Seabird monitoring on Skomer Island in 2021

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Contents

List of tables

List of figures

Summary

This document reports on the 2021 breeding season for seabirds on Skomer Island, drawing together the work of The Wildlife Trust of South and West Wales (WTSWW) staff, volunteers, as well as research institutions including the University of Gloucestershire (coordinated by Dr. Matt Wood), and Heriot Watt University (Prof. Steve Votier). The report includes whole island population counts, study plot counts, estimates of breeding success from fieldwork this year, and breeding adult survival estimates from long-term capture-recapture studies. Part of this work is funded by the Joint Nature Conservancy Council (JNCC), part of the UK Government's Department for the Environment, Farming and Rural Affairs (DEFRA), for the monitoring of Skomer's seabird populations as a key site for the Seabird Monitoring Programme (SMP).

Table 1 summarises population counts for ten species in 2021 and where possible makes comparison with the previous count as well as the mean of the previous five years.

Table 1 Summary table – whole island seabird population counts for 2021

Species and count units	Totals for 2021	Totals for 2020	% change from previous count	Comparison with mean of previous 5 years (%)
Northern Fulmar (AOS)	576	580	-0.69	-3.13
Great Cormorant (AON)	0	1	-100	-100
European Shag (AON)	2	3	-33.33	-56.52
Lesser Black Backed Gull (AON)	7,412	7668	-3.34	22.86[4.]
Herring Gull (AON)	271	298	-9.06	-14.13
Great Black-backed Gull (AON)	103	112	-8.04	-9.33
Black-legged Kittiwake (AON)	1439	1681	-14.40	0.19
Common Guillemot (IND)	27,269	n/a[1.]	-5.31[2.]	12.05[5.]
Razorbill (IND)	8,168	n/a[1.]	8.49[3.]	15.13[5.]
Atlantic Puffin (IND)	34,813	34,796	0.05	26.53

Notes:

1. Not censused in 2020 (see 2.1 Whole island counts)
2. Last census in 2019
3. Last census in 2018
4. New methodology from 2020 onwards
5. % change between 2021 and 2013

Count units used in this report:
AOS-Apparently Occupied Site
AON-Apparently Occupied Nest
AOT-Apparently Occupied Territory
IND-Individual

Northern Fulmar: The whole island population was 576 AOS. This is four fewer AOS than 2020. Productivity in 2021 was 0.45 which is an increase on 2020 (0.28) and the second highest value since 2014.

Manx Shearwater: Within the standard annual census plots, the number of responses (1,410) was comparable with 2019 (1,418). The study plot at the Isthmus had productivity of 0.43, a decrease of 0.22 from 2020 (0.65) and 0.12 lower than the 2012-2021 average (0.56). Adult survival of 0.85 in 2019-20 is below the study average (1978-2020: 0.87).

Lesser Black-backed Gull: The whole island population estimate was 7,412 AON which is 3.34 % lower than 2020. Productivity of 0.67 chicks per AON is higher than 2020 (0.24) and is the highest since 2015. Survival of breeding adult birds 2019-20 was 0.82.

Herring Gull: This year's whole island count of 271 AON is a decrease of 27 AON compared to 2020. Productivity was 0 which is the lowest on record. The annual survival estimate (2019-20) is 0.72, the study average (19778-2020) is 0.82.

Great Black-backed Gull: 103 AON were counted in 2021 which is less than 2020 (112). Productivity was 1.68, which is above the five year average of 1.62.

Black-legged Kittiwake: 1,439 AON were counted in 2021, which is a decrease on the previous year's 1,681. Productivity was 0.79, an increase compared to the previous year (0.60), and higher than the average productivity for the last five years (0.58). The survival rate of breeding adult Kittiwakes in 2019-20 remained low at 0.75. Over the period 1978-2020, survival of breeding adults averaged 0.85 (Figure 23).

Common Guillemot: 27,269 individuals were counted in 2021, which is a 5.31% decrease on the last count in 2019. Productivity was 0.60 which is the lowest since 2011. Adult survival at the Amos study colony was similar overall to that in the last five years.

Razorbill: 8,168 individuals were counted in 2021, this represents an increase of 8.49% since the previous whole island count in 2018. Productivity was 0.5 fledglings per active and regular nest site which is an increase on 2020 (0.46) but below the previous five year average of 0.52. Survival across the long-term-study (1970-2020) averages 0.90, and in 2019-20 was 0.97.

Atlantic Puffin: A total of 34,813 individual Puffins were counted in April. This represents an increase of 0.05% on 2020 (34,796). Puffin productivity was 0.70. This is the same as the productivity in 2020, which was itself a decrease of 0.03 from 2019. The breeding adult survival rate in 2019-20 was 0.85. The study average (1972 to 2020) is 0.91.

Weather

Weather data is collected from two sources. One is our nightly bird log where the days weather is recorded in brief. The second is from the NRW weather station on Wooltack Point on the Marloes Peninsular (51.7367, -5.2474) which records a number of measurements every ten minutes.

Where figures are compared to an average, they are compared to the nearest weather station run by the Met Office which is in Milford Haven (51.708, -5.055) a distance of 8.48 miles from Wooltack Point, so some differences may occur.

Particular weather events that had the potential to impact on breeding birds came in May on the 8th and 20th with winds of force 7 and above.

It was a very dry year with ponds dry from mid-summer right through the autumn and just over half of the expected rainfall occurring.

March – The month began with settled weather and variable winds which broke on 9th March with the first 'storm' of the season. Conditions then returned to a more settled state with the wind in the north only swinging back to south westerly for the last few days of the month. Temperatures were average, however, rainfall was a third of the historical average and wind was much higher than the historical average.

April – An exceptionally dry month with just 2.9mm of rain falling in the whole month. The mean temperature was 1.2°C below the long-term average. The wind was also greater than the long-term average and came from the North for a large part of the month.

May – An exceptionally windy month with storms dominating the month. Overall, temperatures were 2°C below average and rainfall was above average. Wind was almost double the historical average with a maximum gust of 79.2mph recorded on Wooltack Point on 20th.

June – The month began with light to moderate winds, with fog the dominating factor during the first half of the month. Temperatures fluctuated throughout the month and were below average when compared to the long-term data. Rainfall was well below average whereas wind was 50% greater than the historical average.

July – The month started changeable with showers and drizzle, before turning more settled for the second half of the month. This settled second half of the month resulted in the maximum temperature recorded for the year at 26.9°C on 23rd. Temperatures were average, wind was just above average and rainfall was below average.

August – A warm settled start soon gave way to south westerly winds with rain. This weather pattern prevailed until the last third of the month when the weather stabilised and the temperatures rose. Temperatures were below average for the month and rainfall was far below average.

September – A warm start to the month with temperatures in the first half of the month reaching 26.2°C. Apart from a few days of showers in the first half of the month, all the rain fell in the last half with days of persistent rain rounding out the month. Overall, a warm month with above average temperatures and average rainfall.

1 Introduction

Seabirds are a significant component of the marine environment and Britain has internationally important populations of several species. The most recent census of the Manx Shearwater population on Skomer in 2018 estimated 350,000 breeding pairs (Perrins et al, 2020). This affords Skomer's seabird populations even greater importance and probably makes its Manx Shearwater population a higher proportion of a world population than is the case for any other bird species breeding in Britain and Ireland. Skomer is therefore believed to hold the largest Manx Shearwater colony in the world. Other seabird species that breed on Skomer in important numbers include Northern Fulmar, Lesser Black-backed Gull, Black-legged Kittiwake, Common Guillemot, Razorbill and Atlantic Puffin. A national Seabird Monitoring Programme, co-ordinated by the Joint Nature Conservation Committee (JNCC), includes a small number of "key site" seabird colonies, where detailed monitoring of breeding success, annual survival rates and population trends is carried out. These sites are geographically spread to give as full coverage of British colonies as possible.

Skomer Island is the most suitable site for this work in south-west Britain. It is a National Nature Reserve managed by The Wildlife Trust of South and West Wales (WTSWW) under a lease from Natural Resources Wales (NRW). Not only is Skomer the most important seabird colony in southern Britain, but the waters around the island were designated as a Marine Nature Reserve (MNR) in 1991 and became Wales' first Marine Conservation Zone (MCZ) in 2014. Skomer also lies within the *Skomer, Skokholm and the Seas off Pembrokeshire* Special Protection Area (SPA), designated for its seabird interest. Seabird monitoring fits within a broader framework of monitoring marine and terrestrial organisms on and around the island.

There is an impressive data set for seabirds on Skomer. This is especially important for species such as seabirds with long periods of immaturity and high adult survival rates. The Wildlife Trust has been monitoring seabirds on the island since the early 1960s. Additional detailed studies (annual adult survival rates, breeding success and other aspects of seabird ecology) of particular species have been carried out for many years by other bodies, including long-term studies of shearwaters, auks and gulls (managed by Dr Matt Wood, begun by Prof Chris Perrins), the long-term study of Common Guillemot population dynamics (managed by Prof Steve Voter, begun by Prof Tim Birkhead), and Prof Tim Guilford's studies on the migration strategies of seabirds.

In 2021, the study plot counts of Common Guillemot and Razorbill, the whole island counts of all breeding gulls (including Black-legged Kittiwake), breeding success rates of Northern Fulmar, Herring Gull, Great Black-backed Gull, Black-legged Kittiwake and Common Guillemot were partially-funded by JNCC. This work is carried out by the island staff (including trained volunteers) and a contracted Field Worker. Freya Blockley was the JNCC-WTSWW Field Worker in 2021. In 2021 a Seabird Monitoring Volunteer (Izzy Burns) was recruited to provide additional support between 25th May and 26th June.

This report includes other seabird monitoring studies undertaken on Skomer. Dr Matt Wood from the University of Gloucestershire coordinates long-term studies of six seabird species, also partially-funded by JNCC. The JNCC-University of Gloucestershire Field Assistant in 2021 was Josie Hewitt.

The studies of Lesser Black-backed Gulls usually require a significant amount of field work and careful coordination between the JNCC Field Workers, the island staff and volunteers. Systematic nest count areas were not carried out in 2021, instead using previous nest count correction factors to successfully translate eye counts into a 2021 estimate of apparently occupied nests.

1.1 Capture-recapture survival estimates

The survival rates presented here have been calculated in the same way as in the other years since 1978: they are estimates of survival rates of adult breeding birds, from analysis of long-term encounter histories of individual birds, some of which have been alive, and part of these analyses, for many years. These long-term databases are an invaluable ecological record of the fluctuating fortunes of six seabird populations on Skomer Island dating back to 1970 (Razorbill), 1972 (Atlantic Puffin), 1977 (Manx Shearwater) and 1978 (Herring Gull, Lesser Black-backed Gull and Black-legged Kittiwake).

1.1.1 Methods

Estimates of annual survival and re-sighting probabilities are derived from Multi-Event Mark-Recapture (MEMR) analysis of long-term ringing and re-sighting data, using the software programs UCARE and ESURGE. For the purposes of monitoring annual variation in survival rates between years, a model is fitted to allow both survival and encounter probability to vary annually (Cormack-Jolly-Seber model), with more sophisticated analyses taking place in support of other projects as they emerge.

At least two years of observations are needed to obtain an accurate survival estimate for a given year, so the survival estimate for the last year of the study is not comparable with the others and produces an unreliable estimate, and is thus not presented. The survival estimate becomes reliable with two or more years' data, so we await the return of birds next year, for example to distinguish death from temporary absence from the colony. Similarly, the estimates for other more recent years are likely to change (hopefully not much) with the addition of further years of data.

Graphs showing estimated survival rates of the species over the course of the study are presented under each species account. Years for which survival rates are not given are those in which estimates were not sufficiently reliable to be presented (see notes accompanying Figures). A table listing survival estimates of all six species is given in Appendix 2. For those species where a trend is apparent, this is highlighted in the text. Field observations were made from April – August by the fieldworker, and analyses carried out by Matt Wood (University of Gloucestershire).

