

**Explore & Explain: Graphing Population Growth**

A census is a population survey, which records the number and type of individuals.

Dr. Hyrenbach has been censusing the FSP Wedge-tailed Shearwater population since 2009. The tables below show the number of active nests from 2009-2019 during the incubation period (July 14) and the chick-provisioning period (September 14). Active nests consist of incubating adults (with an egg) and chicks (with or without a parent). Remember: a pair of shearwaters in one nest only lay one egg, and can only produce one chick per year. Follow the directions to learn more about the shearwater breeding season and about how their numbers have changed over time at the preserve.

1. **Incubation survey**: Performed yearly, on July 14.

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Active Nests (Total)** | **Incubating Adults****(your symbol: \_\_●\_\_\_)** | **Chicks Alone****(your symbol: \_\_○\_\_)** |
| 2009 | 106 | 106 | 0 |
| 2010 | 78 | 78 | 0 |
| 2011 | 138 | 138 | 0 |
| 2012 | 182 | 182 | 0 |
| 2013 | 201 | 201 | 0 |
| 2014 | 216 | 216 | 0 |
| 2015 | 268 | 268 | 0 |
| 2016 | 226 | 226 | 0 |
| 2017 | 273 | 273 | 0 |
| 2018 | 309 | 309 | 0 |
| 2019 | 318 | 318 | 0 |
| **TOTAL** | **2315** | **2315** | **0** |



1. **Chick-provisioning survey**: Performed yearly, on September 14.

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Active Nests (Total)** | **Incubating Adults****(your symbol: \_\_●\_\_\_)** | **Chicks Alone****(your symbol: \_\_○\_\_)** |
| 2009 | 71 | 0 | 71 |
| 2010 | 61 | 0 | 61 |
| 2011 | 66 | 0 | 66 |
| 2012 | 137 | 0 | 137 |
| 2013 | 175 | 0 | 175 |
| 2014 | 126 | 0 | 126 |
| 2015 | 84 | 0 | 84 |
| 2016 | 91 | 0 | 91 |
| 2017 | 145 | 0 | 145 |
| 2018 | 217 | 0 | 217 |
| 2019 | 218 | 0 | 218 |
| **TOTAL** | **1391** | **0** | **1391** |



**Directions for Calculating Nesting Success**

To quantify how well shearwater reproduction has gone in different years, researchers compare the number of active nests in July (the incubation period) and in September (the chick-rearing period) of the same year. Because the number of active nests in July varies from year to year, this comparison involves calculating the percentage of the nests initially documented in the first count (July) that remained in the second count (September). Note that the number of active nests in July is always larger than in September, because some nests fail: some egg do not hatch into a chick, and some chicks die before they are counted. So, we set up the number of active nests in July as the total (100%) for that year. Then, we calculate the proportion that remain in September. For example, if there were 200 active nests in July and only 50 active nests in September, 25% (50 / 200) of nests were successful and 75% (175 / 200) of nests failed. Note, these proportions add to 100%.

Calculate the nest success rate for each year (2009 - 2019) using a calculator and the provided data sheet. Then, summarize the nest success data across all years, using four variables: the mean (the average of the data), the median (the mid-point of the data), the minimum, and the maximum. Show your work, in the spaces provided in the table below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Year ------- Active Nests**  | **2009** | **2010** | **2011** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **Average** | **Median** |
| September Count | 71 | 61 | 66 | 137 | 175 | 126 | 84 | 91 | 145 | 217 | 218 | 126.5 | 126.0 |
| July Count | 106 | 78 | 138 | 182 | 201 | 216 | 268 | 226 | 273 | 309 | 318 | 210.5 | 216.0 |
| Nesting Success (%) | **67.0** | 78.2 | 47.8 | 75.3 | 87.1 | 58.3 | 31.3 | 40.3 | 53.1 | 70.2 | 68.6 | 61.6 | 67.0 |
| Good or Bad Year? | Median | Good | Bad | Good | Good  |  Bad | Bad  | Bad  | Bad  | Good  | Good |  |  |

 **The Nesting Success for 2009 is calculated as follows:**

Nesting Success for 2009 = [(September 2009) / (July 2009)] \* 100%

Nesting Success for 2009 = (71 / 106) \* 100% = (0.67) \* 100% = 67%

**The mean nesting success is calculated as follows:**

Sum of all values, Divided by the number of values

Mean = (67 + 78 + 48 + 75 + 87 + 58 + 31 + 40 + 53 + 70 + 69) / (11) = (677 / 11) = 61.5

Maximum Value = 87 (in 2013)

Minimum Value = 31 (in 2015)

**The median nesting success is calculated as follows:**

Rank the data, by organizing the values from the smallest to the largest. 

The red values are lower than the median (BAD years)

The blue values are higher than the median (GOOD years)

The median (67.0) represents a “normal” year.

**Discussion Questions**

1. Describe how the patterns differ, in terms of the number (and proportion) of active nests with incubating adults and with chicks, between July and September.

