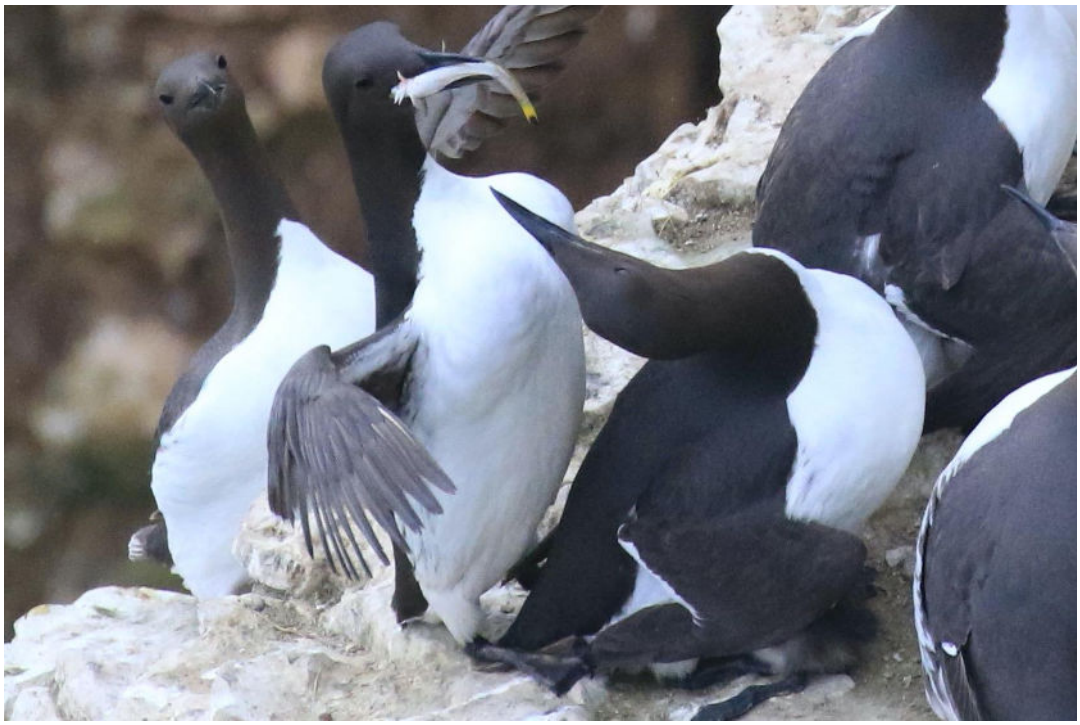
Chick provisioning of Guillemot *Uria aalge* and Razorbill *Alca torda,* in the Flamborough and Filey Coast SPA seabird colony, England, in 2023



Keith Clarkson

Summary

The Flamborough and Filey Coast SPA supports the largest mainland Guillemot and Razorbill colony in the UK. Both species have undergone dramatic population increases in the colony during the last fifty years.

In 2023, observations of adult birds feeding chicks produced a total of 1,542 prey items, in 107 hours of field observations, undertaken between 5 June and 2 July.

Of 842 identified prey items fed to Guillemot chicks 88.2% were clupeids, probably Sprat *Sprattus sprattus*, 9.4% were sandeel *Ammodytes spp.,* 1.8% Lesser Weever *Echiichthys vipera* and 0.5% others. Of 613 prey items fed to Razorbill chicks 91.4% was sandeel spp. and 8.6% were clupeids.

Guillemot feeds were concentrated in the first two-three hours of daylight with a smaller peak in mid-late afternoon and a further small peak in the evening. Razorbill feeds were more uniformly spread across the day although negligeable in the evening.

Although neither species showed any significant seasonal variation in the diet composition the last two days of the study, the 1 and 2 July, saw an increase in the number of large Sandeels fed to Guillemot chicks and the number of small Sprats fed to Razorbill chicks was noted.

Introduction

The Flamborough and Filey Coast SPA, hereafter referred to as F&FC, supports the largest mainland seabird colony in the UK, with an estimated 166,576 breeding pairs of seabird, including 74,989 pairs of Guillemot *Uria aalge* and 30,673 pairs of Razorbill *Alca torda* (Clarkson et al 2022).

The complex relationship between climate change and the impact of commercial fisheries is thought to have contributed to changes in the prey availability of many seabirds and, as a result of food shortages, some species have experienced reduced breeding success and population declines (Furness & Camphuysen 1997, Carroll et al 2017). The effects of food shortages have been particularly pronounced in northern Britain, where seabirds have relied largely on sandeels *Ammodytes* spp. to rear chicks (Anderson et al. 2014). Further south, for example, at the F&FC colony, clupeids (European Sprat *Sprattus sprattus* and Atlantic Herring *Clupea harengus*) are a more important component of the diet of some species (Anderson et al. 2014) and seabird population sizes have largely remained stable or increased (Meade et al 2004, Clarkson et al 2022).

In response to this changing environment, a programme of Guillemot and Razorbill chick diet monitoring was carried out in in the F&FC colony in 2009-12, (Anderson et al 2014), 2015 (Jeavons 2015), 2018 (Baker and Duffield 2018), 2021 (O'Leary 2021) and 2022 (Mitchell 2022).

Against this background the aim of the present research in 2023 was to determine whether the diet of Guillemot and Razorbill chicks:

- differ (as shown by previous studies e.g.),
- vary in different parts of the colony,
- changes diurnally
- changes through the chick-rearing period
- varies between years (based on data from previous years)

An additional aim was to create a photo library of individual feeds for both auk species to facilitate independent verification and provide an historic record.

