Seasonal variation in fledging age among common guillemot (Uria aalge)

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Abstract

The common guillemot (*Uria aalge*) is a good indicator species. The breeding success and development of the chicks can truly tell us a lot about change in the habitat and surroundings. A seasonal decline in fledging weight among the common guillemot chicks on Stora Karlsö has been discovered. The difference in fledging age has been proposed as one of the possible reasons for the seasonal decline of the fledging weight. Other explanations proposed are a seasonal decline in food quality or food quantity. The aim of this study is to get a better understanding of the seasonal decline in the fledging weights of the common guillemot chicks on Stora Karlsö. By examine if the observed weight decline late in the season is attributed to younger fledging age among late fledged chicks. In this study secondary data from an existing database from AukLab on Stora Karlsö was used to analyse the fledging age among 270 chicks between 2022 and 2025. In conclusion, the results of the analysis indicated that the fledging age increased later in season. Another conclusion was that the age of the chicks fledging four or more days after the average fledging date had a higher variance.

Keywords: Seasonal weight decline, Fledging weight, Baltic Sea, Stora Karlsö.

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1. Background

1.1 The Baltic Sea

Changes in the Baltic Sea due to human activity and climate change affects many creatures living in the water but it also has an impact on many terrestrial ecosystems. This is because sea and land are very interconnected, for example movements by seabirds and anadromous fish provide a transfer of nutrients from the sea to land (Doughty et al. 2015). Factors that directly affect the sea, for example the primary production, affect fish populations and indirectly seabirds which influences other organisms as well. As an example, the common guillemot indirectly affects the population of house martins on Stora Karlsö. The guillemots release a lot of nutrition in the surrounding area, which feed a lot of chironomid larvae. The house martins feed on the adult chironomids and therefore common guillemot colony help increase the population of house martins. (Hentati-Sundberg et al. 2020)

To know whether the Baltic Sea is in a healthy state or not, as well as discover new threats that arise, it is important to constantly monitor biotic and abiotic factors. One type of biotic factor is bioindicators. Bioindicators are species that are easy to monitor and that respond to changes in the environment, they are like early warning systems. Environmental stressors like water pollution or climate change can be detected by tracking population size and physical health like their weight. Bioindicators are therefore useful indicators of changes but also good indicators of whether improvement measures are working. (Power et al. 2021). One species found in the Baltic Sea that is a good bioindicator is the common guillemot (*Uria aalge*) (Power et al. 2021).

1.2 Common guillemot (*Uria aalge*)

The common guillemot (*Uria aalge)* is a seabird in the family *Alcidae* (in the tribe alcini). They are about 40-45 cm tall and have a wingspan of 60-70 cm. The common guillemot is a strong swimmer and can dive about 80 m deep to catch fish (Hentati-Sundberg, 2025 a). In the Baltic Sea they mostly eat sprat (Sprattus sprattus) and herring (Bignert & Helander 2015). Their life span is about 30 years, though individuals as old as 47 years have been recorded. The common guillemots become sexually mature at the age of 4-5 years. In May or June, the female will lay one egg, both the male and female will incubate for about one month. Once the chick has hatched the parents alternate protecting and feeding the chick for about three weeks until the chick will fledge (Hentati-Sundberg, 2025 a).

1.3 Nest leaving

There are a many different strategies among birds for timing, nest leaving and development of the chicks. (Perrins 1970). There are two main groups, altrical birds and precocial birds. The Precocial birds leave the nest early, within two days and can eat by themselves and often run. There are other birds that stay in the nest for weeks and are fed by the parents until they can fly, these are called altricial. (Sundeval 1872)

Species in the *Alcidae* family are unusual among birds in the way that their chicks depart the nest when partly grown and complete their growth at sea. Species vary widely in the timing of nest departure and there are also significant genetic, phenotypic and functional differences among individuals of the same species (substantial intraspecific variability) in fledging mass and age. Ydenberg et al (1995) suggest that the latter occurs because individual chicks adapt the timing of their departure from the nest to their specific circumstances, particularly their growth rate and hatching date. (Ydenberg et al. 1995).

Three patterns of development are exhibited in the *Alcidae*. Four species are truly precocial, 15 are semi-precocial and three show a pattern intermediate these patterns. The four precocial species all belong to the genus Murrelets (*Synthliboramphus).* The two chicks leave the nest 1-4 days after hatching at 10-15% of adult body mass. The chicks are never fed in the nest, and both parents participate in taking the chicks to the sea. (Jones et al 1987). In the semi-precocial species the young are fed in the nest by the parents until fully feathered and nearly adult size. Diverse growth rates are evident because of the parental feeding (Sealy 1973). The semi-precocial species remain in the nest for 25-60 days and fledge at 40-100% of adult mass. In most species the young are independent after fledging but in some species the young are attended by one or both parents. The chick fledges in the completed juvenile plumage, usually walking from the nest to the ocean at night.

