Last chance to see? - Analysis of temporal changes of the Atlantic puffin (*Fratercula arctica*) population at Jersey, Channel Islands

Introduction

Picture 1 *Atlantic puffin photograph by Nicolas Guillod.*

The Atlantic puffin (*Fratercula arctica*) is an iconic bird occurring on the English Channel Islands as one of the southernmost populations worldwide. The colonies breeding on Jersey and the other Channel Islands belong to the English-Channel or French-Atlantic sub-population (Young & Harding, 2008).

Puffins spend the winter at sea and come ashore to breed in colonies. Usually they arrive in the Channel Islands around April and leave again around July (Dobson, 1952; Young & Harding, 2008; Miles *et al*., 2015). These seabirds have a slow reproductive cycle, as they are not fertile until six years of age, and then only lay one egg per year. Typically, for breeding, puffins return to the sites where they hatched by themselves (Durant *et al*., 2004) and Jersey, therefore, plays an important role for the annual life-cycle of this sub-population.

Although there are still good numbers of puffins globally it is listed as Vulnerable with a decreasing population-trend according to the IUCN Red List of Threatened Species (BirdLife International, 2015). Since none of the sub-populations are listed separately, it is highly possible that the French-Atlantic sub-population is even more endangered. Annually, about 580,799 pairs breed in the entire United Kingdom, Isle of Man and Channel Islands (RSPB, 2015). Nevertheless, the numbers of the French-Atlantic sub-population are relatively low and have shown a continuous decrease during the 20th Century (Hooper, 2006). In the report “Conservation Status of Jersey’s Birds” the puffin is listed as BDp Severe breeding Population Decline, as it shows “a severe decline in the Jersey breeding

population size, of more than 50% over 20 years (...)". Additionally it is considered as a BR Rarity, meaning a "Jersey typical breeding population of less than 20 pairs (…)" (Young *et al*., 2011).

The reasons for the puffin's decline on Jersey since the past century are not completely understood and may vary with location. Several causes may play a role in the decrease of this sub-population: Puffins usually nest on offshore-islands free of mammalian predators. Most of the introduced mammalian predators, like the Norway or brown rat (*Rattus norvegicus*), black or ship rat (*R. rattus*), domestic cat (*Felis catus*) or American mink (*Mustela vison*), are good climbers and can also reach the puffins' nest-holes on steep cliffs. The puffin is, therefore, especially vulnerable to these invasive species (Young & Harding, 2008). Also native seabirds like herring gull (*Larus argentatus*), lesser black-backed gull (*L. fuscus*) and great black-backed gull (*L. marinus*) might be a cause of puffin declines due to competition by kleptoparasitism or direct predation (Finney *et al*., 2003; Young & Harding, 2008).

Direct human disturbance by tourism and general boat-traffic at the breeding sites might play a role in decrease of breeding-rates as well (Newsome *et al*., 2005; Young & Harding, 2008; Curtin *et al*., 2009). In Newfoundland-populations, Rodway *et al*. (1996) found that productivity of pufflings (puffin chicks) was reduced by 38% in anthropologically disturbed areas compared to undisturbed ranges. This was mainly caused by abandoning eggs before hatching in the disturbed areas. Moreover, effects of the disturbance were found to persist through the following year. However, there is contradictory evidence: after a tourist-hotspot around the puffins' nesting sites at Jersey (Plémont Holiday Village) was closed in 2000, a recovery of the population was not seen (Young & Harding, 2008). This might be an indication that human-presence had little or even no effect on the Jersey-population.

Indirect impacts like climate change cause loss of the puffin's food supply in many colonies (Durant *et al*., 2003; Harris *et al*., 2005). Also, in the English Channel, rising temperatures and other indirect factors like pollution of the sea may play an important role as well. Moreover, one particular fish species, snake pipefish (*Entelurus aequoreus*) has increased in number in the region around Jersey and may have been fed to nestlings, as has been recorded in UK, Norway or Iceland for instance (Harris *et al*., 2006), although it is inedible for puffins (Young & Harding, 2008). Instead, herring (*Clupea harengus)*, capelin (*Mallotus villosus)*, or sandeel (*Ammodytes* spp.) should actually form their main diet (Barrett *et al*., 1987).