Methodology

Study Area

Observations were carried out during a 28 day period, from 5 June to 2 July 2023 (Appendix 1). The data were collected within the F&FC Special Protection Area (SPA) (Figure 1).

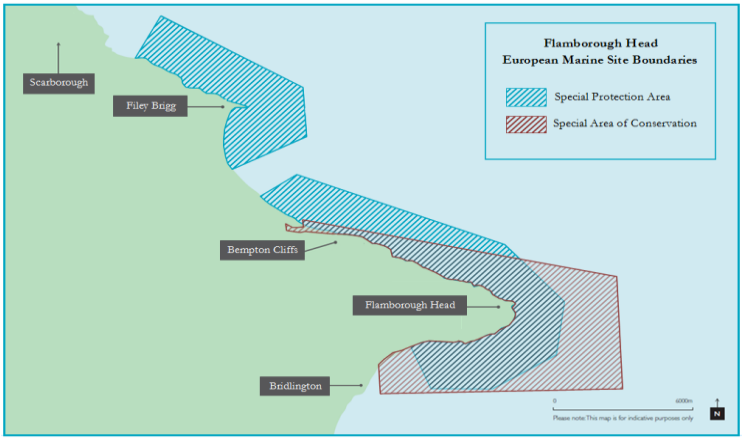


Figure 1. The Flamborough and Filey Coast SPA seabird colony on the Yorkshire Coast, England

Observations were made at Grandstand South, viewed from the Grandstand Viewpoint (54°08'50"N, 000°10'7"W) within the RSPB Bempton Cliffs nature reserve, and at the Carter Lane seabird monitoring site, (54.13N, 0.10W) in the Yorkshire Wildlife Trust's Flamborough Cliffs nature reserve (Figure 2). The two sites are 5 kilometres apart.

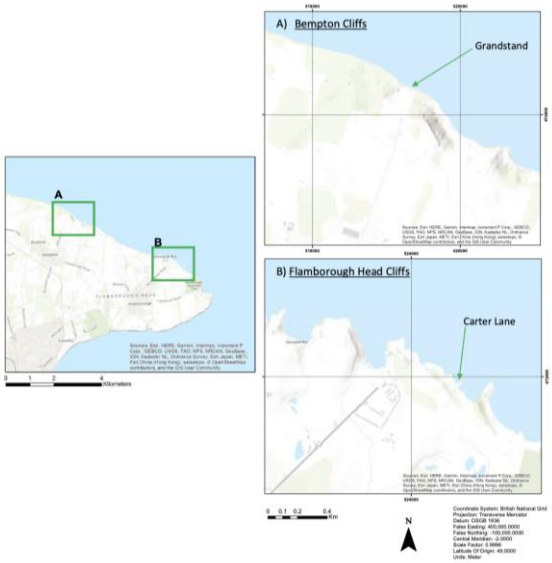


Figure 2. Location of the two chick diet monitoring sites at a) Grandstand South, RSPB Bempton Cliffs, and b) Carter Lane, YWT Flamborough Cliffs

Data collection

Observations were carried out from fixed clifftop viewpoints at both sites. The distance between the observer and the birds was c50m at Grandstand South and c60m at Carter Lane (measured by a Hawke LRF 600 Laser Range Finder by Ruth Jeavons in 2015). Each site held a minimum of 300 visible Guillemot breeding sites and over 50 visible Razorbill breeding sites.

Previous diet studies in the colony showed no significant differences between sites for either Guillemot or Razorbill chick diet composition. (Jeavons 2015) therefore it was assumed that data from the two sites could be combined.

Ideally, observations would have been focussed around 12 days after the median hatching date to enable a direct comparison with other colonies e.g., Skomer Island (Riordan & Birkhead 2018). However, it was not possible to determine median laying date. To compensate for this Guillemot and Razorbill chick feeding observations were carried out over a period of 24 days, between 5 June 2023 and 2nd July 2023, thereby incorporating the main chick-rearing period including 12 days after the median laying date for both species.

The diurnal timing of observations was chosen to maximise the number of 'feeds' recorded. Guillemot feeding rates are recorded as being highest in the first few hours after dawn and again in the evening (Birkhead 1977, Harris and Wanless 1985, Hatchwell 2008). The pattern of Razorbill feeding events is more evenly spread through the day although fewer feeds are recorded in the evening (Harris and Wanless 1986). Once a week, observations were carried out at through the daylight hours to monitor the diurnal feeding pattern.

Data was recorded on record sheets using quick response codes to minimise time spent looking away from the birds. Data was later transferred to an Excel spreadsheet.

Birds were located with the naked-eye as they flew-in towards the cliff. By transferring quickly to 10x40 Zeiss binoculars it was possible, in most cases, to determine and record whether the bird was carrying prey, the identification of the prey item/s, the approximate length of the prey item/s and whether a feed occurred or not.

Whenever possible photographs of feeds were taken with a Canon 7D Mark ll digital single lens reflex (DSLR) camera, and a Canon 100-400mm Mark ll zoom lens. The photographs

helped enable confirmation of fish identification and provide a permanent record of the observations. The photographic record also enabled independent verification by experts (Larson and Craig 2006).

Prey identification

'Fish identification sheets' based upon the RSPB STAR project (Owen et al 2010) were prepared in advance to assist with the identification of prey items in the field. Food items were recorded as Clupeid, Sandeel, Gadoid, Squid and other. It was not possible to distinguish individual species e.g., Sprat *Sprattus sprattus* from Herring *Clupea morhua* or the Sandeels *Ammodytes* spp. due to the similarity between species (Henderson 2014). Feeds, in which the prey item/s were unidentified, were recorded and included in the analysis to enable direct comparison with previous diet studies in the SPA.