There are also birds that have a development pattern in between the precocial and the semi-precocial, they are called intermediate species. One intermediate species is the common guillemot. The chick of the common guillemot fledges at approximately 15- 35% of adult body mass (Ydenberg et al. 1995) and at an age of 15–25 days. The chick leaves the nesting ledge by jumping down from the cliff toward the sea, so called fledging. The chick completes its development at sea accompanied by one parent, most often the male. The chick fledges in the so called “mesoptile” plumage, a juvenile downy feather stage (Ydenberg 1989) in which body and small feathers on the vings (covert feathers) are almost fully developed. While the flight feathers on the wings (remiges) and flight feathers on the tail (rectrices) show little or no growth. (Ydenberg et al. 1995).

The common guillemots’ high wing loading and parental travel time between the nest and feeding areas limit them to only being able to carry small loads of food to their young. The parents are therefore unable to rear their chick beyond a relatively small size which selects for relatively early nest leaving. Relative to the sea, mortality rates in the nest are low and relative to the nest, growth rates at sea are high. On average, larger individuals survive the juvenile period better. In deciding when to fledge the chick consequently faces a trade-off between a high survival rate but low growth rate in the nest or a high growth rate at sea (Ydenberg. 1989). The dense colonial nesting habit of the common guillemot helps to protect their young from terrestrial and aerial predation. The late chicks therefore need to fledge before the density of the colony is low (National park Alaska. 2025)

1.4 Timing

Early breeding often ensures that the period of highest energetic demand coincides with peaks in food availability (Perrins 1970). Females therefore lay their eggs as early as possible in the season (Hedgren 1979). Chicks that hatch early have a greater likelihood of survival and reproduction (Perrins 1970). Guillemots that begin breeding early in the season would therefore have a selective advantage in this context. Perrins theory provides an explanation for why the timing of breeding may influence chick development and their body mass at fledging.

1.4.1 Weight and Growth

Hedgren (1979) found that the average body mass of guillemot chicks fledging at Stora Karlsö decreased by an average of 2.6 g/day after the median fledging date. This makes the last chicks to leave the island weigh on average at least 10% less than early and peak chicks. Four days after the median fledging date the average fledging weight among the chicks decreases significantly (Hedgren 1979)

The observation that chicks of common guillemot weigh less later in the season may have several explanations. One possible explanation is that chicks from late breeding pairs fledge at a younger age and therefore have had less time for growth. An alternative suggestion is that a seasonal deterioration in food quality in combination with a decreased availability of the prey could be responsible for the lower growth rate in late chicks. Late fledged chicks may receive less food for example due to reduced parental feeding rates which may be linked to decreased resource availability later in the season consistent with Perrins theory (1970).

Within the population on Stora Karlsö the late hatched chicks do not grow as fast as those hatched early or mid-season (Hedgren 1979). Chicks that grow more rapidly than average fledge earlier and at higher weight than more slowly growing chicks. A model by Ydenberg (1995) predicts that faster growing chicks fledge at a greater mass and younger age than slower growers. (Ydenberg et al. 1995). There is equal part of the chicks with low fledging weight and high fledging weight that returns to the colony (Tärnström 2017).

1.5 Stora Karlsö

Stora Karlsö is an island on the west coast of Gotland in the Baltic Sea (57°17′08″N 17°58′21″Ö). The island has an area of about 2.5 km^2. It is a nature reserve founded in 1970 and it is an EU Natura 2000 Site (Länsstyrelsen Gotland, n.d) but it is protected privately from 1887 by Karlsö jagt- och djurskyddsförening AB (Stora Karlsö, 2023). The island has steep cliffs and a rich birdlife. One of the most studied species on the island is the common guillemot (*Uria* aalge), with research conducted from 1997 resulting in a long-term dataset.