Historically there may have been a population-size of 200-300 pairs on Jersey during 1911-1914, which decreased rapidly from 1915 to only 20 pairs (Dobson, 1952) and as few as two individuals at the time of writing (JerseyBirds, 2015).

This essay focusses on recent temporal changes to identify of the current status of the Atlantic puffin population on Jersey, as it has been done by Eaton *et al*. (2009) on several other bird species.

Assuming that climate change may play an important role for the puffin's decline, temperature was correlated to the population size.

Methods

Because of their relatively small colony-size and the fact that Jersey puffins use rock-holes instead of self-burrowed nests, it is hard to apply common survey-methods such as quadrat- or transect-sampling. Therefore, only direct counts as an estimation-method is practicable in this region. The counting includes individuals swimming on the sea below the nesting-sites or flying towards their nests (Young & Harding, 2008). Only data collected using this method was considered for the following analysis. Data on the Jersey puffin-population in 1998-2015 was provided by Dr G. Young, Conservation Biologist at Durrell Wildlife Conservation Trust.

To identify whether climate-change affects the population size in puffins, temperature has been used as an indicating factor. Puffins usually start breeding around April (Dobson, 1952; Miles *et al*., 2015). Therefore, temperature was taken from the previous months (January and March), assuming that temperature before the beginning of egg-laying-season effects the reproduction-rates.

Population size was compared to both sea- and air-temperature per particular year. The sea-temperature was obtained at St Helier Harbour, while air-temperature was taken from Maison St. Louis Observatory, Jersey. The mean-temperature of the month per year was measured in °C. Data was provided by the Meteorological Section - Department of the Environment, Jersey.

To check for potential correlation of both variables, a Pearson-test was carried out. To visualise the results, a scatterplot graph was created and the value of R^2 was calculated.

Results

Figure 1 shows the change in population-size during the study-period. The counting-records gave an 18-year mean of 12.33 birds.

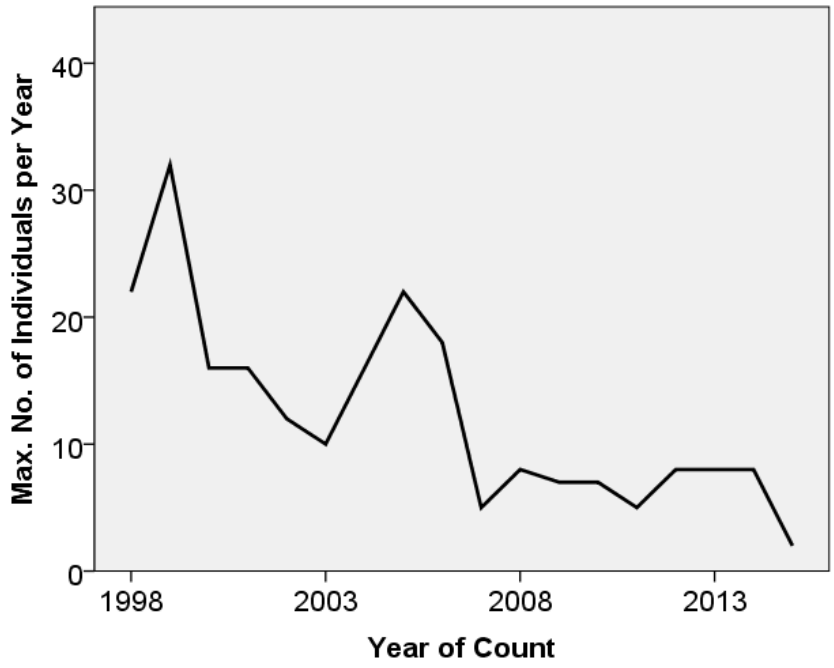

Figure 1 *Population-development of Atlantic puffin on Jersey between 1998 and 2015.*

Table 1 shows the results testing the hypothesised factors for Pearson-Correlation and Regression-Analysis.