Prey-size

The standard auk chick diet methodology of categorising prey-size into small, medium, or large was adopted (Harris and Wanless 1986).

Guillemots are single-prey loaders and typically carry one item lengthways along the bill although occasionally smaller items are carried across the bill. An assumed bill length from base of culmen to bill tip of 44mm (T. R. Birkhead pers. comm.) was adopted to estimate prey length. Prey items were categorised into small, medium, or large relative to the length of the bill:

- small (less than 60mm) - if none of the fish or item protruded beyond the bill tip
- medium (60-80mm) – if the tail fin protruded from the bill and,
- large (>80mm) – if more than the tail protruded

Razorbills, in contrast are typically multiple prey loaders, with the prey carried cross-ways in the bill. The Razorbill bill length ranges from 46-52mm (Brown et al 2009) and an assumed bill length of 49mm was used to estimate prey length. Prey was recorded as small (less than 50mm), medium (50-70mm) or large (>70mm).

Recording prey length in the Razorbill is difficult because items are not always carried in their middle, and it is rarely possible to see both sides of the bird's bill. A Razorbill when feeding

a chick, typically arrives head down, shielded by the brooding bird and either lays the prey on the ledge or allows the chick to remove a fish one at a time hidden from view of the observer. A photograph of the bird in flight as it arrives at the ledge provided the most accurate way of recording the prey items

Data analysis

For the Guillemot, only identifiable fish delivered to chicks was used to compare the diet with that of the Razorbill. Auks without chicks were regularly observed visiting breeding ledges carrying either 'display fish' or fish presumably for chicks that had been predated or had fledged (Heubeck 2009). These fish were recorded (Appendix Two) but excluded from the analysis.

The chick-rearing season was divided into three equal periods - early, medium, and late, to facilitate seasonal comparisons.

Photo library

A library has been created containing all the available images of 'feeds'. This library is accessible via RSPB Bempton Cliffs (Reference to be provided by DA)

Results

Composition and size of prey fed to Guillemot chicks

At total of 842 prey items was identified and 71 remained unidentified. All feeds comprised a single prey item.

With the exception of one large prawn and a European Common Squid *Alloteuthis subulata* all prey items were fish, mainly clupeids (88.2%) and sandeels *Ammodytes spp*. (9.4%) (Table 1). 15 Lesser Weever *Echiichthys vipera*, three gadids *Gadidae spp*., and one Butterfish *Pholis gunnellus* were also recorded.

Table 1. Identified prey fed to Guillemot chicks at the Flamborough and Filey Coast SPA colony in 2023

	Sandeel	Clupeid	Lesser Weever	Other Prey items
No. of identified prey items observed (n=842)	79	743	15	5
Percentage of feeds	9.4%	88.2%	1.8%	0.6%

Composition and size of prey fed to Razorbill chicks

A total of 195 feeds was observed comprising 613 identified prey items (all fish), 16 unidentified fish.

The Razorbill chick diet comprised 91.4% sandeels *Ammodytes* spp. and 8.6% clupeids.

The number of prey items fed to Razorbill chicks per feed

Razorbill chick feeds typically comprise multiple prey items (Figure 3). The mean number of sandeels fed per visit was 4.01 (range 1-8). The number of clupeids carried per feed was typically lower with many feeding trips involving just a single fish, with a mean of 1.8 Clupeids per feed (range 1-6).

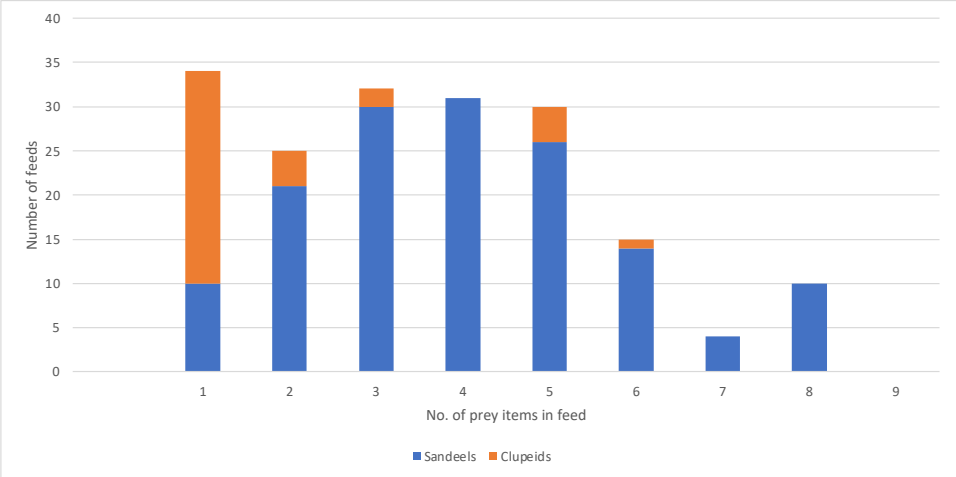


Figure 3. The frequency in the number of sandeels and clupeids per feeding visit fed to Razorbill chicks at the Flamborough and Filey Coast SPA colony, 2023

Composition of prey fed to auk chicks at two sites

Guillemots at Bempton Cliffs delivered a slightly larger proportion of clupeids to their chicks than those at Flamborough Head (Table 2). For the purpose of comparison with previous studies the data from the two sites has been combined.

Table 2. A comparison of Guillemot chick diet composition between sites within the Flamborough and Filey Coast colony, 2023.