The population of common guillemots is continuously monitored on Stora Karlsö and the population has fluctuated over time. The population estimates indicate that the numbers of common guillemots are increasing on the island and the population is now estimated at 25.000 breeding pairs in 2025 making Stora Karlsö one of Europe’s largest auk colonies (Hentati-Sundberg, 2025 a). The earlier population declines have been linked to various factors including outbreaks of avian influenza and exposure to environmental pollutions such as PCB and DDT which have been detected in eggs from the colony of common guillemots on Stora Karlsö. In addition to this, driftnet fisheries have historically contributed to increased adult mortality through bycatch in the Baltic Sea. However, in recent years the population has increased substantially. This recovery is likely driven by a combination of decreasing concentrations of some environmental toxins together with the decline and subsequent prohibition of driftnet fishing. Furthermore, stricter hunting regulations, a reduction in oil pollution and improved food availability are considered key factors underlying the population growth observed since the 1980s. (Hentati-Sundberg & Olsson 2016).

According to Hentati-Sundberg et al (2025 b) the construction of AukLab an artificial nesting facility for auks built in 2008 on Stora Karlsö has greatly facilitated research. AukLab has an outer section with 35 breeding ledges for common guillemot capable of hosting at least 300 breeding pairs and 67 nest boxes for Razorbills (*Alca torda*). It enables close observation of the birds with minimal disturbance and makes installation of technological equipment much easier which enables the collection of detailed data. On the exterior of AukLab artificial shelves for the auks are equipped with cameras, scales and microphones, allowing constant monitoring of the colony and collecting of highly precise data.

The volume of data collected is huge making manual processing almost impossible. Therefore, artificial intelligence (AI) is used to analyse data identify patterns and extract relevant clips. (Hentati-Sundberg et al. 2025 b). The number of chicks ringed and weighed varies among years with an average of 1.179 chicks processed annually between 1991-2004 (Österblom et al. 2006). Between 2005-2025 on average 2275 chicks are captured, weighed and ringed each year to maintain and expand the data series.

This extensive and detailed dataset provides the opportunity to investigate complex ecological and behavioural patterns in the guillemot population at Stora Karlsö over time. In this study the database is used to statistically examine whether chicks that fledge late in the season fledge at a younger age and therefore weigh less. Secondary data analysis from AukLab was chosen because it allows analysis of patterns across many individuals over time.

1.6 Aim

The aim with this study is to get a better understanding of the seasonal decline in the fledging weights of the common guillemot chick on Stora Karlsö. My hypothesis is that observed weight decline late in the season is attributed to younger fledging age among late fledged chicks.

2. Method

This study is based on secondary data taken from an existing database covering multiple aspects of the breeding common guillemot at Stora Karlsö. The dataset was pre-processed to include only relevant individuals. Data between 2022 and 2025 was retained since these years provided higher temporal precision than previous years. Breeding attempts with missing values in either the hatching date of the egg or in the fledging date of the chick were also removed because these were chicks and eggs that have been lost. The final dataset included only the individuals that survived all developmental stages until fledging between year 2022 and 2025.

To allow for comparison between year, the time variables were standardized, by converting calendar dates into the number of days elapsed since January 1 of the respective year.

Furthermore, the fledging age was calculated as the difference between the fledging date and the hatch date expressed in days for all the chicks that fledged 2022-2025.

To quantify relative fledging date the average fledging date was calculated for each year and the individual fledging date of each chick was compared to the average fledging date that year. The Individual fledging date was expressed as the deviation in days from the corresponding annual average. With 0 meaning a chick fledging on average fledging day that season, 1 is one day after the average and -1 is one day before average fledging date. Indicating whether a chick fledged earlier or late relative to others in the same year. This creates a scale on how many days from the average fledging date the chick fledged, in this study called relative fledging date.

2.1 Statistical analysis

The relationship between relative fledging date and chick fledging age was analysed using scatter plots with relative fledging date as the independent variable (x-axis) and fledging age (days) as the dependent variable (y-axis). The negative numbers represent the early fledged chicks, 0 meaning that the chick fledged on average fledging date that year. The relationship was investigated with a linear model with H_0 that there is no relationship between x (relative fledging date) and y (fledging age).

2.1.1 Late and early fledged

The chicks were divided into two groups, early fledged (chicks who fledged before four days after average fledging date) and late fledged (chicks who fledged four or more days after the average fledging date). Moreover, the average fledging age among early and late chicks was calculated. Furthermore, to examine if there are any difference in fledging age between the groups of late and early chicks. The two groups' fledging ages was analysed using a homoscedasticity two sampled t-test. The fledging ages of the group were tested for equality of variance with Levenes test.

All the calculations were performed using Microsoft excel and Phyton 3 including plotting and pivot tables. The code to Phyton 3 was generate with help from ChatGPT (GPT-5.3) from SciPy and NumPy for descriptive statistics.