1.1.2 The value of long-term capture-recapture studies

This approach requires more resources than simpler techniques (in terms of fieldwork, database management, and analytical expertise), but the approach is well worthwhile because it brings three considerable benefits:

- Firstly, by monitoring the same individually marked seabird colony, variation can be controlled between individuals and sites. In other words, it makes the survival estimates much more accurate if the same birds are followed, in the same place, over many years.
- Secondly, the analytical approach can correct for birds that are tricky to see, or a year of challenging field conditions (like bad weather). Just because a bird hasn't been seen in the past year it doesn't mean it has died: it may not have been possible to find it in its burrow or re-sight it on a cliff ledge, because it's shy or awkward to see, or because this year's weather made telescope re-sightings more difficult. Long-lived seabirds sometimes have gaps in breeding, so it may also be taking a year off! This 'unseen' bird might come back in future years and correcting for this 'encounter probability' greatly increases the accuracy of survival estimates, if you have data over a sufficiently long period.
- Thirdly, and most importantly, if a trend is observed that is of concern from a conservation perspective or a pattern that might facilitate discovering more about seabird ecology, the improved accuracy of this approach over more simplistic estimates gives a much better chance of finding out *why* survival rates (or encounter probabilities, or frequency of gaps in breeding) might be changing.

That, after all, is the point of monitoring seabirds in the first place, and why long-term projects are an invaluable resource for this and future generations of people who care about seabirds, their island breeding colonies, and the wider marine environment.

2 General methods

Detailed instructions, including methods and maps etc. for all protocols are given in the seabird section of the Skomer Management Plan. These act as 'how to' documents for all projects covered by this report and undertaken by the various field workers.

2.1 Whole island counts

Whole island counts of the cliff nesting species were carried out in June (1st - 20th June) and two complete counts were made.

It was decided to return to previous counting methodologies in 2021 and count every species. Due to the previous rotational system and the effects of the Covid-19 pandemic, some species had been missed on their rotation and have not been counted for two years.

In mid-June 1999, black-and-white photographs were taken of all count sections and these are filed on the island. Since 2013 new photographs of most of the sections were taken in order to update the existing ones, as vegetation and the cliffs themselves have changed over the years. In 2014 boundaries of Bull Hole were changed to allow easier counting. In 2016 the Seabird Monitoring Volunteer (Tracey-Ann Hooley) updated the last few photographs and created a new folder for use in the field. Additionally, all section photographs are stored digitally on the island computer and a spare copy of the folder is kept in the island office.

The Lesser Black-backed Gull colonies were counted by eye from established vantage points between the 12th and 15th of May. It was decided in 2021 that a standard correction factor should be applied to eye counts going forward to minimise the disturbance caused on the colonies by walk through counts.

Count units (explained under summary) and methods follow those recommended by Walsh *et al* (1995) but note that the Lesser Black-backed Gull census methodology has been developed on the island (see Sutcliffe 1993).

Graphs showing whole island populations since the 1960s are presented for each species. Note that in past years different counting units and methods have been used for some species, although those in recent years have been standardised and are recorded in the site management plan. General trends can nonetheless be identified with some confidence.

2.2 Study plot counts of Common Guillemots *Uria aalge* and Razorbills *Alca torda*

Common Guillemot counts continued at the Wick study plots (A, B, C, D). Ten counts of the study plots were made by the Field Worker (Freya Blockley) during the first three weeks of June using methods outlined in Walsh *et al.* (1995).

All ten recommended counts of Razorbill were conducted in the first three weeks of June at historic study plots. However, counts of only half of the High Cliff study plot continued as of changes made in 2018. In mid-June 1999, black-and-white photographs were taken of all study plot sites and these are filed on the island. In the intervening years new plot photographs have been taken to update the existing ones where vegetation and the cliffs have changed over the years. Edits were made of the colony sub divisions to remove gaps between them which caused ambiguous boundaries.

2.3 Breeding success

Methodology follows that of Walsh *et al.* (1995). Brief details are given separately in each species account. Black-and-white photographs of the breeding success plots were taken in mid- June 1999 and are filed on the island, but these have now all been replaced by more up to date colour images. All occupied Guillemot, Razorbill and Kittiwake breeding plots were re-photographed in 2014 as vegetation and the cliffs themselves have changed over the years. Of particular note is a large cliff collapse at South Stream cliff over the winter of 2013-2014.

3 Northern Fulmar *Fulmarus glacialis*

3.1 Breeding numbers - whole island counts

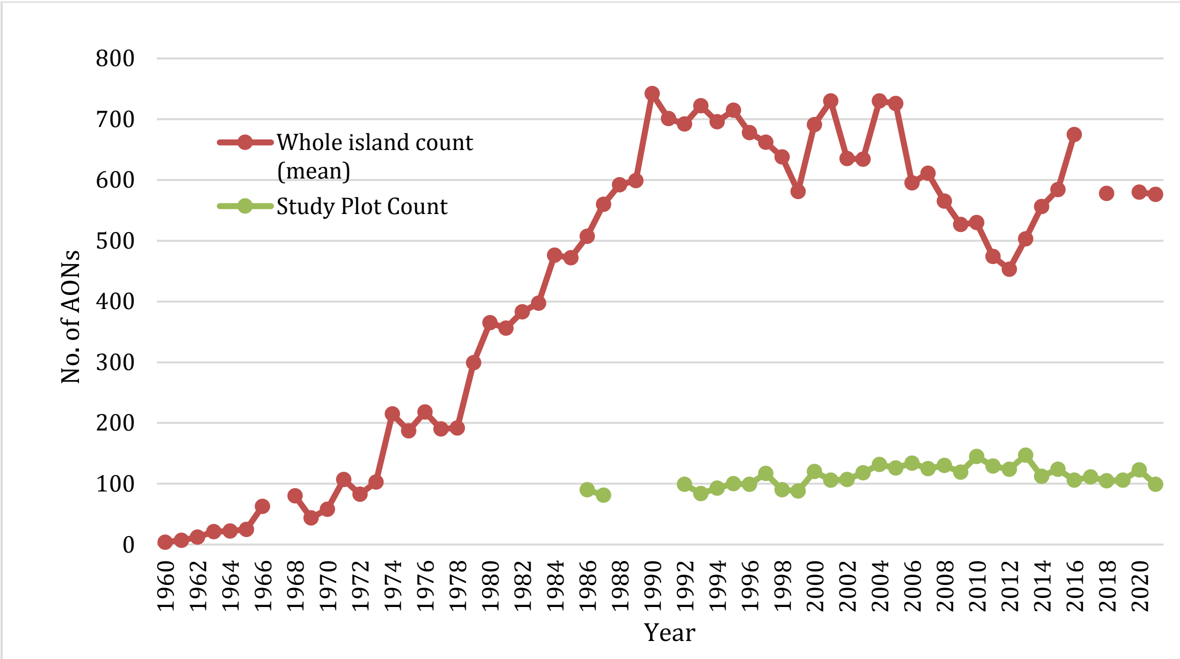
A mean of 576 AOS (range: 599-552) were counted in June 2021. This represents a decrease (-0.69%) in numbers since the last whole island count in 2020 (see Table 2). The number of occupied sites within the productivity study plots were down from 123 AOS in 2020 to 99 AOS in 2021.

Table 2 Northern Fulmar whole island counts 2004-2021

Year	Total	% change from previous count	5 year % change	10 year % change
2004	730	+15.1	+5.6	
2005	726	-0.5	-0.5	
2006	595	-18.0	-6.3	
2007	611	+2.7	-3.6	
2008	565	-7.5	-22.6	
2009	527	-6.7	-27.4	
2010	530	+0.6	-10.92	
2011	474	-10.57	-22.42	
2012	453	-4.43	-19.82	
2013	503	+11.04	-4.55	
2014	556	+10.54	+4.91	-23.42
2015	584	+5.04	+23.21	-1.85
2016	675	+15.58	+49.01	+10.47
2017				
2018	578	-14.37*	+4.29	+5.51
2019				
2020	580	+0.35*	+0.14	+6.52
2021	576	-0.69	-3.13	+5.49

*% change between 2018 and 2016, 2020 and 2018

Figure 1 **Northern Fulmar breeding numbers (whole island counts) 1963-2021**



3.2 Breeding success

3.2.1 Methods

Each of the seven Fulmar plots was visited three times, 3-4 days apart, during late May to early June (26th May to 2nd June). Sites were mapped and considered occupied if either an egg was seen or a bird appeared to be incubating on all three visits. This follows productivity monitoring method 1 (nest-site mapping) outlined by Walsh *et al*. (1995).

Plots were then monitored roughly every 14 days, until nests had either failed or chicks were classed as 'large' and could therefore be assumed to fledge. The last sites were visited on 8th September.

The final productivity for the island is given as the total number of fledged chicks divided by the number of Apparently Occupied Sites across all plots.

3.2.2 Results

143 sites were monitored, of which 99 apparently occupied sites were identified. Productivity for the island was 0.45 (Table 3). This is very similar to the historical average (1986-2020) of 0.46 (Figure 2), and higher than both the 0.28 reported last year, and the five-year average of 0.38 (Table 4).

If productivity is calculated as the average of the plot means (combining Tom's House, Basin East and South Haven into one plot due to small sample size) as suggested by Walsh *et al*. (1995), the productivity is still 0.45.

As per the management plan, 3 study plots (South Haven, Tom's house and Basin East) were combined as each plot had <10 pairs and when utilised to obtain mean productivity of all the study plots it resulted in 0.45 (Table 3).

Table 3 Northern Fulmar productivity on Skomer Island 2021

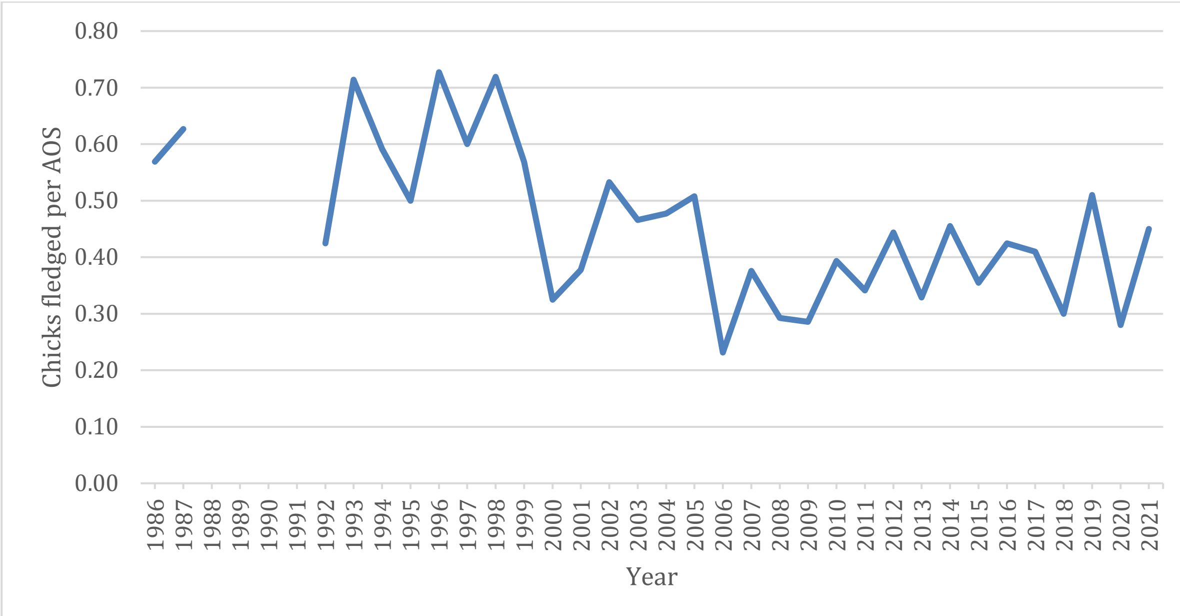
Site	No. sites monitored	No. sites occupied	Chicks fledged	Productivity per site
Tom's House	1	1	0	0.00
Basin (West)	38	22	8	0.36
Basin (East)	15	7	4	0.57
North Haven	42	33	17	0.52
South Haven	13	7	3	0.43
Castle Bay	16	12	6	0.50
Matthew's Wick	18	17	7	0.41
Totals	**143**	**99**	**45**	**0.45**

Table 4 Northern Fulmar productivity on Skomer Island 2012 – 2021

Year	No. Sites monitored	No. Sites occupied	No. Large fledged	Productivity
2016	161	106	45	0.42
2017	133	111	45	0.41
2018	143	105	31	0.30
2019	137	106	54	0.51
2020	139	123	34	0.28
2021	143	99	45	0.45
			Mean*	**0.38**
			SD*	**0.06**
			SE*	**0.04**

* Mean, SD and SE excludes results from 2021.