Table 1*: Test results of correlation tests between the maximum number of Atlantic puffin individuals per year (1998-2015) on Jersey and temperature using Pearson-Correlation and Regression-Analysis.*

Factors	Sig.	Pearson Correlation	Regression Analysis
No. Individuals, Air-Temp. March	P=0.867	r_{18}=-0.091	y=0.308x+9,633; $F_{1,16}$=0.029; R^2=0.002
No. Individuals, Sea-Temp. March	P=0.721	r_{18}=-0.091	y=-0.828x+19.454; $F_{1,16}$=0.132; R^2= 0.008
No. Individuals, Air-Temp. January	P=0.649	r_{18}=0.115	y= 0.687x+7.501; $F_{1,16}$=0.215; R^2= 0.013
No. Individuals, Sea-Temp. January	P=0.727	r_{18}=0.088	y=0.873x+4.542; $F_{1,16}$=0.126; R^2=0.008

The graphs in **Figure 2** visualise the above findings.

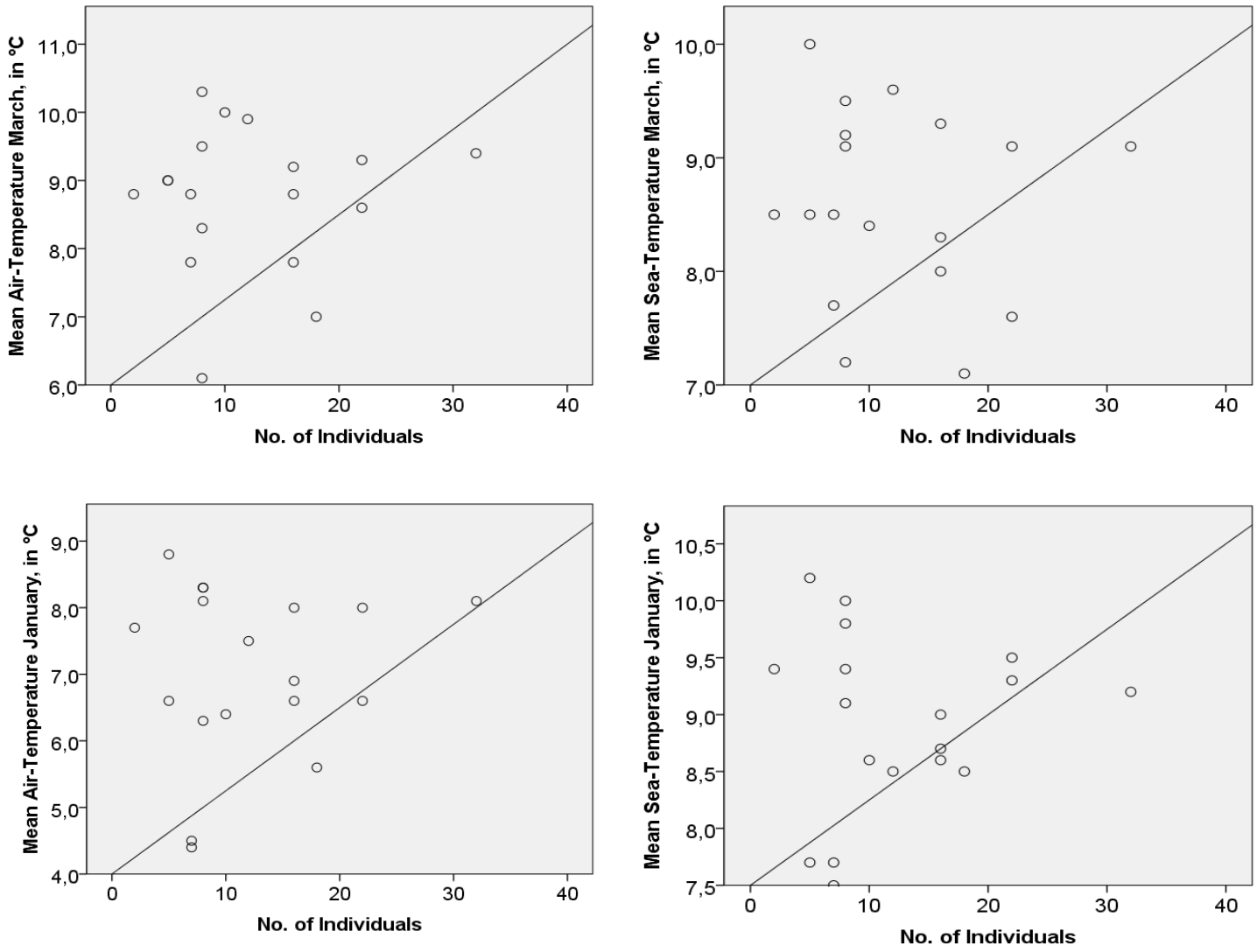

Figure 2 *Scatterplots of maximum number of individual puffins counted on Jersey per year (1998-2015) and mean sea-/air-temperature in March/January before breeding season.*

Discussion

The methodology used to estimate the number of puffins between 1911- 1915 is undocumented and unlikely to be based on scientific evidence. However, the records of the high numbers in 1911-1914 and the drastic decline in 1915 were both collected by the same person (Roderick Dobson: Dobson, 1952). Therefore, although the accuracy of the exact numbers is questionable, it can be assumed that there were high numbers of puffins present at Jersey, which then had a drastic decline. However, the reason for such a dramatic decline within only four years remains unknown.

The usage of the direct-counts-method was only established during the past 18 years. To prevent any bias, older data has, therefore, been ignored, and exclusively data obtained by the direct-counts-method has been analysed. It was expected to find a negative correlation of temperature on number of individuals. As this hypothesis could not be proved, it is suggested to repeat analysis based on a bigger time-frame than 18 years.

There remain concerns about the direct-counts-method. The maximum numbers of birds have not always been counted at the same time of the year. In addition, it is possible that non-breeding animals were included in the counts, as the applied method was forced to count all individuals, not just breeding-pairs.

The numbers from 1998-2006 show no clear trend, but from 2007 on numbers are obviously declining (see **Figure 1**). Most striking is that, while the first half of the counting period gives a yearly mean of 18.22 puffins, the total counting-period gives an 18-year mean of only 12.33 birds. One reason for the decline might be linked to old-age of the individuals at Jersey, which do not reproduce anymore. The slow speed of decline might be another indicator for