3. Results

The relevant data in this dataset during the period 2022-2025 resulted in 270 chicks who managed to fledge from AukLab. The number of chicks in the dataset per year are presented in table 1. The average fledging date, average hatch date and average egg laying date are presented in table 2. The average fledging age among all individuals between 2022-2025 was 19.45 days.

Table 1: Number of chicks per year in the dataset.

Year	Numbers of chicks in the dataset
2025	85
2024	68
2023	64
2022	53

Table 2: Average days elapsed since 1 January each year when the egg was laid, hatched and when the chick fledged.

Year	Average egg laying date (days after 1 January)	Average hatch date (days after 1 January)	Average fledging date (days after 1 January)
2025	140.8	173.3	192.8
2024	141.8	174.5	193.3
2023	140.1	172.9	192.8
2022	137.9	170.7	192.0

The Scatter plot shows that chicks fledging later in the season was slightly older than early fledged chicks, but the linear regression was insignificant ($p = 0.139$) ($p>0.05$). See (figure 1) which does not give statistic support for a linear relationship. Moreover, visual inspections of the data (figure 1) indicated that four days after the average fledging date the fledging ages has a higher variance, some chicks are very young and some very old. Not as many around the average fledging age of 19.45 days. Both the youngest fledged chick (13 days old fledges at 4.97 days after average fledging date) and one of the two oldest chicks (27 days old fledges at 4.88 days after the average fledging date) fledges 5 days late, see figure 1.

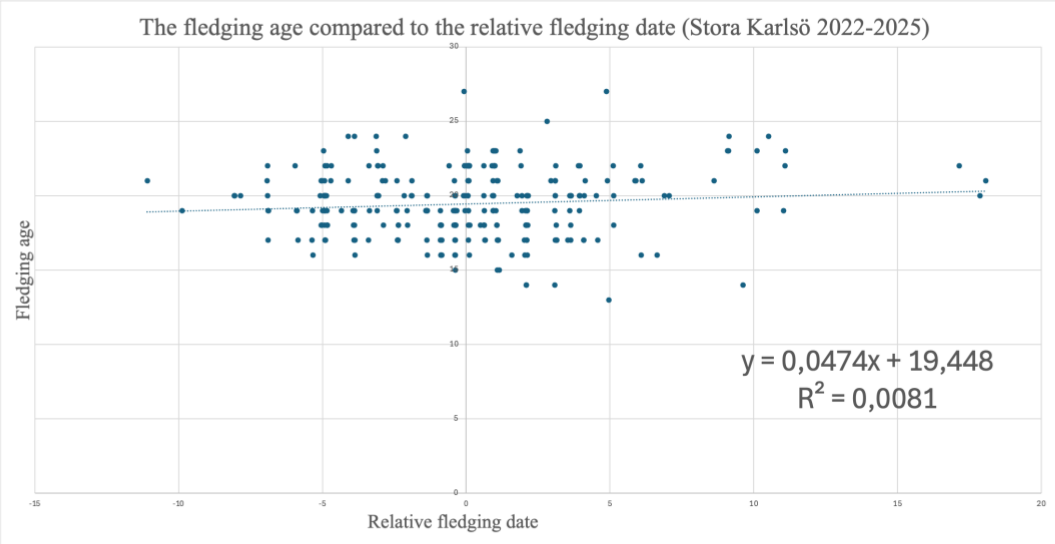

Figure 1: The diagram shows the relative fledging date and the fledging age among chicks at Stora Karlsö between 2022 and 2025.

An analysis of the two groups, late- and early fledged chicks resulted in the average fledging age of the late chicks was 20.24 ± 2.95 days. The early chicks had a lower average fledging age of 19.32 ± 2.17 days. A homoscedasticity two sampled t-test of the fledging age between the two groups was conducted. The test demonstrated a statistically significant difference of fledging age between the groups $p = 0.029$ ($p < 0.05$).

4. Discussion

This study examines if the seasonal decline in fledging weight among common guillemots on Stora Karlsö can be explained by lower fledging ages later in the season. Contrary to my hypothesis, I found that from approximately four days after the average fledging date a significant age difference becomes evident. The average fledging age for the late chicks was 20.24 ± 2.95 days while the early chicks had a lower average fledging age of 19.32 ± 2.17 days. The t-test between the two groups' fledging ages resulted in statistically significant result. The significant result means that beyond four days after average fledging date the chicks were generally older. Furthermore, after four days the fledging ages had a higher variance, that is very low and high values among the late fledged chicks. One of the oldest and the youngest chick both fledged five days late. This aligns with a pattern in fledging weight. According to Hedgren (1979) daily average weight showed higher variance and in general showed a progressive decline among chicks that fledged four or more days after average fledging date. Both the fledging ages and the fledging weights had a higher variance four or more days after the average fledging date. Also, a decline in fledging weight and an increase in fledging age was visible.