Figure 2 **Northern Fulmar productivity on Skomer Island 1986-87, 1992-2021**



Note: The historical productivity data in this graph is given as the total number of fledged chicks divided by the number of AOS' across all plots.

3.3 Timing of breeding

The first egg was seen at the Wick on 24th May and the first chick was seen at the Basin West study plot on 29th June.

Table 5 Northern Fulmar phenology records 2014-2021

	2014	2015	2016	2017	2018	2019	2020	2021
First egg	15th May	23rd May	24th May	29th May	27th May	24th May	16th May	24th May
First chick	10th July	9th July	9th July	10th July	15th July	2nd July	2nd July	29th June

4 European Storm Petrel *Hydrobates pelagicus*

As part of a continuing project to estimate survival of breeding adult Storm Petrels on Skomer, four ringing visits were made to the small breeding colony at Tom's House between 19th July and 2nd August. Ringing visits take place in mid-late July and August, after the incubation period, in order to minimise disturbance to the colony.

During these four visits, a total of 77 individual Storm Petrels were caught; 46 of these were new birds, while the remaining 31 had been ringed previously. Of these 31 re-encounters, 18 were ringed on Skomer in previous years (the oldest having been ringed as an adult in 2011), while nine birds had been ringed in the nearby breeding colony on Skokholm. Of the remaining four re-encounters, two were ringed elsewhere in Wales (St Justinian, Pembrokeshire, and Porth Iago, Gwynedd), one was ringed at Hartland Point, Devon and the final bird was ringed in June 2009 on the Calf of Man.

Previous preliminary analysis of ringing data from Tom's House (2006-17) indicates a survival rate of 0.88 for breeding adults, and 0.59 for transient birds: a large number of birds (approx. 75%) are encountered once and never recaptured, most likely non-breeding birds prospecting for nesting sites. These factors currently hinder the estimation of annual survival rates, but survival estimates averaged over longer time periods (e.g. five years) will be valuable.

The project is a team effort between the University of Gloucestershire, WTSWW staff and volunteers.

5 Manx Shearwater *Puffinus puffinus*

5.1 Breeding study plots census

The number of responses in 2021 was 1,410 which is eight fewer than 2019. The number of burrows increased from 4429 in 2019 to 4479 in 2021. The most responses (202 from 775 burrows) were heard in plot L which is located on the north side of the Neck. The census was undertaken entirely by WTSWW staff and volunteers, including a dedicated Seabird Monitoring Volunteer (Izzy Burns). The use of MP3 (instead of tape) was continued in 2021.

Figure 3 Number of responses in breeding study plots 1998-2021

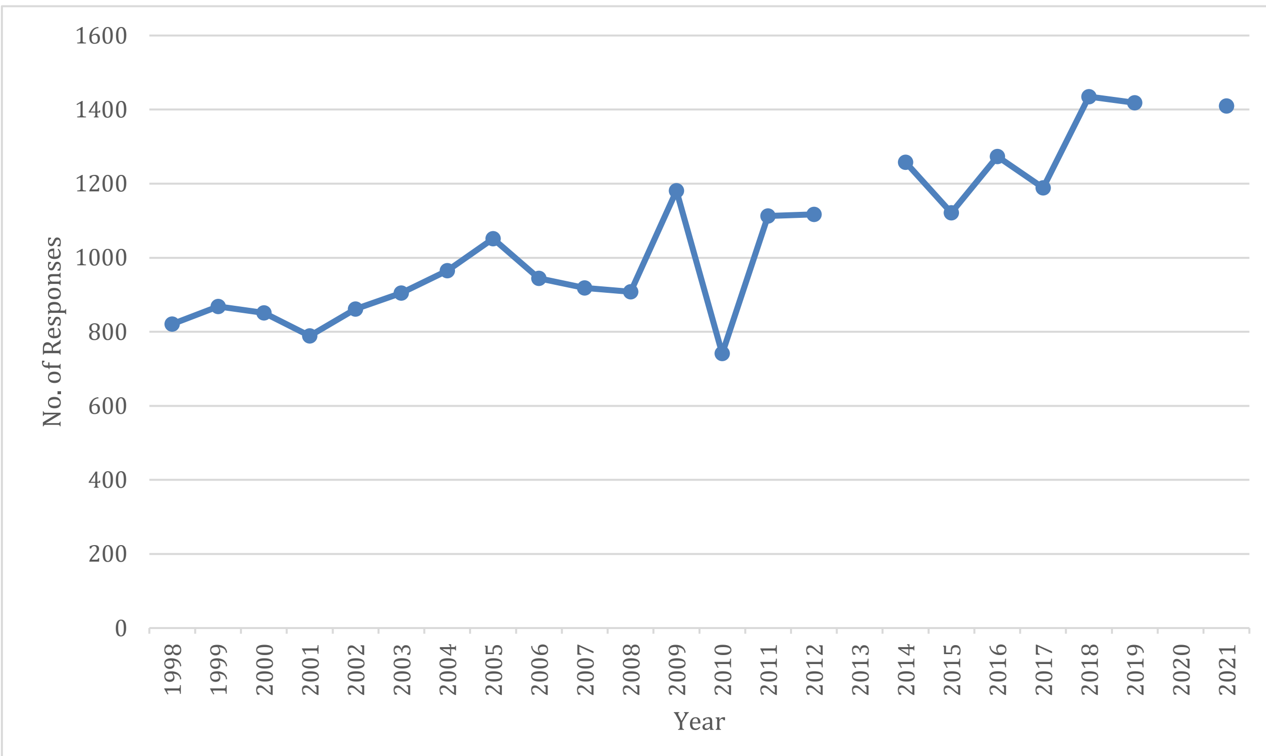


Figure 4 Number of burrows in breeding study plots 1998-2021

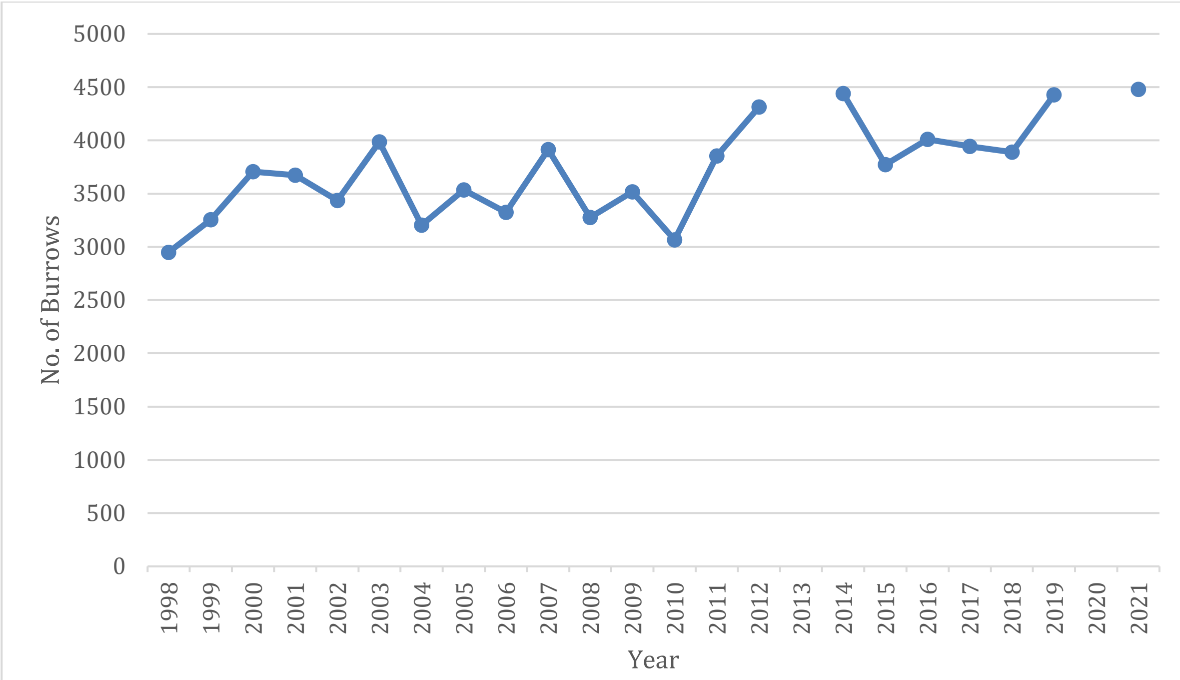


Table 6 Manx Shearwater responses to playback in census plots 1998-2021

No. responses

Site/Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
A	12	15	17	12	20	15	16	12	28	10	23	20	9	13	17		24	14	21	16	23	30		25
B	19	35	18	19	32	28	32	15	21	30	12	15	9	18	19		20	15	13	20	18	25		23
C	56	45	27	35	36	45	52	41	53	66	69	82	30	66	41		102	72	70	50	80	49		65
D	81	65	61	51	71	55	52	64	64	73	61	57	31	80	97		112	70	89	85	87	100		104
E	17	14	17	15	14	7	9	9	10	5	8	3	5	5	5		5	6	4	2	3	6		4
F	3	3	2	5	5	6	4	7	8	6	6	3	4	3	9		9	4	13	7	11	9		9
G	2	6	4	3	9	7	5	8	9	2	9	12	6	7	9		16	10	10	8	11	8		12
H	23	17	10	15	16	10	14	16	13	17	14	22	12	18	32		12	16	28	15	33	21		30
I	72	88	74	117	75	67	102	134	111	116	83	169	110	135	144		134	143	176	148	165	129		181
J	77	75	107	67	54	66	81	73	42	70	72	80	46	95	93		118	63	88	84	120	114		117
L	147	132	186	131	142	164	185	244	150	157	156	222	123	159	179		215	200	221	218	215	250		202
M	85	80	67	62	79	94	71	75	66	73	65	81	33	95	89		85	73	81	65	93	86		79
N	51	67	39	49	52	44	40	63	75	23	37	70	41	82	62		77	64	74	103	108	125		95
O	27	29	38	34	30	36	84	34	40	29	25	38	30	51	45		47	55	56	53	42	71		47
P	30	60	57	67	78	77	32	67	95	72	117	93	80	107	127		98	99	96	101	131	129		134
Q	34	26	17	17	29	26	32	32	32	31	20	65	20	25	28		27	33	34	36	37	31		45
R	48	44	65	39	56	83	91	92	72	65	62	53	65	79	65		77	69	97	71	115	101		90
S	37	67	45	51	63	75	63	65	55	73	69	96	87	75	56		80	115	102	107	143	134		148
Total	**821**	**868**	**851**	**789**	**861**	**905**	**965**	**1051**	**944**	**918**	**908**	**1181**	**741**	**1113**	**1117**		**1258**	**1121**	**1273**	**1189**	**1435**	**1418**		**1410**