	No. and percentage of Sandeels fed to chicks	No. and percentage of Clupeids fed to chicks	No. and percentage of Lesser Weever fed to chicks	No. and percentage of other species fed to chicks
Bempton	19 (6.0%)	291 (92.4%)	3 (1.0%)	2 (0.6%)
Flamborough	60 (11.4%)	452 (85.7%)	12 (2.3%)	3 (0.6%)
TOTAL	79 (9.4%)	743 (88.2%)	15 (1.8%)	5 0.6%)

(n=842, Chi-squared=8.31, 2df, p =0.01) (Lesser Weever and others were combined)

Similarly, there was a statistical difference between the dietary composition of prey fed to Razorbill chicks at the Bempton and Flamborough Cliffs sites (Table 3). To enable comparison with previous studies the data has been combined as the difference between sites was less than 10%.

Table 3. A comparison of Razorbill chick diet composition between sites within the Flamborough and Filey Coast colony, 2023

	No. and percent sandeels fed to chicks	No. and percent of clupeids fed to chicks
Bempton	105 (98.1%)	2 (1.9%)
Flamborough	455 (89.9%)	51 (10.1%)
TOTAL	560 (91.4%)	53 (8.6%)

(n = 613, Chi-squared = 7.54, 1 df p =0.006)

Size of prey fed to Guillemot and Razorbill chicks at two sites

There was no apparent difference in the size of clupeids fed to Guillemot chicks at Bempton Cliffs and Flamborough Cliffs (Table 4).

Table 4. A comparison between the frequency and size of clupeid prey items fed to Guillemot chicks at different sites within the Flamborough and Filey Coast colony in 2023

		Small (<50 mm)	Medium (50 - 70 mm)	Large (> 70 mm)
Bempton	No. and percentage of clupeids fed to Guillemot chicks (n=291)	21 (7.2%)	164 (56.4%)	106 (36.4%)
Flamborough	No. and percentage of clupeids fed to Guillemot chicks (n=452)	36 (8.0%)	280 (61.9%)	136 (30.1%)

(n= 743, Chi-squared = 3.24, 2 df p= 0.198)

Similarly, there was no significant statistical difference in the size of sandeels fed to Razorbill chicks at either Bempton or Flamborough Cliffs (Table 5).

Table 5. A comparison between the frequency and size of sandeel prey items fed to Razorbill chicks at different sites within the Flamborough and Filey Coast colony in 2023.

		Small	Medium	Large
Bempton	No. and percentage of sandeels fed to Auk chicks (n=103)	40 (38.8%)	58 (56.3%)	5 (4.9%)
Flamborough	No. and percentage of sandeels fed to Auk chicks (n=450)	194 (43.1%)	208 (46.2%)	48 (10.7%)

(n= 553, Chi-squared = 5.09, 2 df, p=0.784)

Diurnal variation in prey fed to auk chicks

The number of prey items fed to Guillemot chicks was highest in the first three hours of daylight with a smaller secondary peak in mid-late afternoon (Figure 4).

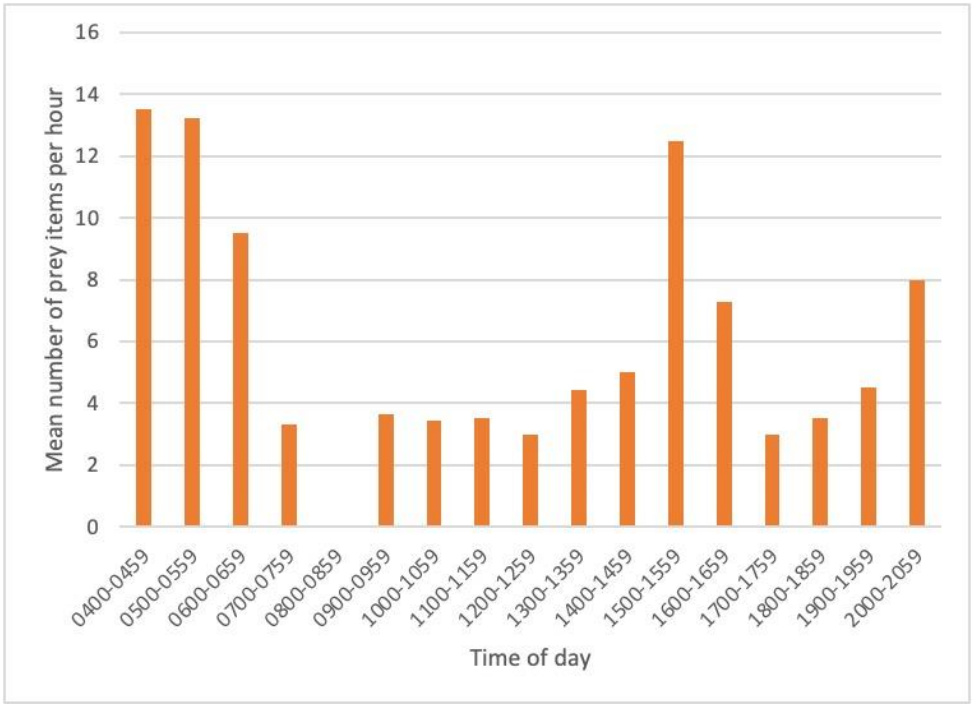


Figure 4. Diurnal frequency of Guillemot chick feeds

Razorbill chick feeds were more evenly distributed through the day with very few feeds in the evening (Figure 5).

