1. **(1 pt) mathbioLibrary/setABiocLabs/Lab121_J3_plankton.pg**

Because of the accuracy of WebWork, you should use 5 or 6 significant figures on all problems.

Since the death of Sonny Bono, there has been renewed interest in the Salton Sea. The Salton Sea formed from 1905-1907 when an engineering mistake plus heavy rains on the watershed of the then undammed Colorado River combined to break through a levee. The lake was originally freshwater but became saltier than seawater as there is no outlet and a lot of evaporation. The water going into it is fairly salty (leached from the agricultural soils). The creatures in it are mostly marine, some introduced on purpose and some accidentally with the establishment of a sport fishery. If it weren't for the agricultural and municipal wastewater flowing into the Sea, it would have dried up long ago. This water also has a lot of fertilizers, which cause massive algal blooms, and a large biomass of invertebrates and fish. People like to fish there because it is so easy to catch fish, but there are also large fish kills, which are NOT pleasing. There are many birds at the Sea (there's lots of food for them), but they also experience large die-offs at times from avian epidemics (crowding).

There are not very many kinds of metazoan zooplankton (6) in the Salton Sea, but often there is a high density present. Dr. Debbie Dexter (retired SDSU) was studying marine invertebrates in the Salton Sea, and a presentation of some of her work can be found on the second floor of the Life Sciences building. Mary Ann Tiffany provided the background information above and the data below on some of the zooplankton.

The table below lists the number/liter of various zooplankton for data averaged over depth for station S-1 (in the center of the north basin of the Salton Sea at a depth of 14 meters). The first column lists the number of days after January 1, 1997 when the data were taken. The second column represents the rotifer, *Brachionus rotundiformis* , the third column represents the nauplius form of the barnacle (*Balanus amphitrite*) larvae, and the last column is the nauplius form of the copepod, *Apocyclops dengizicus* .

Date	Rotifers	Barnacles	Copepods
21	0.045	4.466	0.06
34	0.047	2.04	0.063
53	0.073	0.7	0.102
78	0.167	0.573	0.251
106	51.785	0.295	0.093
154	182.403	0.035	45.687
175	372.655	0.031	50.25
199	295.288	0.035	14.56
225	802.128	0.039	59.539
249	532.203	0.031	21.629
277	33.723	0.031	2.992
311	9.245	0.056	4.551
329	0.93	0.149	1.65
371	0.047	0.491	0.144
402	0.081	1.618	0.159
423	0.178	1.925	0.097
454	5.826	0.408	0.08
479	299.183	1.923	0.08

a. In your Lab Report, create a separate graph for each of these species in Excel using a logarithmic scale for the population. Determine the season of the year when each of these species is most productive.

Peak season for rotifers is (Winter, Spring, Summer, Fall) ____

Peak season for barnacles is (Winter, Spring, Summer, Fall) ____

Peak season for copepods is (Winter, Spring, Summer, Fall) ____

b. As seen in the graphs above, the populations of these zooplankton have very large changes in numbers from very low densities to relatively high densities. Without a logarithmic scale these fluctuations in population appear to jump rapidly between high and low densities. It follows that to fit a polynomial through the data we need to use the natural logarithms of the data.

Take the natural logarithm of the data for Barnacles, then plot these values against time. Use Excel's Trendline to find the best fourth order polynomial through the logarithm of the data versus time. (Be sure to have at least 5 significant figures for your coefficients.) The polynomial has the form:

$$P(t) = a_4t^4 + a_3t^3 + a_2t^2 + a_1t + a_0.$$

List the values of the coefficients that Trendline gives you:

$a_4 =$ ____

$a_3 =$ ____

$a_2 =$ ____

$a_1 =$ ____

$a_0 =$ ____

Use this polynomial to approximate the population at $t = 106$, then determine the absolute error. Find the polynomial value and the corresponding population (which requires conversion from the natural logarithm).

$P(106) =$ _____

Population at $t = 106$ is _____

Absolute Error is _____

Find the polynomial value, population, and absolute error at $t = 199$.

$P(199) =$ _____

Population at $t = 199$ is _____

Absolute Error is _____

Find the polynomial value, population, and absolute error at $t = 311$.

$P(311) =$ _____

Population at $t = 311$ is _____

Absolute Error is _____

c. In your Lab Report, create the graph of the natural logarithm of the data for Barnacles and show the Trendline passing through this graph. Describe how well the polynomial fits the data. Briefly discuss the seasonal variation in the population for Barnacles.

d. Differentiate the polynomial found in Part b. The derivative will have the form:

$$P'(t) = b_3t^3 + b_2t^2 + b_1t + b_0.$$

List the values of the coefficients for this derivative:

$b_3 =$ _____

$b_2 =$ _____

$b_1 =$ _____

$b_0 =$ _____

A quartic polynomial has three minima and maxima. Find when these minima and maxima occur and state the value of $P(t)$ and the populations at these extrema. Assume the minima and maxima occur at times $t_1 < t_2 < t_3$.

$t_1 =$ _____

$P(t_1) =$ _____

Population at t_1 is _____

What type of extremum is this? (Maximum or minimum) _____

$t_2 =$ _____

$P(t_2) =$ _____

Population at t_2 is _____

What type of extremum is this? (Maximum or minimum) _____

$t_3 =$ _____

$P(t_3) =$ _____

Population at t_3 is _____

What type of extremum is this? (Maximum or minimum) _____

The Salton Sea provides a valuable place for birds to congregate on their migrations. A maximum would be a good time for birds to feed at the Salton Sea. If January 1 corresponds to $t = 0$, then find the date that the maximum population of Barnacles occur (in the form MM/DD). Use only the maximum that occurs within the range of the data and assume there are 365 days in the year.

Date of the Maximum population = _____

e. In your Lab Report, write a brief paragraph discussing how well the derivative of the polynomial finds the actual maximum and minimum populations both in time and number. Does this provide a reasonable way to model this complex ecosystem?