*Not censused in 2013 and 2020

Table 7 Manx Shearwater burrows in census plots 1998-2021

No. burrows

Site/Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
A	51	70	87	94	98	145	87	35	105	62	91	61	87	69	100		97	62	99	106	71	78		87
B	75	102	193	240	98	91	78	81	74	108	49	91	53	74	176		79	79	61	37	35	61		49
C	299	255	259	202	193	332	287	262	309	387	346	236	246	385	358		429	301	278	263	316	317		318
D	200	235	296	244	320	313	98	210	253	303	204	206	201	238	316		428	286	256	235	205	268		303
E	63	65	66	67	61	58	48	37	49	38	48	32	46	40	42		39	63	33	33	35	41		36
F	14	17	12	11	17	20	15	18	15	13	13	12	17	17	15		40	26	24	15	16	21		28
G	11	16	15	14	22	21	14	22	29	19	34	25	19	28	21		53	34	27	27	30	26		52
H	98	97	120	120	140	126	88	118	85	167	84	87	89	141	110		143	106	109	125	118	122		169
I	271	293	199	321	260	309	236	389	230	331	246	465	278	437	442		395	367	431	383	412	471		449
J	339	311	455	401	360	359	305	224	219	337	407	315	275	351	438		439	322	395	388	464	428		485
L	473	506	596	560	593	661	527	693	445	709	472	604	422	560	716		749	641	711	708	677	808		775
M	234	231	240	188	175	218	167	141	168	154	152	191	157	213	212		214	178	172	203	185	184		177
N	207	249	261	288	248	261	221	252	282	214	235	215	221	222	226		223	265	250	306	289	292		277
O	93	99	140	152	110	142	278	119	125	156	139	84	185	148	246		182	163	171	163	99	234		228
P	151	205	234	204	228	270	124	283	264	257	254	303	256	329	319		301	262	317	295	332	352		306
Q	84	82	77	95	85	71	112	132	108	119	85	111	77	106	104		125	123	100	103	81	118		121
R	190	235	329	236	214	314	278	276	279	197	158	167	189	287	214		237	213	231	230	231	262		280
S	97	187	127	237	213	274	241	244	286	344	260	311	248	209	260		268	282	345	325	293	346		339
Total	**2950**	**3255**	**3706**	**3674**	**3435**	**3985**	**3204**	**3536**	**3325**	**3915**	**3277**	**3516**	**3066**	**3854**	**4315**		**4441**	**3773**	**4010**	**3945**	**3889**	**4429**		**4479**

*Not censused in 2013 and 2020

5.2 Breeding Success

Manx Shearwater breeding success in the Isthmus study plot in 2021 was 0.43, a decrease of 0.22 from 2020 (0.65) which was itself an increase on 2019 (0.52). Breeding success in 2021 was 0.12 lower than the 2012-2021 average (0.56) and below average for the 1995-2021 average (0.59). Breeding success of Manx Shearwaters in the Isthmus study plot in 2021 is detailed below in Table 8, Figure 5, and shows annual variation in breeding success since 1995.

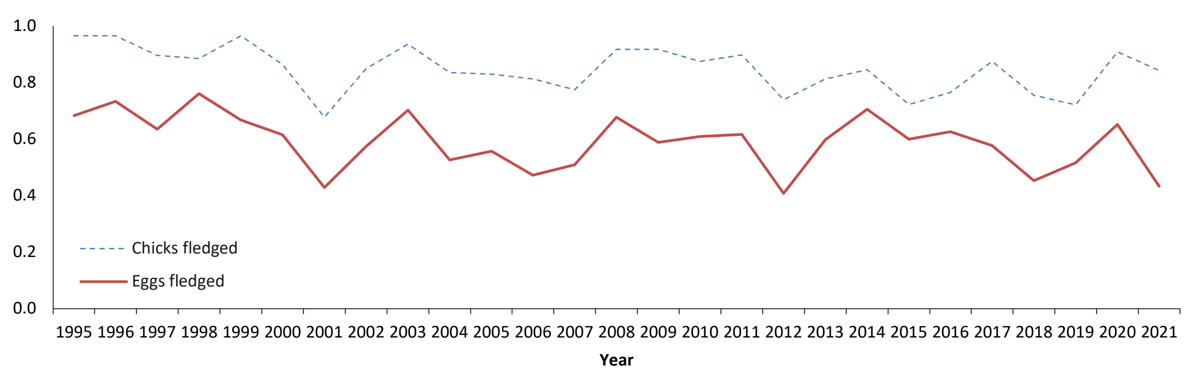
Table 8 Manx Shearwater breeding success at The Isthmus study plot in 2021

Total number of eggs laid	37
Number of eggs known or assumed to have failed1	18
Number of eggs known or assumed to have hatched2	19
Number of chicks known or assumed to have died3	3
Number of chicks surviving to ringing age	16
Hatching success4	51%
Fledging success5	84%
Number of fledged young per egg laid	**0.43**

Notes:

1. Eighteen eggs are known to have failed, having been found abandoned or broken, or having disappeared before they could have hatched.
2. Nineteen chicks were found between 23rd June and 14th August. By this latter date all monitored burrows were known to have either successfully hatched or failed at the egg or young chick stage.
3. Three chicks were presumed to have died or been predated when burrows were discovered empty on ringing visits.
4. Hatching success = % of eggs known or assumed to have hatched.
5. Fledging success = % of chicks surviving to a large size.

Figure 5 Annual variation in Manx Shearwater breeding success 1995-2021



Productivity varies between years but appears to show a stable long-term average. Although three of the last four years have been below the 1995-2021 average (0.59), 2021 appears to continue the long-term trend. In 2021 there were 37 active burrows followed for productivity which is lower than the recommended

100, although it is possible to calculate a productivity estimate here. Much of The Isthmus study plot was fragile in 2021, as a result of little to no grass growth over the spring and summer, a periodic feature of the vegetation variation on Skomer. This restricted safe access to study burrows and may have contributed to the high numbers of deep and empty study burrows.

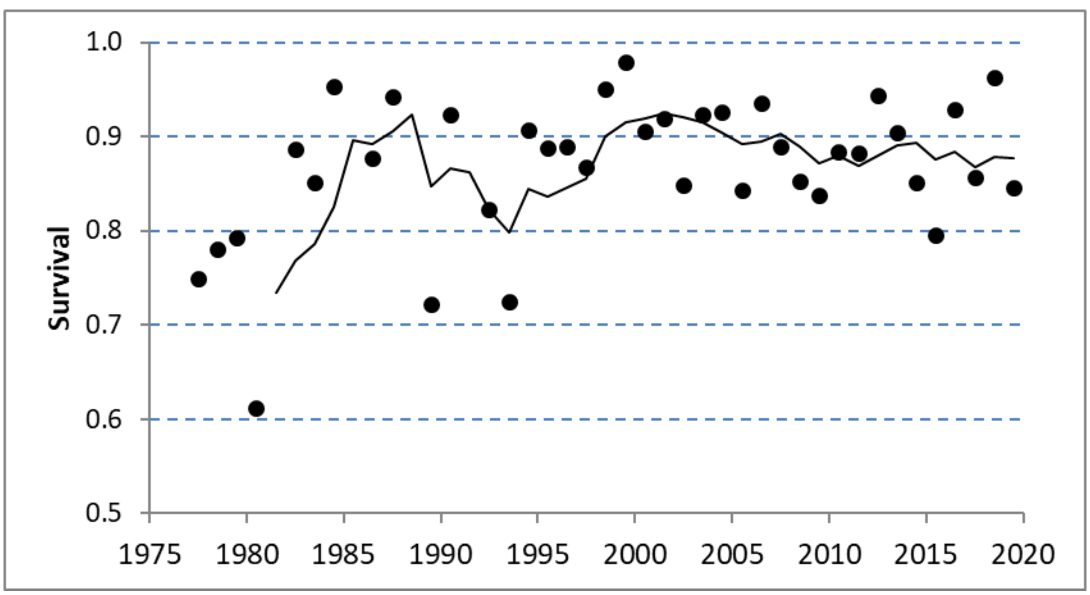
136 burrows were checked by hand (or with the burrow scope/leg hook as needed). 26 were too deep to reach with any of these methods, 46 were empty (such burrows were checked on at least two occasions throughout the season), 27 contained Puffins and thus just 37 of the 136 burrows checked were occupied by Manx Shearwaters.

5.3 Adult survival

The shearwater survival estimates are based on birds that are marked in burrows on The Isthmus, providing invaluable information on the demography of shearwaters (Wood et al 2021). Usually all but a few of the nests are reached every year and the majority of the birds breeding in them are caught, however restricted access to the study plot hindered recapture of marked birds to an extent in 2021. Fortunately, it was possible to estimate survival for 2019-20 at 0.85, close to the study average (1977-2020) of 0.87.

In addition, survival rate for adult breeding Manx Shearwaters in 2018-19 was estimable (0.96), after issues the previous year perhaps due to issues with 2020 fieldwork impacted by Covid-19: resightings in 2021 seem to have addressed this. A return to regular fieldwork patterns in future years will further refine survival estimates.

Figure 6 **Survival rates of adult breeding Manx Shearwaters 1978-2020 (using encounter data to 2021)**



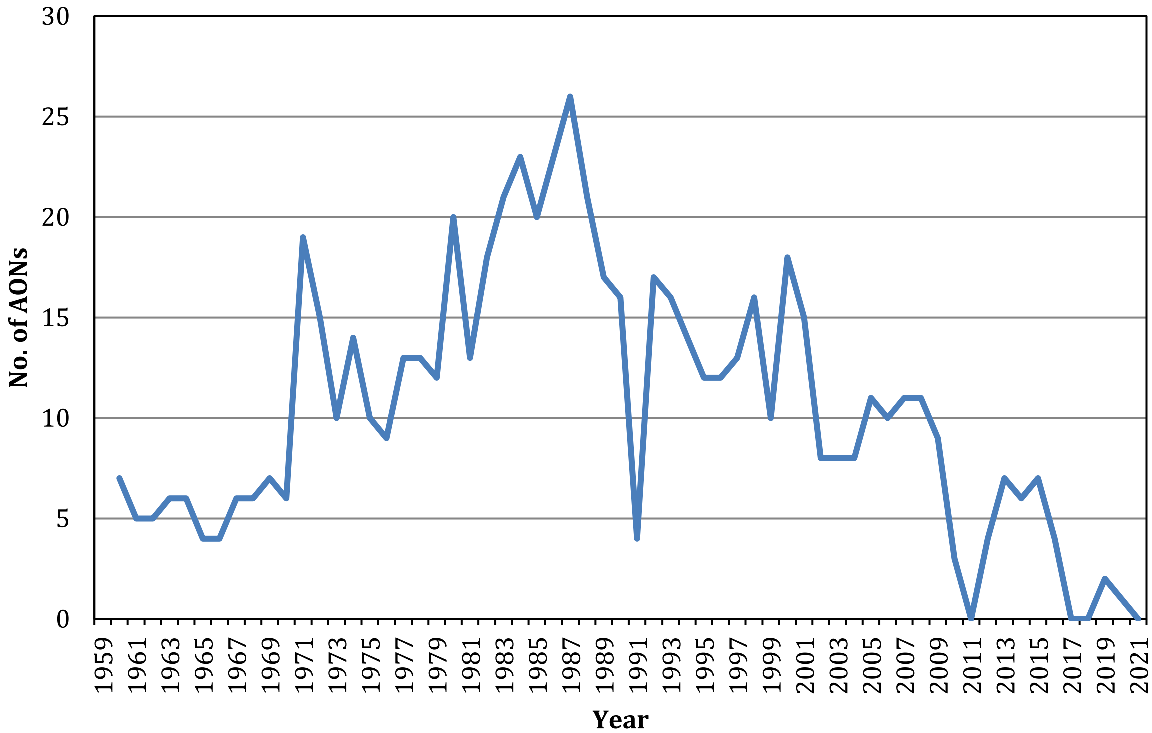
Notes:
1. Fitted line shows the five-year moving average
2. Survival was non-estimable in 1981-2, 1988-9, 1991-2. The last transition in such analyses is non-estimable, requiring at least one further year's data. See Section 1.1)
3. Appendix 2 gives the estimated survival rates for 1977-8 to 2019-20
4. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

6 Great Cormorant *Phalacrocorax carbo*

6.1 Breeding numbers

Great Cormorant (hereafter Cormorant) did not breed on Skomer in 2021, after one pair breeding in 2020. Cormorants are now a sporadic breeder on Skomer with the species preferring Middleholm instead, where there were around 10 pairs.