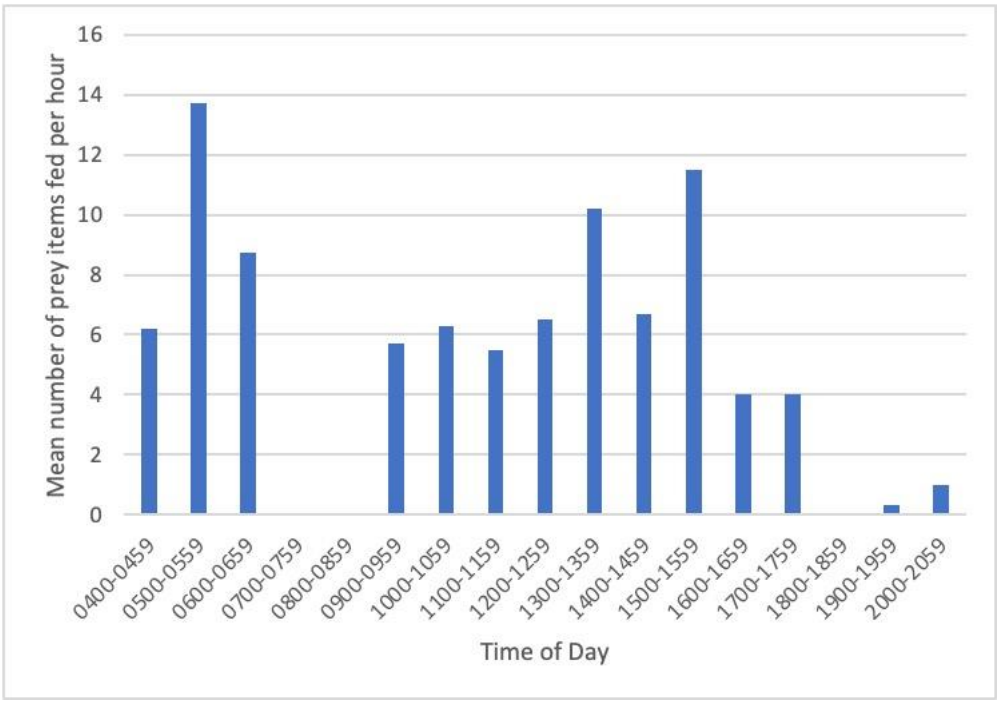


Figure 5. Diurnal frequency of Razorbill chick feeds

The diet composition of Guillemot chicks varies significantly through the day (Table 6), with the proportion of clupeids in the diet declining through the day before increasing again towards dusk.

Table 6. Diurnal variation in the diet of Guillemot chicks in the Flamborough and Filey Coast SPA colony 2023

Time	No. hours observation	No. & percentage of Clupeids fed to chick	No. & percentage of Sandeels fed to chick	No. & percentage of Lesser Weever fed to chick	Total no. of feeds
0400-0759h	10	106 (93%)	3 (2.60%)	5 (4.4%)	114
0800-1159h	6.75	36 (80%)	9 (20%)	0 (0%)	45
1200-1559h	6.75	53 (75%)	17 (23.9%)	1 (1.1%)	71
1600h-1959h	9.25	37 (68.5%)	16 (29.6%)	1 (1.9%)	54
>2000h	3.5	22 (96%)	1 (4%)	0 (0%)	23

(n=307, Chi-squared = 29.51, df =8, $p<0.001$)

In contrast, the proportion of clupeids in Razorbill chick diet increases through the day (Table 7).

Table 7. Diurnal variation in the diet of Razorbill chicks in the Flamborough and Filey Coast SPA colony 2023.

Time	No. hours observation	No. & percentage of Clupeids fed to chick	No. & percentage of Sandeels fed to chick	Total no. of fish
0400-0759h	10	2 (1.7%)	115 (98.3%)	117
0800-1159h	6.75	26 (30%)	62 (71%)	88
1200-1559h	6.75	29 (28.1%)	74 (71.9%)	103
1600h-1959h	9.25	10 (43.5%)	13 (56.5%)	23
>2000h	3.5		3	3

(n = 335, chi-square = 41.26, df = 4, $p<0.001$)

Seasonal variation in auk chick diet through the nestling period

The Guillemot chick diet remained remarkably consistent throughout the main chick-rearing period with no statistically significant variation through the season (Table 8).

Table 8. Frequency of main prey types fed to Guillemot chicks, through the chick-rearing period at Flamborough and Filey Coast SPA, 2023

Date	No. of hours observation	Number and percentage of Clupeids fed to chick	Number and percentage of Sandeels fed to chick
5-14th June	24	213 (95.5%)	10 (4.5%)
15-24th June	18	187 (92.6%)	15 (7.4%)
25th June-2 July	21	148 (93.1%)	11 (6.9%)

(n=584, df=2, chi-square =1.8, p=0.406)

There was no statistically significant difference in the composition of the Razorbill chick diet through the season (Table 9).

Table 9. Frequency of main prey types fed to Razorbill chicks, through the nestling period at Flamborough and Filey Coast SPA, 2023

Date	No. of hours observation	Number and percentage of Clupeids fed to chick	Number and percentage of Sandeels fed to chick
5-14th June	24	4 (3.0%)	129 (97.0%)
15-24th June	18	4 (2.7%)	145 (97.3%)
25th June-2 July	21	9 (8.2%)	101 (91.8%)

(n=392, df= 2, chi-squared=5.467, p=0.065)

Anecdotally, on the last day of observations towards the end of the chick-rearing period, a detectable shift in diet composition occurred for both Razorbill and Guillemot. Of 21 Guillemot chick feeds 57% were sandeel, 29% clupeids and 14% Lesser Weever. In contrast, Razorbill chick feeds showed an opposite trend with 58 sandeels (65%) and, remarkably, 31 clupeids (35%) being fed to chicks.