The slightly higher fledging age for late chicks may be explained by Ydenberg et al (1995). Ydenberg explains that chicks that grow more rapidly than average fledge earlier and at higher mass. This aligns with the results from this study that the fledging age is a little higher for the late fledged chicks. This implies that the chicks with slower growth rate fledge later and weigh less. Within the population on Stora Karlsö the late hatched chicks do not grow as fast as those hatched early or in mid-season. (Hedgren 1979). In line with Perrins (1970) early chicks have an advantage because the higher energy demand more likely matches with a peak of food availability. Therefore, the later chicks should fledge at a higher age and at a lower weight. So, if the ones with faster growth fledge at a higher mass, a lower age and early combines with that the ones fledging late should have a lower growth rate, fledge at a lower weight and higher age.

The lack of statistical significance in the regression analysis is likely attributable to the high variance observed in the data. Among late hatching chicks there appears to be substantial variation in age. Some of the chicks are relatively young and leave the nest at an early age, while others grow more slowly. The latter of the two reach an older age and fledge at a later stage but still have a lower body mass. This heterogeneity in developmental timing results in a wide spread of ages among late fledged ones. This agrees with Hedgren (1979) daily average fledging weight became more variable and in general showed a progressive decline (Hedgren 1979) the fledging ages become more variable and so do the weight. But showed a slightly decline in weight in line with a slightly higher fledging age. Thereby increasing the standard deviation and reducing the likelihood of detecting a linear statistically significant relationship.

According to Ydenberg (1989) relative to the sea, mortality rates in the nest are low while growth rates at sea are higher. I believe this inference depends on time as well. The dense colonial nesting habit of the common guillemot helps to protect their young from predation. When most of the colony have left the shelf the chicks that are still there are more vulnerable for predation. (National Park Alaska. 2025). My proposal is therefore that at the end of the season, four or more days after the average fledging date the dense in the colony is lower and therefore the risk of predation increases. This makes the shelfs probably less safe and it may be more beneficial for the survival of the chick to fledge. Ydenberg (1989) writes that larger individuals survive the juvenile period better. Because of the common guillemots' high wing loading and parental travel time between the nest and feeding areas limits them to only being able to rare them to certain weight. (Ydenberg 1989). To avoid predation and to increase growth rate the chicks need to fledge. Consequently, all chicks must leave the nest for survival. The too young fledges at a low weight because they have not had enough time to grow in the nest and the older, with lower growth rate need to fledge to avoid predation. This can be an explanation to why the fledging ages have a higher variance among the late fledged chicks.

4.1 Conclusions and further recommendations

This study contributes valuable insights, but further studies are required to better understand the results. Such as if there is any difference in survival and breeding rate between early and late fledged chicks and if fledging weight have any influence. Further examinations about the common guillemot's food, does the food quality or quantity decrease during the season and does this have any influence on the later hatched chicks' development. It would be valuable to research whether the older or the younger late fledged chicks are the ones that contribute most to the decline in fledging weight. According to Tärnström (2017) equal part of the chicks with low fledging weight and high fledging weight return to the colony. Although Ydenberg (1989) writes that the chicks with higher fledging weight have a higher survival rate. Based on this, a higher amount of the heavier chicks should be surviving and therefore these birds should constitute a larger proportion of the returning birds to the colony. An explanation may be that the faster grown chicks for example to a greater extent search for or start new colonies, while the surviving slower grown chicks tend to go by the safe card and return to the colony. This would make the same number of guillemots from the early and late fledged chicks return to the nest next year.

Because of the high variance of weight and age among the late fledged chicks it would be interesting to link the weight to the age with an individual. And by that examine if the age and weight are related. This would lead to a better indication of whether the older or the younger chicks are the ones contributing the most to the seasonal decrease in fledging weight. Moreover, I think it would be interesting to investigate the connections between chick and parents for example if the parents to the late fledged chicks, fledged late as well or are the parents of late fledged chicks more likely to be inexperienced.

In conclusion, contrary to the hypothesis the analysis of the data indicates that there is a weak correlation that the common guillemot chicks that fledge later in the season have a slightly higher fledging age. Another conclusion is that the fledging ages had a higher variance later in season. The fledging ages can be a part of an explanation to describe the seasonal decline in fledging weights among common guillemot chicks on Stora Karlsö. But further research is needed to get a better understanding of other factors which affect it.

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