Figure 7 Great Cormorant breeding numbers 1960-2021



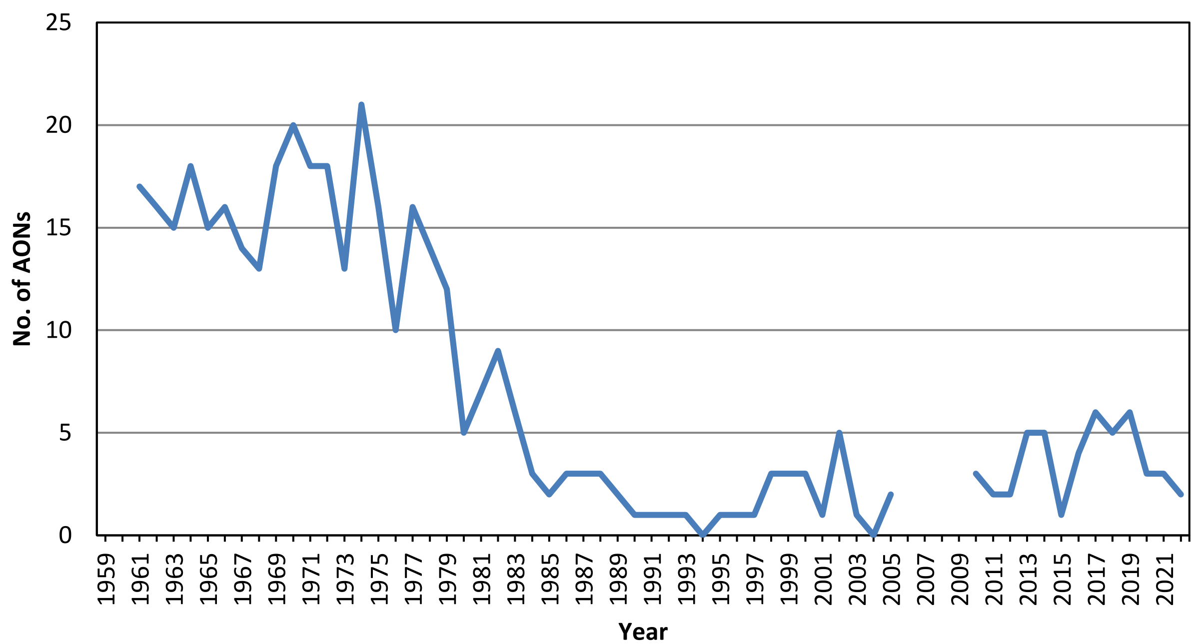
7 European Shag *Phalacrocorax aristotelis*

7.1 Breeding numbers

In the 1960s/70s the European Shag (hereafter Shag) colony on Skomer was concentrated on Shag Hole Bay, on the north side of The Neck. Over a period of years these moved to Middleholm and by the early 1990s Shags had more or less ceased to breed on the main part of Skomer (Figure 8). A few pairs, however, have continued to breed on the north coast of Skomer, at the base of Double Cliff, and on the Garland Stone. In 2021 two nests were located at the base of Double Cliff.

Efforts to locate Shag nests were primarily undertaken during the whole island counts (1st – 20th June), therefore the number of nests on Skomer may be underestimated due to the species' prolonged and variable breeding season and also that nests are well hidden and difficult to observe.

Figure 8 **European Shag breeding numbers 1960-2021**



7.2 Breeding success

Two large chicks were seen in one nest whilst conducting seabird counts. This gives a conservative estimate of productivity of exactly 1.

The Shag colony on Middleholm has been monitored and all accessible chicks ringed to obtain breeding data since the early 1980's. This work has been undertaken by the South Pembrokeshire Ringing Group with permission from the National Trust, who own the island. A visit to count nests and chicks was made on the 7th of June 2021 and all accessible chicks were ringed. The total number of nests (13) found was five fewer than 2019. Productivity was 1.88 which is the lowest since 2002.

8 Lesser Black-backed Gull *Larus fuscus*

8.1 Methods for estimating breeding numbers

The Lesser Black-backed Gull colonies were counted by eye (Eye Counts) from established vantage points between the 12th and 15th of May. The Eye Counts were conducted by Mike and Ted Wallen. In addition to the Eye Counts an assessment of vegetation height and burrow density was recorded for each sub-colony to build up a picture of the detectability of nests.

It was decided in 2021 that walk through correction counts would no longer be conducted to minimise the disturbance caused to the declining colonies on Skomer. Instead, the average correction factor (2.46; 2011 - 2019) of walk through counts was applied to eye counts.

8.2 Breeding numbers – results

From Eye Counts, a total of 3,013 AONs and AOTs were counted from standardised viewpoints around the island (Table 9), very close to the 2020 estimate of 3,086 AON/AOT. Continuing with the new methodology the average correction factor (2.46) is then applied. This approach gives a population estimate of 7,412 breeding pairs in 2021, a decrease from 7668 in 2020. This represents an increase of 22.86% over the five year average but due to a change in methodology it is likely that the numbers are not comparable.

Figure 9 Lesser Black-backed Gull breeding numbers 1961-2021

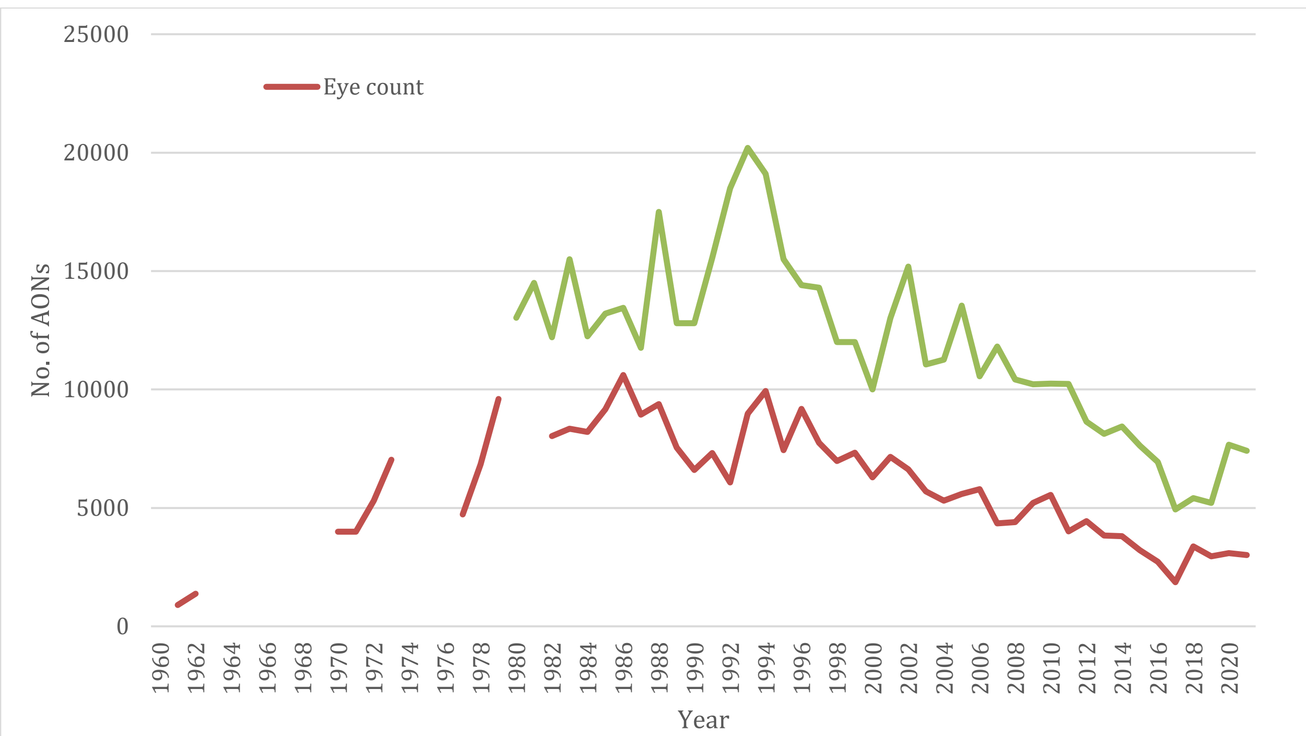


Table 9 Counts of Lesser Black-backed Gull AONs in 2021

Sub-colony	Mean eye count
1 South Old Wall	44
2 Marble Rocks	96
3 Abyssinia	66
4 Anvil Rock	67
5 Bull Hole	108
6 Pyramid Rock	50
7 North Plain	233
8, 9, 10 Sheer Face	110
11 Double Cliff	31
12 North slopes (boat count)	23
13 N-Valley Rise	197
14 Green Plain (+18 Harold Stone)	266
15 (boat count)	1
16 W/S Field (+ 24)	15
17 (extinct)	0
19 Wick Cliff	0
20 Tom's House-Sk Head	21
21 South Gorse Hill (+X)	128
22 Garland Stone	22
23 NW Neck	8
25 Wick Basin to Wick Stream	7
26 Mew Stone	3

27 Landing	0
28 The Spit	5
29 Mew Stone to Wick	0
30 Garland Stone to Bull Hole	1
31 Boat Shed	0
A (extinct, boat count)	0
B Neck E	91
C Neck main ridge	92
D South Castle	90
E Neck SW coast	5
F South Haven	31
G South Stream Cliff	49
H Welsh Way	38
I High Cliff	42
J S-Wick Ridge	50
K (extinct)	0
L Welsh Way Ridge	69
M Wick Ridges North	123
N Wick Ridges South	74
O Moory Meadow	70
P South Stream	64
Q Bramble	15
R Lower Shearing Hays	168
S New Park	125
T Shearing Hays	32
U Captain Kites	21

V Wick Basin (extinct?)	0
W The Basin	29
X Gorse Hill West (now part of 21)	
Y Field 11	104
Z Basin-South Pond	129
	Mean CF
	Total

* AONs are rounded to the nearest whole number, and so may not sum to the total number cited in the text

8.3 Breeding success

The estimated number of fledged Lesser Black-backed Gull chicks in 2021 was 4949, almost triple the estimate in 2020 (1672). The number of fledglings is calculated using a simple capture:recapture technique (Lincoln-Petersen estimate). As many large chicks as possible are ringed, and then the ringed:unringed ratio observed in the field when most of the chicks have fledged. This ratio is used to ‘scale up’ from the number of fledglings ringed to an estimate of the total number on the island.

The standard target is to ring at least 300 large chicks, but numbers fell short of this in 2021, with a total of 252 Lesser Black-backed Gull chicks ringed over ten dates between 7th July and 1st August.

The ringed/resighting estimates based on these are shown in Table 10 and the productivity in Table 11.