Discussion

The prey fed to Guillemot chicks was 88.2% clupeid (probably Sprat *Sprattus sprattus)*, 9.4% sandeel, 1.8% Lesser Weever *Echiichthys vipera* and 0.5% others. The diet composition for Razorbill chicks was 91.4% sandeel spp. and 8.6% clupeid spp. The diurnal pattern of chick-feeding differed slightly between the two species. Guillemot feeds were concentrated in the first two-three hours of daylight with a smaller peak in mid-late afternoon and a further small peak in the evening. Razorbill feeds were more uniformly spread across the day and were negligeable in the evening. The proportion of clupeids in the Guillemot chick diet declined through the day, increasing again towards dusk. Whilst in the Razorbill chick diet the proportion of clupeids increased during the day.

Although neither species showed any significant seasonal variation in the diet composition the last two days of the study, the 1 and 2 July, an increase in the number of large sandeels fed to Guillemot chicks and the number of small Sprat fed to Razorbill chicks was noted.

Auk chick diet varies significantly between years although there appears be no overall trend across the years. Throughout this period the mix of prey items in the Guillemot chick diet is dominated by clupeids whilst Razorbill chick diet is predominantly sandeels (Table 10).

Table 10. Annual variation in the percentage composition of Guillemot and Razorbill chick diet, at the Flamborough and Filey Coast colony, 2007-2023

		Auk chick diet composition (%)					
	Year	2009-11	2015	2018	2021	2022	2023
Guillemot	No. of identified prey items	481	656	240	70	365	842
	Clupeid	<75%*	95.1%	85.8%	96%	79.1%	88.2%
	Sandeel	>25%	4.3%	14.2%	4%	15.7%	9.4%
	Lesser Weever	0	0	0	0	0	1.8%
	Other	<2%	0.6%	0	0	5.2%	0.6%
Razorbill	No. of identified prey items		546	345	187	277	613
	Clupeid		10.3%	2.9%	3.6%	1.4%	8.6%
	Sandeel		89.7%	96.8%	96.4%	98.6%	91.4%
	Other		0	0.3%	0	0	0
	Source of data	(Anderson et al 2014)	(Jeavons 2015)	(Baker & Duffield 2018)	(O'Leary 2021)	(Mitchell 2022)	

(Guillemot n=2173, df = 15, chi-squared =64.4, p<0.001; Razorbill n=1968, df = 8, chi-squared = 36.64, p<0.001).
*<75% is figure quoted in the original paper (Anderson et al 2014)

These findings are set against a background of large ongoing increases in the local breeding auk population (Clarkson et al 2022) at a time when there are significant concerns about the impacts of both climate change driven increases in surface sea temperatures and overfishing, on forage fish population stocks (Carroll et al 2017).

The increases in the Guillemot population correlates with ongoing growth in other colonies including Skomer, Rathlin and the Farne Islands auk populations (JNCC 2021) but elsewhere, and across much of Scotland, the story is one of declines (Miles 2013 and Miles et al 2016). A factor favouring Guillemot colonies located in the south of their UK range is that these colonies coincide with the main range of the Sprat *Sprattus sprattus* (Heesen et al 2015) which provides a valuable alternative food source to sandeels (Anderson 2014).

Studies of Guillemot chick diet within the F&FC SPA since 2007, including this study, show that clupeids comprise an important and increasing component of their diet (Anderson et al 2014, Jeavons 2015, Baker and Duffield 2018, O'Leary 2021, and Mitchell 2022). Baltic Sea studies have shown a positive correlation between the abundance of Sprats and the size of the local Guillemot and Razorbill populations (Hjernquist & Hjernquist 2010).

Sandeels constitute a large proportion of the diet of several species of seabird including the northern UK Guillemot population, Razorbill and Black-legged Kittiwake *Rissa tridactyla* (hereafter referred to as Kittiwake) (Anderson et al 2014). In parts of the North Sea seabird productivity has been linked to the availability of sandeels (Frederiksen et al 2006).

The F&FC SPA also supports the UK's largest Kittiwake colony with 43,000 pairs in 2022. However, numbers have declined since the 1980s and breeding productivity has declined over this period (Clarkson et al 2022). Kittiwake breeding success at the F&FC SPA colony is positively correlated with the Sandeel Spawning Stock Biomass (SSB) i.e., the number of sexually mature Sandeels, which in turn, is influenced negatively by fishing mortality, two years before spawning, and increased surface sea temperatures although there was no direct relationship between surface sea temperatures and Kittiwake productivity (Carroll et al 2016).

Despite the impact of SSB on Kittiwake breeding success the ongoing growth in the Razorbill population and the high proportion of Sandeels in Razorbill chick diet suggest that sandeel availability is not currently limiting Razorbill breeding success in the F&FC SPA.
The chick diet study also provided evidence that Lesser Weever *Echiichthys vipera* are regularly selected by adult Guillemots as a food source for chicks. It is likely that the number of Lesser Weever brought back by Guillemots was higher than recorded with earlier specimens going unidentified. Without knowledge of their key identification features (Appendix Three) they may have been missed in earlier studies.

Suggested Improvements to the auk diet methodology at the F&FC SPA

1) Estimating fish / prey size. Use the photo library to develop a more precise field guide to prey size estimation and revisit bill length measurements using the British race of Guillemot *Uria aalge albionis*. The current small, medium, and large size categorisation is too crude when so many fish exceed the large threshold.