a non-breeding population. This allows the assumption that no more young are produced which then would return to Jersey to breed there too when turning fertile. However, the demography, survival and recruitment rates of the Jersey-population are unknown (Young & Harding, 2008), which made it hard to establish the true status of the colony and which is very relevant for such a small population. Additionally, further studies should be carried out in order to discover whether there is a link between trends of prey-species populations around Jersey and change in climate, since it is suspected that the puffins' decline may be to do with their prey availability.

Little information exists on the distribution of this colony during winter-periods (Young & Harding, 2008). Globally limited data on the non-breeding season assumes that many adult puffins die during winter months. The survival of other puffin colonies has been shown to be positively correlated to the effects of sea temperature on recruitment of their main prey species (Harris *et al*., 2005). Although this analysis did not show any correlation to temperature (see **Table 1**), the most likely factor is assumed to be the decline in food supply near breeding colonies due to warming of the sea, as Durant *et al*. (2003) found in Norwegian colonies. The puffin is known to be highly vulnerable to the impacts of climate change including rising sea-temperature and linked changes in prey-distribution and abundance (BirdLife International, 2015). Climate change as an impact on the Jersey-population should, therefore, not be ignored.

There are higher numbers counted on other, smaller, Channel Islands (see **Table 2**). Historical data even reports many thousands of birds on Alderney (Lockley, 1962). Although the southernmost

puffin-colonies are declining in number (Hooper, 2006), they are clearly bigger than the Jersey population.

Table 2 Maximum number of Atlantic puffins counted in 1999-2001. Source: Hooper, 2006.

Location	Individuals
Herm (including Jethou)	40
Sark (including Brecqhou)	50-60
Alderney (including Burhou)	220-225

Due to a higher human population-density on Jersey, the puffin's distribution might be restricted by invasive predators and human presence. Invasive mammal predators like the Norway rat began occurring on this island in the 18th century. The black rat was introduced already in Roman times (Young & Harding, 2008). Avoiding the pressure, the puffins on Jersey may be restricted to breed on sites that are harder to access by invasive mammalian predators. These alternative breeding sites are small and poor-quality areas like gaps along the cliffs instead of the commonly used burrows on cliff-tops.

