the model is compare to the actual real life situation (error analysis).

**CORRESPONDING QR LESSON:**

We are continuing with the same question:

1. Look carefully on the logistic model that you gave found in number 2 and the actual data given in the table. Make some comment on how close do you think the logistic model fit the actual data? There were many ways you can do this. For example, you can find the derivative of your model at some given point (for example at 2001, 2005, 2008 etc) and compare this with the growth rate you have found in number 1.
2. What happen if you only use the data from 1997 to 2006 instead of all the data up to 2012? In other word, create another logistic model using only the data from 1997 to 2006. Then use your model to find population from 2007 to 2012 and compare them with the actual population. What goes wrong? Is there any difference between these two models?

**QR GOALS#3** (Attitudes, Values and Habits of Mind): When modeling real life application problems (mentioned above), students will be able to predict the future (for example estimate the population of certain country in 1940 etc.). This will show students the power and importance of differential equation (or in general mathematics) in everyday life.

**CORRESPONDING QR LESSON:**

We are continuing with the same question:

1. Using the logistic model that you have found in question number 2, find the estimated population of the seal in 2030? In 2050? Does it make sense? Think about some of the fact we have learned in general about logistic population growth.
2. In real life, many factor can contribute birth and death rate of seal population. For example a sudden change in the environment, food shortage etc. Think about at least three other situations which may affect the logistic model of seal population.