2) Prey identification - Update the 'field guide' to include 'in situ' photos of other prey e.g., Lesser Weever and European Common Squid
3) Consider undertaking future auk diet monitoring at the Carter Lane viewpoint at Flamborough Cliffs, to reduce interruptions from the public and maximise the number of feeds recorded.

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Appendices

Appendix One: Auk diet sampling effort, Flamborough and Filey Coast SPA (5 June 2023 – 2 July 2023).

Date	Location	Time	Hours	No. of Guillemot feeding events	No. of Razorbill feeding events	Observer
5 June 2023	Grandstand South, RSPB Bempton Cliffs	0510h-0750h	2.5	21	2	Keith Clarkson (KC)
5 June 2023	Carter Lane, YWT Flamborough Cliffs	0900h-1030h	1 .5	4	0	KC
6 June 2023	Carter Lane, YWT Flamborough Cliffs	0515h-0715h	2	23	4	KC
6 June 2023	Grandstand South, RSPB Bempton Cliffs	0745h-0945h	2	11	2	KC
7 June 2023	Grandstand South, RSPB Bempton Cliffs	1630h-1830h	2	15	2	KC
8 June 2023	Carter Lane, YWT Flamborough Cliffs	0415h-0715h	3	47	7	KC
8 June 2023	Carter Lane, YWT Flamborough Cliffs	0730h-1030h	3	8	7	Amy King
8 June 2023	Carter Lane, YWT Flamborough Cliffs	1045h-1315h	2.5	14	5	KC
8 June 2023	Carter Lane, YWT Flamborough Cliffs	1330h-1630h	3	15	1	Luíse O'Donovan
8 June 2023	Carter Lane, YWT Flamborough Cliffs	1630h-1930h	3	17	0	Mike Babcock (MB)

8 June 2023	Carter Lane, YWT Flamborough Cliffs	1930h-2130h	2	7	1	KC
9 June 2023	-	-	-	-	-	-
10 June 2023	Grandstand South, RSPB Bempton Cliffs -	0500h-0800h	3.5	44	7	KC
11 June 2023	Carter Lane, YWT Flamborough Cliffs	0510h-0810h	3	36	10	KC
12 June 2023	Grandstand South, RSPB Bempton Cliffs	0400h-0800h	4	44	2	KC
13 June 2023	Carter Lane, YWT Flamborough Cliffs	0440h-0740h	3	48	8	KC
14 June 2023	Grandstand South, RSPB Bempton Cliffs	0430h-0730h	3	39	2	KC
15 June 2023	Carter Lane, YWT Flamborough Cliffs	0415h-0715h	3	49	13	KC
15 June 2023	Carter Lane, YWT Flamborough Cliffs	0900h-1200h	3	10	10	MB
15 June 2023	Carter Lane, YWT Flamborough Cliffs	1400h-1700h	3	33	7	KC
15 June 2023	Carter Lane, YWT Flamborough Cliffs	1845h-2100h	2.5	28	0	MB
16 June 2023	-	-	-	-	-	-
17 June 2023	-	-	-	-	-	-
18 June 2023	Grandstand South, RSPB Bempton Cliffs	0515h-0715h	3	16	5	KC

19 June 2023	Carter Lane, YWT Flamborough Cliffs	0450h-0750h	3	36	8	KC
20 June 2023	Grandstand South, RSPB Bempton Cliffs	0500h-0800h	3	47	2	KC
21 June 2023	Carter Lane, YWT Flamborough Cliffs	0450h-0750h	3	45	4	KC
22 June 2023	Grandstand South, RSPB Bempton Cliffs	0445h-0745h	3	57	3	KC
23 June 2023	Carter Lane, YWT Flamborough Cliffs	0400h-0700h	3	52	6	KC
23 June 2023	Carter Lane, YWT Flamborough Cliffs	0900h-1200h	3	32	5	MB
23 June 2023	Carter Lane, YWT Flamborough Cliffs	1315h-1615h	3	39	13	KC
23 June 2023	Carter Lane, YWT Flamborough Cliffs	1900h-2100h	2	20	1	MB
24 June 2023	-	-	-	-	-	-
25 June 2023	Grandstand South, RSPB Bempton Cliffs	0435h-0735h	3	36	2	KC
26 June 2023	Carter Lane, YWT Flamborough Cliffs	0430-0745h	3.25	35	12	KC
27 June 2023	Grandstand South, RSPB Bempton Cliffs	0425h-0725h	3	61	4	KC
28 June 2023	Carter Lane, YWT Flamborough Cliffs	0500h-0800h	3	28	5	KC
29 June 2023	Grandstand South, RSPB Bempton Cliffs	0430h-0730h	3	43	4	KC

30 June 2023	Carter Lane, YWT Flamborough Cliffs	0430h-0730h	3	30	4	KC
1 July 2023	Carter Lane, YWT Flamborough Cliffs	1645h-1945h	3	17	4	KC
2 July 2023	Carter Lane, YWT Flamborough Cliffs	0430h-0730h	3	17	5	KC
2 July 2023	Carter Lane, YWT Flamborough Cliffs	1030h-1330h	3	11	15	KC
TOTAL			107.75 hours	1135	192	

Appendix Two: Composition of prey items brought to the breeding ledges in absence of chicks