However, Vík í Mýrdal, Iceland, for instance shows massive numbers of puffins, although high numbers of tourists are present there too. The birds there seem to accept the presence of people (Grant & Nettleship, 1971), which may be an indicator that direct human pressure alone might not have a great impact on the population decline on Jersey.

Conclusion

Although the Atlantic puffin is considered a flagship species of the Channel Islands, they have not been studied sufficiently and very little is known of their local ecology. The causes for the puffins' decline on Jersey are not fully identified. Although this analysis did not show any correlation to it, climate change as a factor should not be neglected as a potential main reason for the puffins' decline in the English Channel. While the puffin might have resisted only single factors causing pressure on its population, the combination of all these factors may be the causation for the eventual decline. Anthropologically disturbed areas, invasive mammalian predators, rising temperatures, decline in prey availability, and change in available fish species… summing up these factors, combined they were tough enough to effect the puffin's population in the end.

After all, few actions have been taken to conserve the colony on Jersey yet. An explanation might be the high financial expenses linked to proper management. Sustainable managed wildlife-tourism could be used to support the financial income for puffin-conservation. Also listing the sub-

populations on the IUCN's Red List, would increase the awareness and support an ongoing investigation of this issue. Global management slowing down climate change is a matter of course.

More effort should be put into the puffins' conservation on the Channel Islands, to prevent the same fate on the other islands as is happening on Jersey, where the puffin will be extinct soon.

Acknowledgements

This assessment was written for the module "Invasive Species and other Drivers of Distribution Change" as part of the Master of Science class "Animal Behaviour: Applications for Conservation" at Anglia Ruskin University, Cambridge.

I am grateful to Paul Aked, senior Meteorologist at the Meteorological Section of the Department of Environment, Jersey for providing me with data on climate.

Special thanks got to Dr Glyn Young, Conservation Biologist at Durrell Wildlife Conservation Trust, Jersey, for his motivation, support and effort by providing me with reading material, data on the puffin population, and his time for letting me interview him.

References

Barrett, R.T., Anker-Nilsson, T., Rikardsen, F., Valde, K., Røv, N. & Vader, W., 1987. The food, growth and fledging success of Norwegian puffin chicks *Fratercula arctica* in 1980-1983. *Ornis Scandinavica*, 18: 73-83.

BirdLife International, 2015. *Fratercula arctica*. The IUCN Red List of Threatened Species 2015. [online] Available at: <http://dx.doi.org/10.2305/IUCN.UK.2015-4.RLTS.T22694927A82593109.en> [Accessed 06 December 2015].

Curtin, S., Richards, S. & Westcott, S., 2009. Tourism and grey seals in south Devon: management strategies, voluntary controls and tourists' perceptions of disturbance. *Current Issues in Tourism*, 12: 1, 59–81.

Dobson, R. 1952. *The Birds of the Channel Islands*. Staples Press, London.

Durant, J.M., Anker-Nilssen, T., Stenseth, N.C., 2003. Trophic interactions under climate fluctuations: the Atlantic puffin as an example. *Proceedings of the Royal Society B-Biological Sciences*, 270 (1523), 1461-1466.

Durant, J.M., Anker-Nilssen, T., Stenseth, N.C., 2004. Regime shifts in the breeding of an Atlantic puffin population. *Ecology Letters*, 7:5, 388-394.

Eaton, M.A., Brown, A.F., Noble, D.G., Musgrove, A.J., Hearn, R.D., Aebischer, N.J., Gibbons, D.W., Evans, A. & Gregory, R.D., 2009. Birds of Conservation Concern 3 - The population status of birds in the United Kingdom, Channel Islands and Isle of Man. *British Birds*, 102: 296–341.

Finney, S.K., Harris, M.P., Keller, L.F., Elston, D.A., Monaghan, P. & Wanless, S., 2003. Reducing the density of breeding gulls influences the pattern of recruitment of immature Atlantic puffins *Fratercula arctica* to a breeding colony. *Journal of Applied Ecology*, 40:3, 545-552.