In July, all shearwaters (100%) at the preserve are adults incubating eggs. This month is the peak of the incubation period, when one adult incubates the egg at the colony, while the other one feeds at sea.

In September, all shearwaters (100%) in the nests are adults incubating eggs. This is the peak of the chick-rearing period, when all eggs have hatched and chicks are large enough that they are less susceptible to predation by rats and cats, and are less likely to starve if food is scarce. Usually, by the time chicks survive to the middle of September, they survive to the middle of November and fledge.

1. Describe the patterns in the total number of active nests in July between 2009 and 2019.

(Hint: What year has the maximum number and what year has the minimum?)

In July, the maximum shearwater count is 318 (in 2019), and the minimum shearwater count is 78 (in 2010). Looking at these two values, it looks like the number of active nests has increased over time.

In fact, this number suggests the number has increased over three-fold: 318 – 78 = 240. 240 / 78 = 3.1

1. Describe the patterns in the total number of active nests in September between 2009 and 2019.

(Hint: What year has the maximum number and what year has the minimum?)

In September, the maximum shearwater count is 218 (in 2019), and the minimum shearwater count is 71 (in 2010). Looking at these two values, it looks like the number of active nests has increased over time. In fact, it suggests the number has almost doubled: 218 – 71 = 147. 147 / 71 = 1.9

1. How do the years with the maximum and minimum counts in July and September compare?

These years match pretty well:

2010 was the year with the minimum number of shearwaters in both July and September.

2019 was the year with the maximum number of shearwaters in both July and September.

1. Can you think of two reasons why a chick count in September could be low?

A low number of chicks at the preserve in September is the result of: (1) a low number of breeding

shearwaters in July and (2) low egg hatching and chick survivorship between July and September.

In some years, the low number of nesting shearwaters in July limits the number of chicks produced at

the preserve. 2010 is an example of a year with a low number of nesting birds and a low number of chicks.

In other years, there are high numbers of nesting shearwaters in July, but few eggs hatch and few chicks

survive by the time the September colony count takes place. 2011 is an example of a year when a large

number of shearwaters were incubating eggs in July, but few chicks were counted in September.

1. Describe the overall trend in the population, using the number of incubating adults (in July).

**NOTE for teacher:** Biologists use the number of adults at breeding colonies, rather than the number of chicks, to track population changes in seabird populations for two reasons: (1) the number of chicks produced varies due to the number of breeding adults and the survivorship of the chicks, which is related to oceanographic conditions affecting food availability and predation from introduced predators (cats, rats); and (2) when chicks leave to sea in November, they will have to survive for several years before they return to the colony, when are 5 or 6 years old. Because adults have high survivorship and can return to breed ever year, their counts provide a much more reliable perspective of the trend in the population over time. These issues can be discussed with advanced classes.

1. Does the number increase every year? Calculate the proportion of years when the number increases and use that probability to predict a population increase in the future.

The number of incubating adults in July does not increase every year. It increases in 8 of the 10 years, (except in 2010 and 2016). Therefore, 80% of the time, there is a year to year increase in the number of active nests at the preserve, based on the July counts.

The table below shows the change in the number of active nests (in July), from one year to the next. For instance, there were 106 nests in 2009 and 78 nests in 2010. The change in the number of nests was negative: 78 minus 106 = -28. In 2010 there were 28 fewer nests than in 2009.

|  |  |  |  |
| --- | --- | --- | --- |
| **Year** | **Active Nests** | **Calculation** | **Change** |
| 2009 to 2010 | 78 | 78 - 106 | **-28** |
| 2010 to 2011 | 138 | 138 - 78 | **+60** |
| 2011 to 2012 | 182 | 182 - 138 | **+44** |
| 2012 to 2013 | 201 | 201 - 182 | **+19** |
| 2013 to 2014 | 216 | 216 - 201 | **+15** |
| 2014 to 2015 | 268 | 268 - 216 | **+52** |
| 2015 to 2016 | 226 | 226 - 268 | **-42** |
| 2016 to 2017 | 273 | 273 - 226 | **+47** |
| 2017 to 2018 | 309 | 309 - 273 | **+36** |
| 2018 to 2019 | 318 | 318 - 309 | **+9** |
| **Average** |  |  | **+21.2** |

Overall, with 11 years we have 10 steps from one year to the next.

Out of these 10 year-to-year changes, 8 were positive (increases) and 2 were negative (decreases)

The probability of a yearly increase is 8 / 10 = 80%.

The probability of a yearly decrease is 2 / 10 = 20%.

The probability of a stable population, with no change is 0 / 10 = 0%.

1. Calculate the average number of active nests added every year, to estimate how many active nests we would expect to have in the future. Calculate the minimum and the maximum number of active nests added every year, to consider the possible population changes from year to year.

 Minimum number of active nests added per year = -48 (number declined by 48).

Maximum number of active nests added per year = +60 (number increased by 60).

The average number of active nests added per year = +21.2 (number increased by 21.2).

Therefore, on average, we increased 21.2 active nests each July, even though some years there were larger increases (up to 60 nests) and in other years there were declines (up to 48 nests).