Table 10 **Estimated number of Lesser Black-backed Gull fledglings in 2021**

Date	No. ringed fledglings seen	No. unringed fledglings seen	Total no. fledglings seen	Est. No. of fledglings
07/08/2021	15	457	472	8874
09/08/2021	21	358	379	5089
12/08/2021	35	299	334	2691
13/08/2021	27	274	301	3144

Note: Estimated number of fledglings = (total fledglings seen x number of fledglings ringed) / number of ringed fledglings seen.

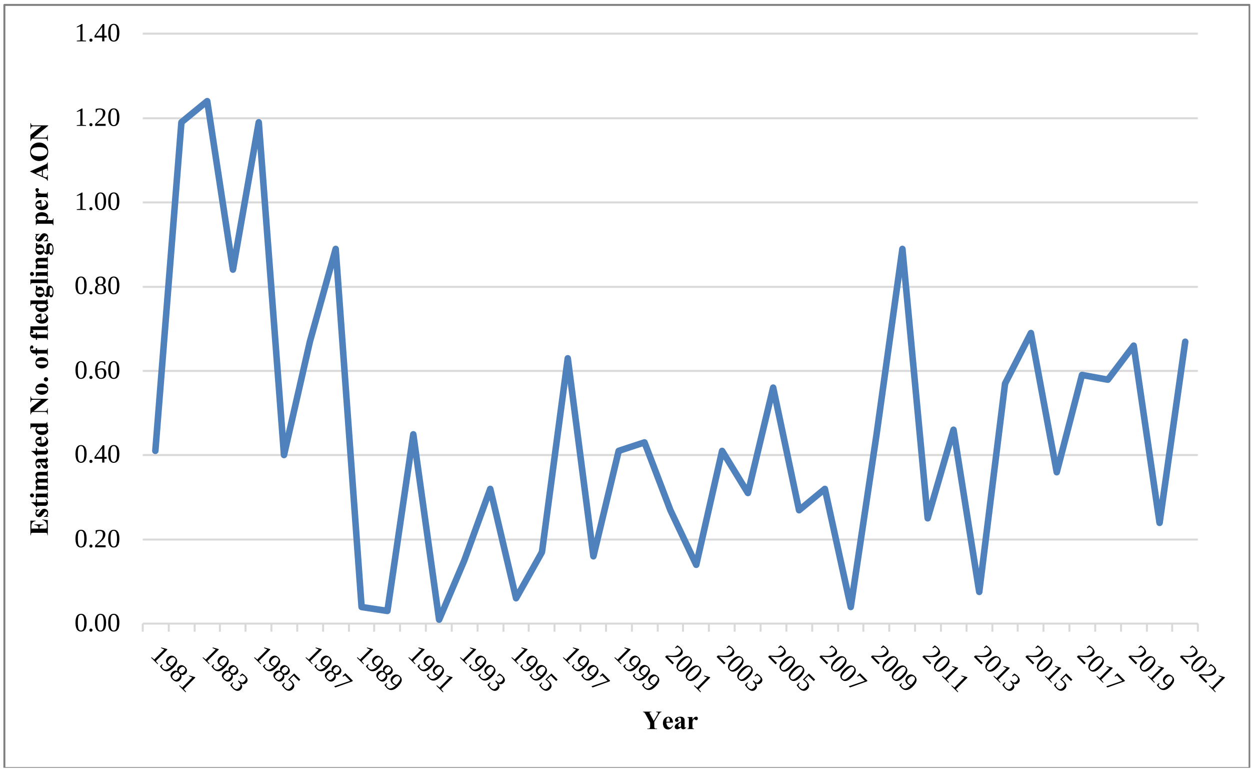
Table 11 **Estimated productivity of Lesser Black-back Backed Gulls in 2021**

	Estimated number of fledglings	Productivity
Maximum	8874	1.20
Minimum	2691	0.36
Mean	4949	0.67

Note: Productivity is calculated as the number of fledglings per AON. Number of fledglings is estimated by mark:recapture on Skomer Island excluding The Neck, and the number of AONs from corrected eye-counts (7412 using walk-through correction factors for 2011-2019 only). See Section 8.1 for method.

Estimated productivity (number of chicks fledged per AON) in 2021 was 0.67. This is fairly consistent with the historic low levels of productivity on Skomer since 1981 and is an increase of 0.43 from 2020 (0.24), which was itself a decrease of 0.42 on 2019 (0.66).

Figure 10 **Productivity of Lesser Black-backed Gulls per AON 1981-2021**

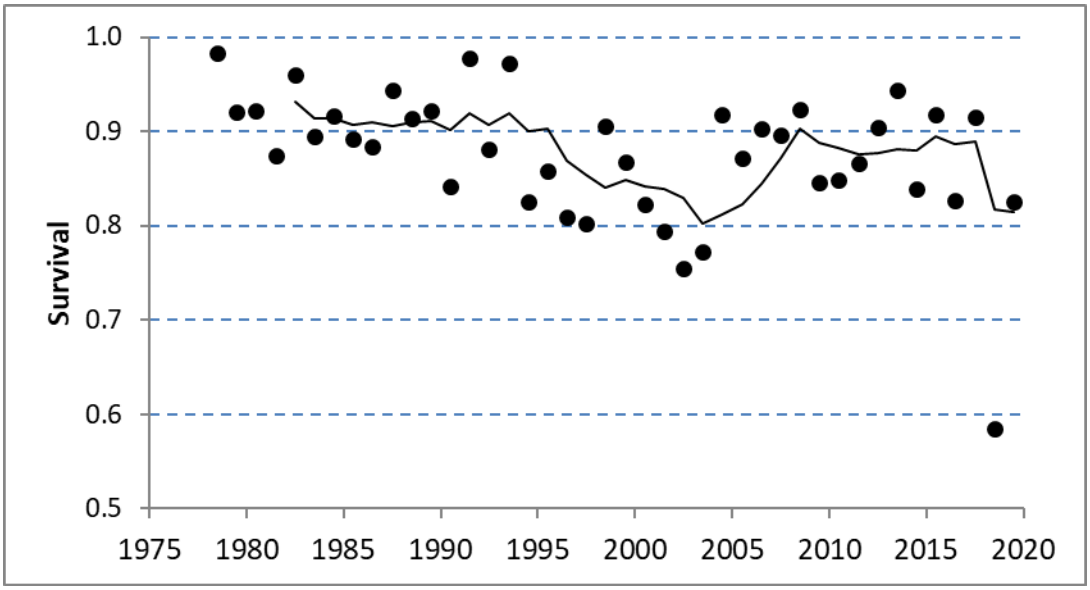


8.4 Adult survival

After declining number of resightings of ringed birds at the study area in Lower Shearing Hays, in 2021 a new study site was added at North Pond to boost the number of ringed birds. Overall survival 1978-2020 has averaged 0.87, but there has been considerable variation over time (Figure 11). The steady decline in survival from the late 1970s to the early 2000s appears to have recovered somewhat in recent years, but not to the levels of the 1970s and 80s when the population was increasing.

Survival of breeding adult birds 2019-20 was 0.82. Additional data from 2021 appears to have confirmed the marked drop in survival 2018-19.

Figure 11 Survival rates of adult breeding Lesser Black-backed Gulls 1978-2020 (includes encounter data to 2021)



Notes:

1. Fitted line shows the five-year moving average
2. The final transition in the series in such analyses cannot be estimated reliably without at least one further year's data (see Section 1.1)
3. Appendix 2 gives the estimated survival rates for 1978-2020
4. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

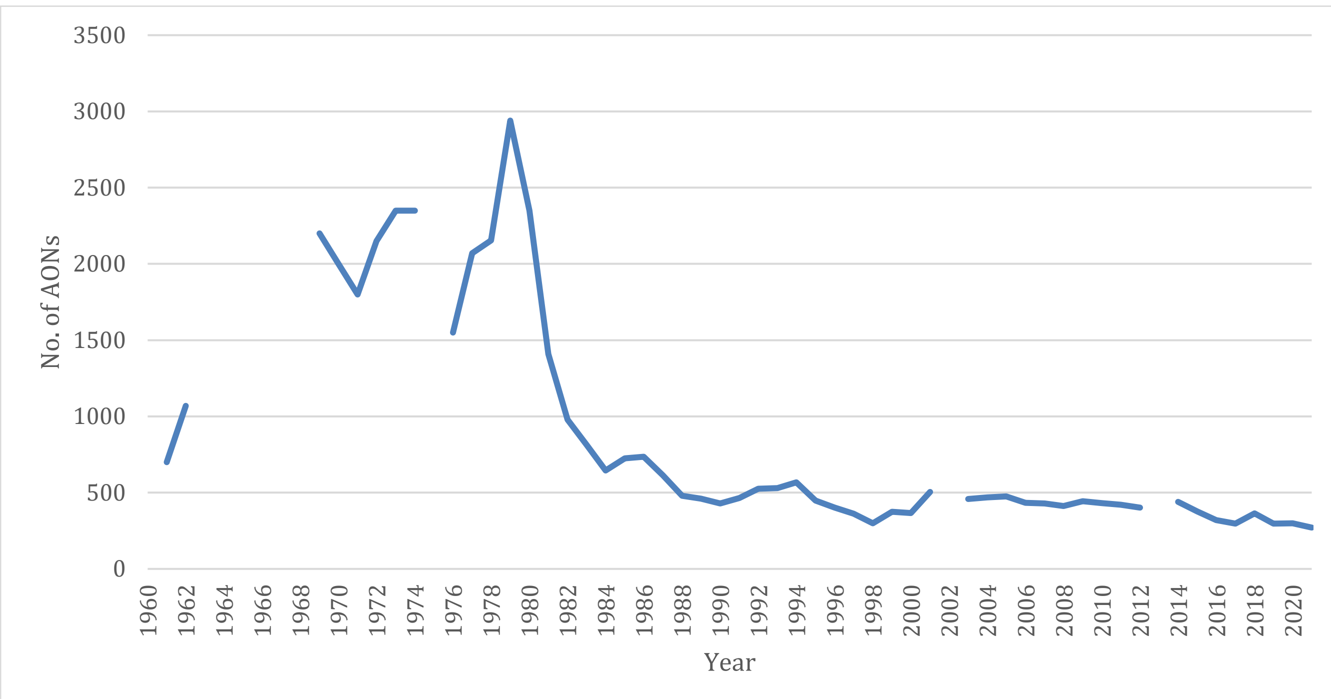
9 Herring Gull *Larus argentatus*

9.1 Breeding numbers

A total of 271 Herring Gull nests were counted in 2021 (Figure 13). This represents a decrease of 9.06% from 2020. It is worth noting that vegetation height is an important variable that is difficult to remove and may result in some fluctuation in counts. Moreover, no correction factor is used on the eye counts (as is the case for Lesser Black-backed Gulls). Approximately 199 of the AONs counted in 2021 were coastal with the remainder (72) nesting inland. This means that 73% of Herring Gulls were coastal nesting in 2021.

Skomer's Herring Gulls fell into heavy decline in the 1980s but have stabilised at a lower level since then (Figure 13). Although the number of AONs on Skomer continues to decline, productivity had, up until 2021, remained relatively consistent over the last 10-15 years indicating that Skomer's Herring Gull population dynamics are possibly stabilising or declining gradually. The national trend is also one of stabilisation after a decline since monitoring began in 1969-70. Botulism may have been an important factor in this decline as well as changes in refuse management and fisheries discards.

