Protection Island - SOLUTIONS

1. Census is in October-November: fall. This is after the breeding season, and so the number of eggs/chicks that survive to the next census should be relatively close to 1.
2. I assume the 35 count occurred on May 1938.
3. d = 17/110. This assumes that the mortality between the 1938 and 1939 census reflects the mortality for all years.
4. b is defined as the number of chicks per adult surviving to the census in October-November. g. suggests 8.73 x .645 = 5.63 eggs hatching per nest, however, this is larger than the number of chicks per clutch reported in h. f. suggests 5.86 x .836 = 4.90 eggs hatched per nest. I have ignored h. because it is the higher g. and, therefore, less likely to include post-hatching survival of chicks. b should be constant across years so we will take the average of b calculated in 1938 and 1939 from f. and g. Let n be the number of individuals per nest. We will assume n = 2, however, as the population is polygamous this is not clear.

   b_{1938} = 5.63/n = 2.815 eggs hatched per individual in 1938

   b_{1939} = 4.90/n = 2.45 eggs hatched per individual in 1939

   b = (2.815 + 2.45)/2 = 2.63 eggs hatched per individual, which is assumed to be equal to the number of chicks per individual that survive to census.

5. $\lambda = 1 + b – d = 1 + 2.63 – 17/110 = 3.48$. Increasing.
6. I want to compare observations to model predictions, however, the observed population size data is limited and the 1937 and 1938 population size observations are from May. I will define N_0 as October 25, 1937 and approximate this value from the data. October is 5/12 of a year later than May. The per year change in population size from 1937 to 1938 is 35-10 = 25. Using a linear approximation, my approximated population size on October 25, 1937 is N_0 = 10 + 25 x 5/12 = 20.4 individuals.
7. N_1 = 3.48 x 20.4 = 71: October 1938 (actual size: ~110 birds)

   $N_2 = 3.48^2$ x 20.4 = 247: October 1939 (actual size: ~400 birds)

   The predictions are underestimating the true population size, a larger value of N_0 might correct this, however, the data are lacking and the model is a simplification so there is little to be gained from calibrating either for a perfect fit. Reasons of lack of fit may be geometric growth assumptions not met: non-deterministic births and deaths, polygamy, year-to-year variation in births and deaths, resource limitation, predator-prey dynamic, age-specific survivorship and reproduction.
8. t = Ln(1000/20.4)/Ln(3.48) = 0.777/0.249 = 3.12 years after October 25, 1937, i.e. the population should be near 1000 at the 1940 census (log to the base 10 or base e yields same result). Due to the reproductive ecology the population cannot be large in December than it is in October, so it doesn't make sense to predict the population will eclipse 1000 in December 1940 if it hadn't already in October 1940.
9. Doubling time Ln(2)/Ln(3.48) = 0.56 years. Assumes geometric growth, i.e. no resource limitation.