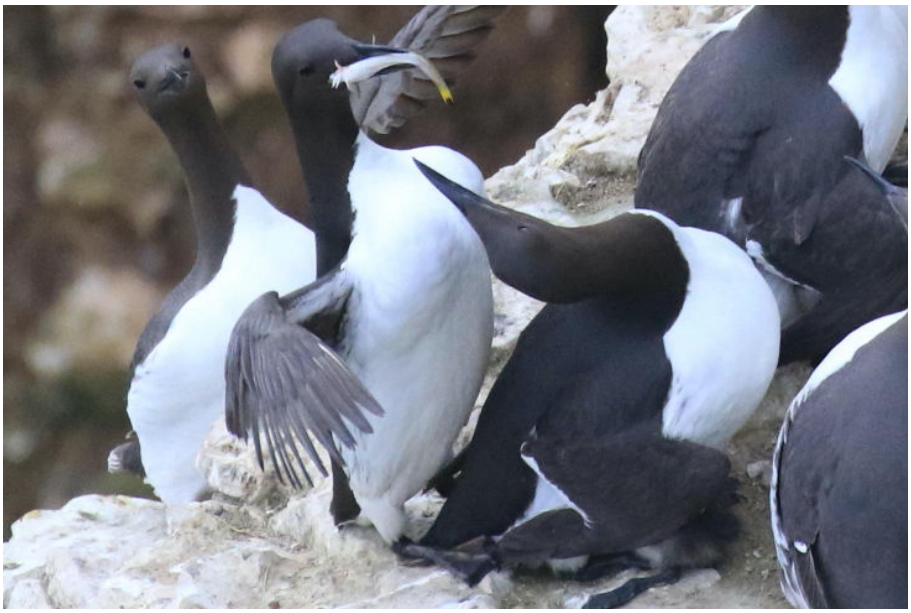
During the study 217 Guillemot and 11 Razorbills were seen visiting the breeding ledges with prey items in the absence of a chick. There was no statistically significant difference between the composition of prey brought to the nesting ledges by Guillemots, in the absence of a chick, and those brought to feed chicks.

	Number and frequency of Sandeels	Number and frequency of Clupeids	Number and frequency of Lesser Weever	Number and frequency of other prey items
No. of identified prey items fed to chicks (n=842)	79 (9.4%)	743 (88.2%)	15 (1.8%)	5 (0.6%)
No. of identified prey items brought to ledge in absence of chick (n=213)	30 (14.1%)	175 (82.2%)	8 (3.7%)	0
Total	109 (10.2%)	928 (87.1%)	23 (2.2%)	5 (0.5%)

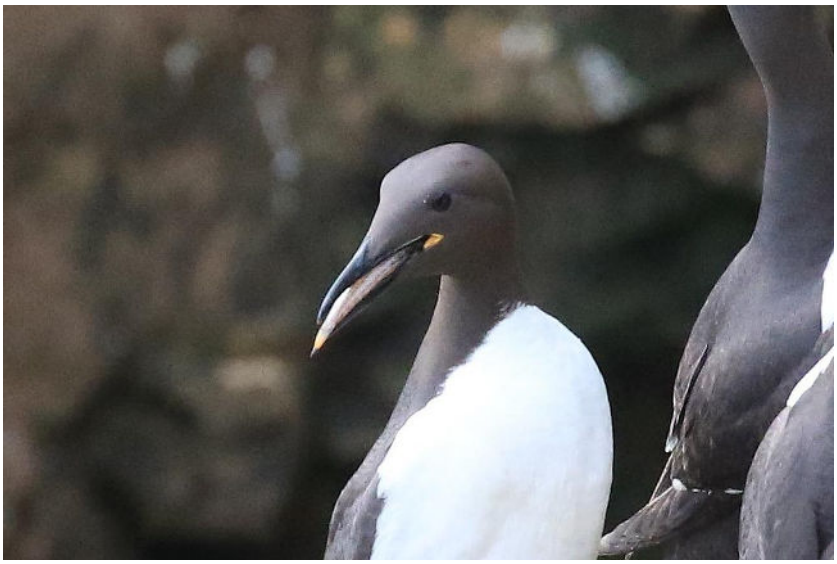
(n=1055, chi-squared=5.58, p=0.06) df

Appendix Three: The identification of Lesser Weever *Echiichthys vipera* as a prey item in Guillemot *Uria aalge* chick diet.

The chick diet study provided evidence that Lesser Weever *Echiichthys vipera* are regularly selected by adult Guillemots as a food source for chicks with a minimum of 23 fish being identified. It is likely that the number of Lesser Weever brought back by Guillemots was higher, and that they may have been missed in earlier studies but they remained unidentified in the early days of the study until the characteristic features were learnt – a striking black-tipped yellow tail fin, pearly white underside contrasting with grey brown almost Gadid-coloured upperside and prominent pelvic and pectoral fins creating a diagnostic narrow-cross-like profile when seen from beneath.



Lesser Weever *Echiichthys vipera* large, c.80mm, showing characteristic pearly-white underside with pectoral and pelvic fins, and striking black-tipped yellow tail-fin. Photo: Keith Clarkson



Lesser Weever *Echiichthys vipera* medium-length, c.65mm, showing characteristic grey-brown upperside (dorsal fin and spines laid flat and rarely seen erect) and striking black-tipped yellow tail-fin. Photo: Keith Clarkson

Lesser Weever is an important natural Sandeel predator which is found to be abundant in areas where Sandeels are common e.g., the Dogger Bank (Engelhard et al 2008). Lesser Weever can inflict painful injuries on humans, injecting a protein-based toxin into the skin through the venomous dorsal and opercular spines (Henderson 2014). It is not known whether the toxin has any effect on seabirds or, if so, how they reduce the potential risk of injury to adults and nestlings. The only reference obtained to date, of Lesser Weever featuring in the diet of seabirds, is of a single specimen taken by European Shag (Steven 1933).