Figure 12 Herring Gull: Number of AONs 1961-2021



9.2 Breeding success

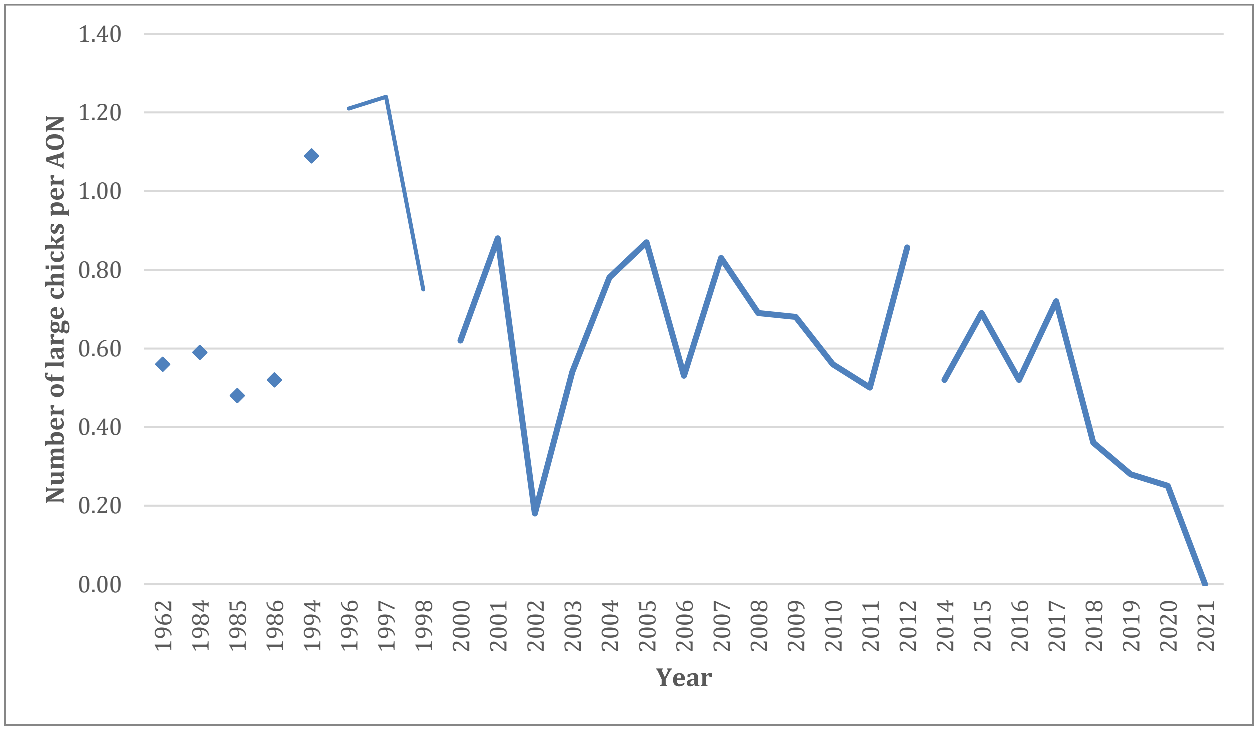
The study site at Tom's House was visited on eleven occasions between 2nd May and 20th July to map apparently occupied nests (AONs) and monitor chick development.

The final productivity is given as the total number of fledged chicks divided by the total number of AONs within the study plot. For the first year since monitoring began, no chicks fledged from the study nests, giving a productivity of 0 (Table 12 and Figure 13), which is far below the historical mean of 0.65.

Table 12 Productivity of Herring Gulls on Skomer in 2021

	AON	Large Chicks	Productivity
Tom's House	25	15	0

Figure 13 Breeding success of coast-nesting Herring Gulls, 1962-2021

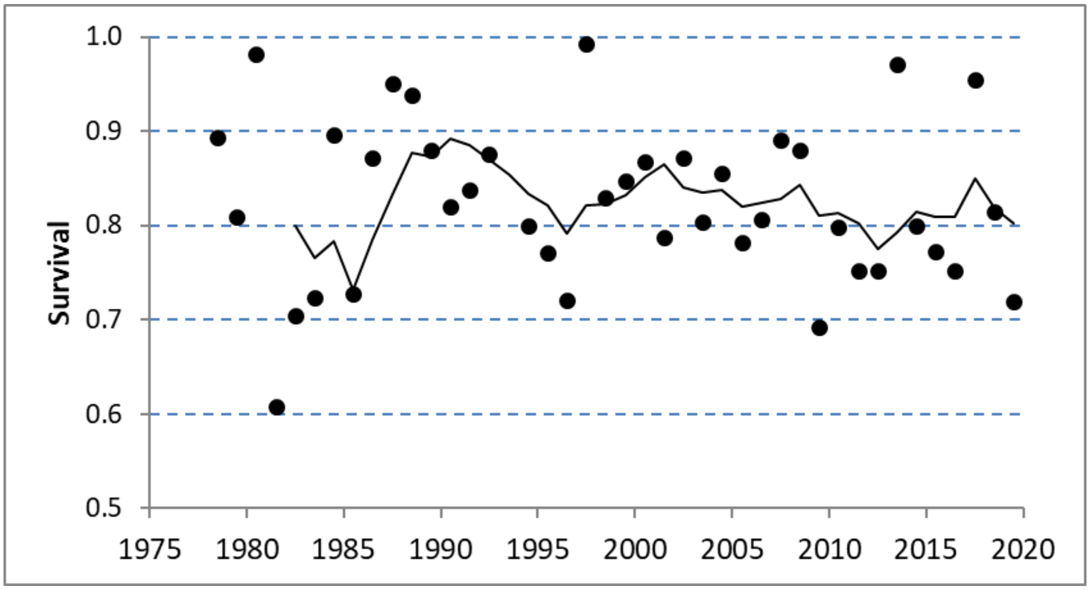


9.3 Adult survival

This study was originally based on birds nesting along the north coast, but the breeding population at that colony dropped so markedly that a second study plot in the area from Tom's House to Skomer Head is now used instead, extended in 2017 to Wick Basin. However, the population size here is still smaller than desirable, and it may be necessary to start an additional study plot. From 2017, adult Herring Gulls have been colour-ringed on Skokholm Island to explore this option and allow us to maintain a useful sample size across the Skokholm, Skomer and Middleholm SPA.

The most recent annual survival estimate (2019-20) is 0.72, the study average (19778-2020) is 0.82.

Figure 14 Survival rates of adult breeding Herring Gulls 1978-2020 (includes encounter data to 2021)



Notes:

1. Fitted line shows the five-year moving average
2. Survival was non-estimable in 1980-81, 1993-4, 1997-8 (the final transition in the series in such analyses is not estimable, Section 1.1)
3. Appendix 2 gives the estimated survival rates for 1978-2019
4. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

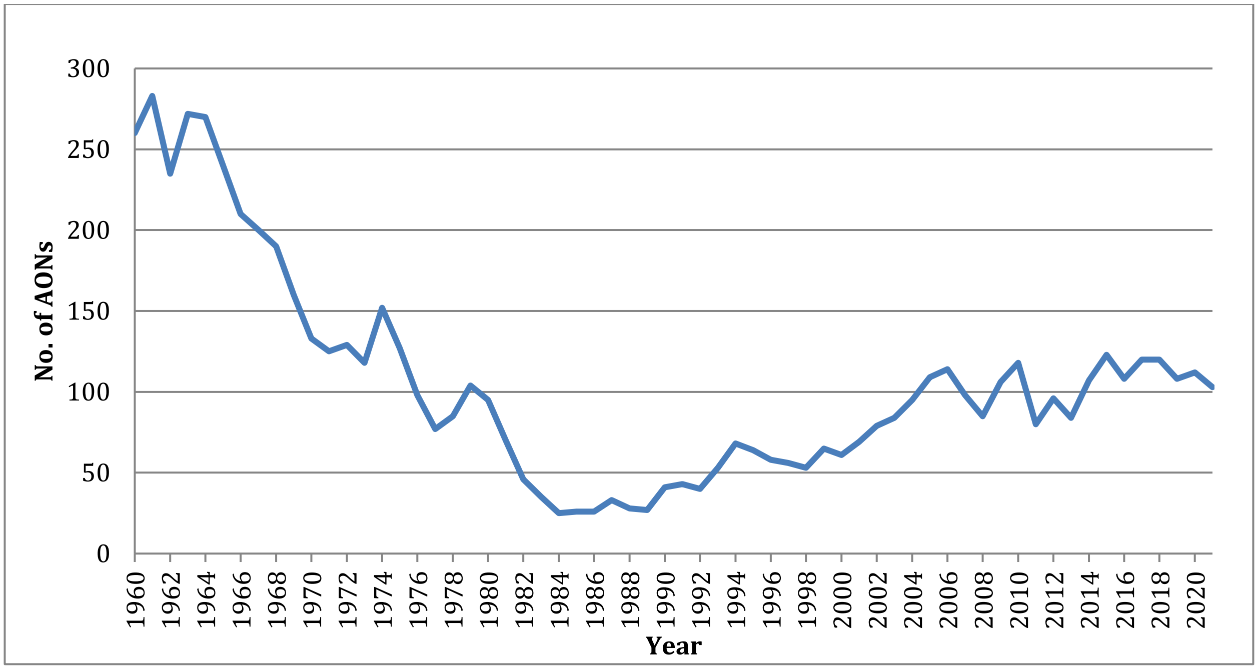
10 Great Black-backed Gull *Larus marinus*

10.1 Breeding numbers

A whole island total of 103 AON were counted in 2021 compared to 112 in 2020. The decline since the 1960s has been attributed largely to control measures in the 1960s and 1970s that were implemented as a result of the species perceived predatory impact on other seabirds. An outbreak of botulism in the early 1980s also contributed to the decline (Sutcliffe 1997).

The national trend is one of slow decline since 1999. However recent data from Skomer Island suggests that the islands population may be recovering from earlier setbacks between the 1960s and 80s (Figure 15), a trend even more marked on the nearby Skokholm Island (Brown, R. and Eagle, G. 2017). This is undoubtedly due to the discontinuation of control measures combined with the abundance of prey (particularly seabirds and Rabbits) on the islands. The population appears to have stabilised in the previous few years, however.

Figure 15 Great Black-backed Gull breeding numbers on Skomer Island 1960-2021

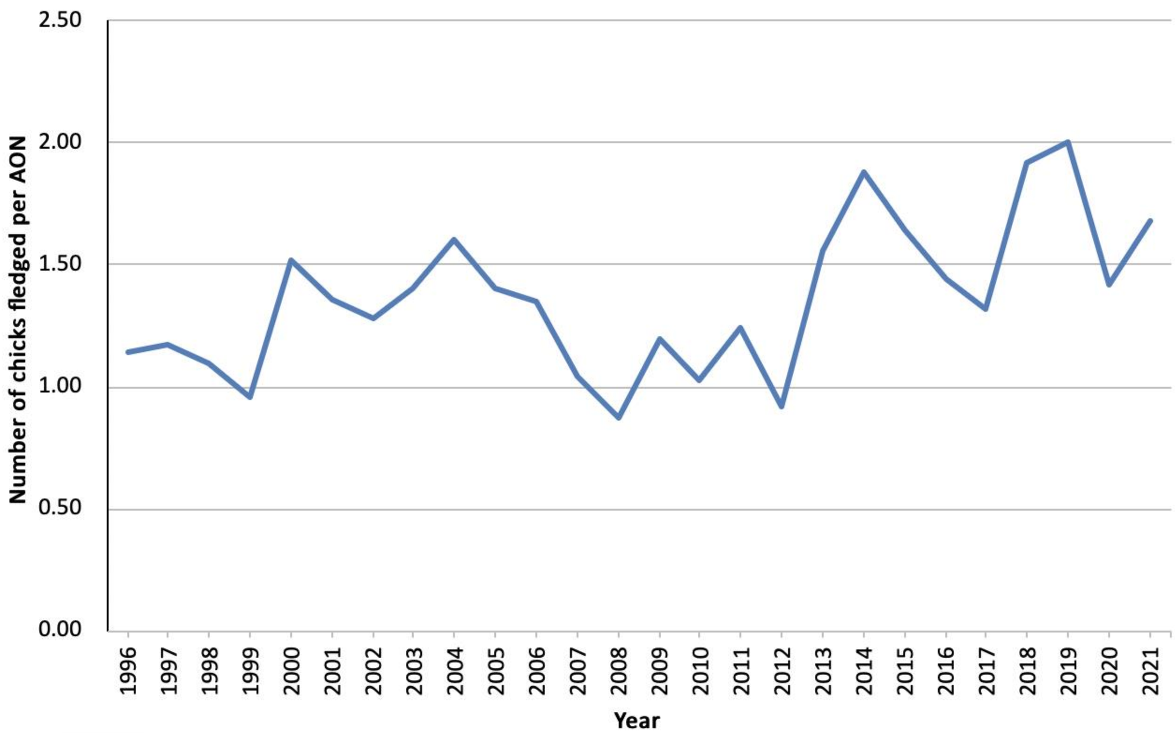


10.2 Breeding success

Monitoring of the breeding success of Great Black-backed Gulls has been included in the JNCC contract since 1999.