Grant, P. R. & Nettleship, D. N., 1971. Nesting Habitat Selection by Puffins *Fratercula arctica* L. in Iceland. *Ornis Scandinavica*, 2:2, 81-87.

Harris, M.P., Anker-Nilssen, T., McCleery, R.H., Erikstad, K.E., Shaw, D.N, Grosbois, V., 2005. Effect of wintering area and climate on the survival of adult Atlantic puffins *Fratercula arctica* in the eastern Atlantic. *Marine Ecology Progress Series*, 297, 283-296.

Harris, M.P., Beare, D., Toresen, R., Nøttestad, L., Kloppmann, M., Dörner, H., Peach, K., Rushton, D.R.A., Foster-Smith, J., Wanless, S., 2006. A major increase in snake pipefish (*Entelurus aequoreus*) in northern European seas since 2003: potential implications for seabird breeding success. *Marine Biology*, 151:3, 973-983.

Hooper, J. 2006. Seabird 2000: Breeding Seabirds of the Bailiwick of Guernsey 1999-2001. *Report and transactions, La Société Guernesiaise,* 26: 73-86.

JerseyBirds, 2015. [online] Available at: <http://www.jerseybirds.co.uk> [Accessed 10 December 2015].

Lockley, R.M., 1962. "Hatching time" and "Distribution". In: *Puffins*. National History Library ed. Garden City, N. Y.: Doubleday. p.92 and p.190.

Meteorological Section - Department of Environment, Jersey, 2015.

Miles, W.T.S., Mavor, R., Riddiford, M.R., Harvey, P.V., Riddington, R., Shaw, D.N., Parnaby, D. & Reid, J.M., 2015. Decline in an Atlantic Puffin Population: Evaluation of Magnitude and Mechanisms. *Plos One*, 10(7).

Newsome, D., Dowling, R. & Moore, S., 2005. Wildlife Tourism - Aspects of Tourism: 24. Channel View Publications. Clevedon.

Rodway, M.S., Montevecchi, W.A. & Chardine, J.W., 1996. Effects of investigator disturbance on breeding success of Atlantic puffins *Fratercula arctica*. *Biological Conservation*, 76:3, 311–319.

The Royal Society for the Protection of Birds (RSPB), 2015. *Puffin*. [online] Available at: <https://www.rspb.org.uk/discoverandenjoynature/discoverandlearn/birdguide/name/p/puffin/index.aspx> [Accessed 06 December 2015].

Young, G., 2015. Interviewed by Kaja Heising. (Personal communication, 01 December 2015)

Young, H.G. & Harding, P., 2008. Atlantic Puffin *Fratercula arctica* and other seabirds at Plémont, Jersey, Channel Islands. *Report to Plémont Estates Ltd*.

Young, H.G., Dryden, M. & Pinel, J., 2011. *Conservation Status of Jersey's Birds: Jersey's bird populations in the 21st Century*. Durrell Wildlife Conservation Trust, Jersey.

Appendix I- Data base

Year	Nr Puffins	Air Mar	Sea Mar	Air Jan	Sea Jan
1998	22	9,3	9,1	6,6	9,3
1999	32	9,4	9,1	8,1	9,2
2000	16	9,2	9,3	6,9	8,7
2001	16	8,8	8,3	6,6	8,6
2002	12	9,9	9,6	7,5	8,5
2003	10	10	8,4	6,4	8,6
2004	16	7,8	8	8	9
2005	22	8,6	7,6	8	9,5
2006	18	7	7,1	5,6	8,5
2007	5	9	10	8,8	10,2
2008	8	8,3	9,1	8,1	9,4
2009	7	8,8	8,5	4,5	7,5
2010	7	7,8	7,7	4,4	7,7
2011	5	9	8,5	6,6	7,7
2012	8	10,3	9,2	8,3	10
2013	8	6,1	7,2	6,3	9,1
2014	8	9,5	9,5	8,3	9,8
2015	2	8,8	8,5	7,7	9,4

Sources:

Jersey Bird Report 2007-2015. Ornithology Section, Société Jersiaise.

JerseyBirds, 2015.

Meteorological Section - Department of Environment, Jersey, 2015.

Young & Harding, 2008.