Twenty-five Great Black-backed Gull nests were selected from across the island during May. These nests were visited between 24th June and 20th July, during which 42 large chicks were recorded and assumed to have fledged. This gives a productivity of 1.68 chicks per breeding pair, which is higher than the historical mean (1996 – 2020) of 1.35 (Figure 16).

Figure 16 Great Black-backed Gull productivity on Skomer Island 1996-2021



10.3 Diet study

Since 2008 the diet of Great Black-backed Gulls has been monitored by recording the frequency of prey remains found around 25 nests. Prey items were recorded within a five-meter cross-shaped transect, centred on each nest. The number of Manx Shearwater and Rabbit carcasses within a 10-metre radius of the nest were also recorded for comparison with historic records of Manx Shearwater predation levels. Surveys were conducted in early August, after chicks had fledged. This study was not completed in 2020, so results will be compared with 2019.

In 2021 Manx Shearwater made up 10% of the prey remains recorded within the five meter transects around the 25 surveyed nests (Figure 17), which is higher than the 8% recorded in 2019. Manx Shearwater remains were found at 92% of nests surveyed (Figure 18), again up from 84% in 2019.

Rabbit remains were found at 52% of nests and represented 3% of the prey items recorded in 2021(Figure 17, Figure 18). This is lower than was seen in 2019 when they were found in 72% of nests and made up 8% of prey items.

This season, an average of 13.6 Manx Shearwater carcasses were found within a 10-metre radius of each nest (Figure 19). This is higher than the 10.6 reported in 2019, higher than the historical average of 7.94, and is in fact the highest ever recorded. Care needs to be taken when comparing results between years, as what should be counted as a 'carcass' could be interpreted differently.

The average number of Rabbit carcasses found within a 10-metre radius of each nest was 2.28, which is lower than the 4.2 recorded in 2019.

Figure 17 Great Blacked-backed Gull diet remains within a five-metre cross-shaped transect around 25 Great Black-backed Gull nests in 2021

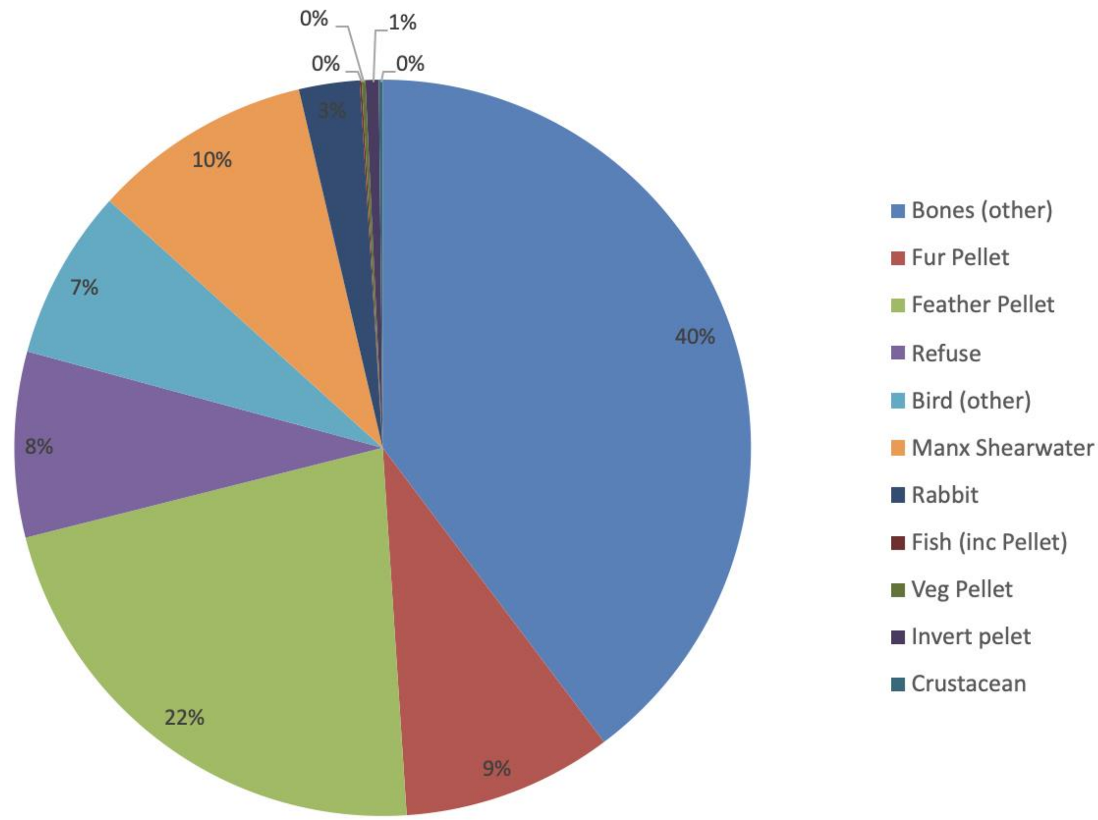


Figure 18 Percentage of occurrence of food items within a five metre radius cross-shaped transect around 25 Great Black-backed Gull nests in 2021

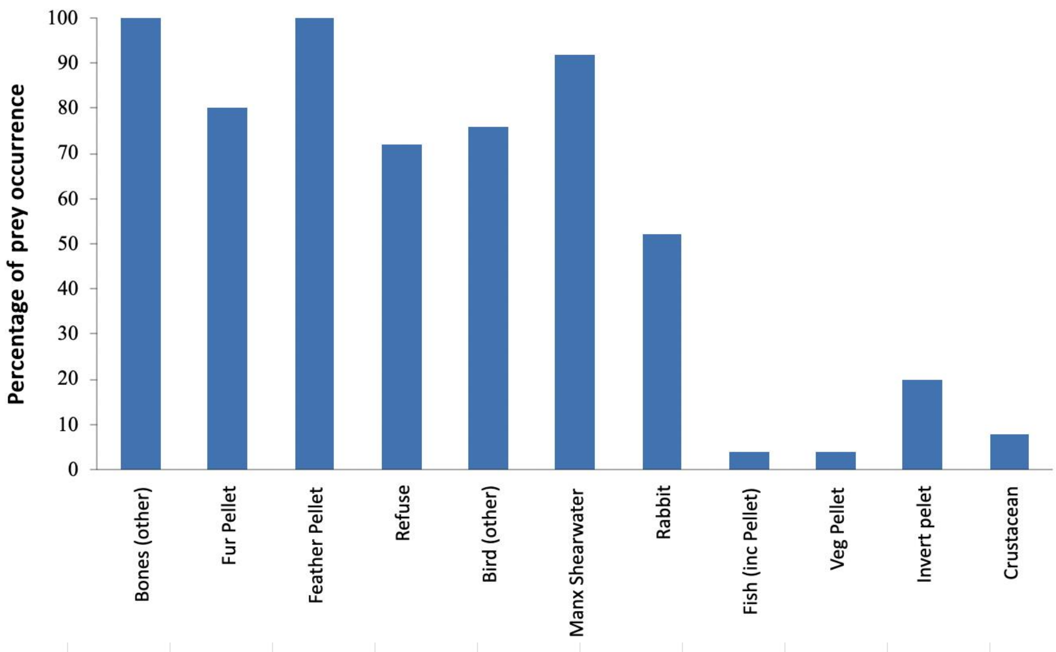
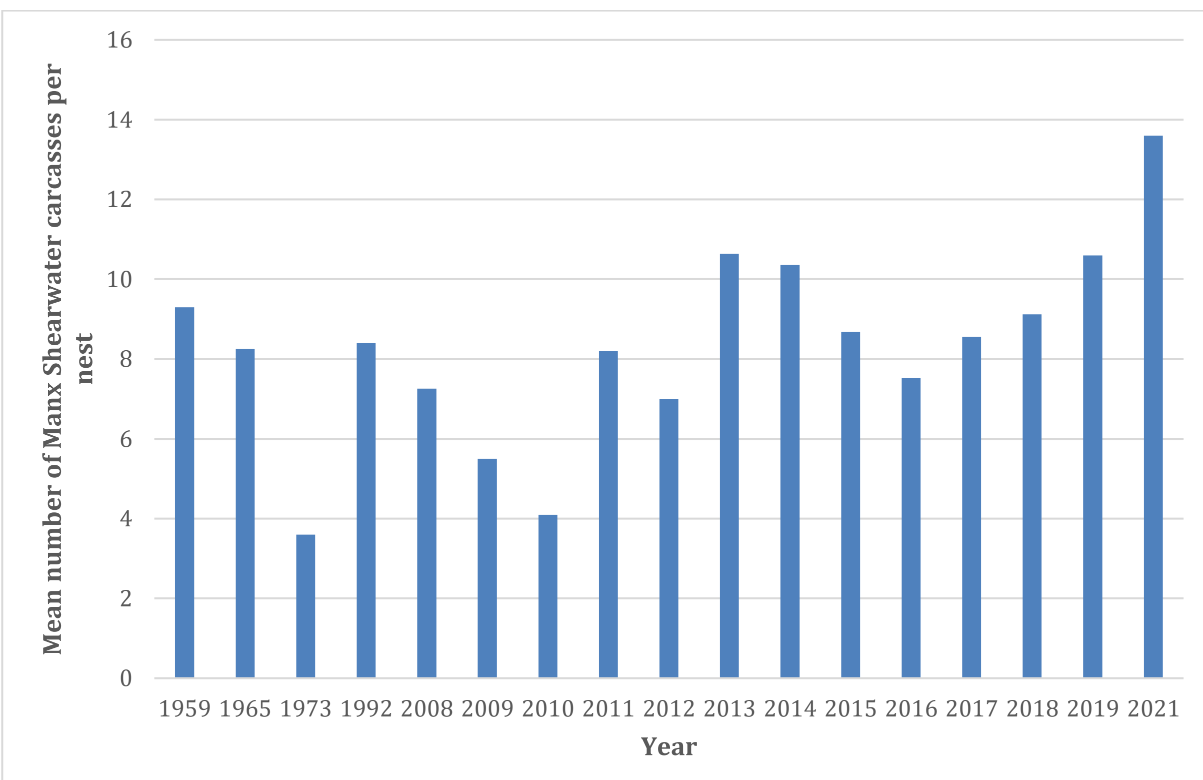


Figure 19 Mean number of Manx Shearwater carcasses found within 10m radius of 25 Great Black-backed Gull nests 1959; 1965; 1973; 1992; and 2008–2021



11 Black-legged Kittiwake *Rissa tridactyla*

11.1 Breeding numbers

A total of 1,439 AON were counted in 2021 which is a decrease from 1,681 in 2020 (Figure 20). 1,439 AON is however, very similar to 1,451 counted in 2019. This year's total is 0.21% higher than the mean of the previous five years (2016-2020: 1,436 AON) (Table 13) and is a 2.04% decrease on than the mean of the previous ten years (2011-2020: 1,469 AON).

Nationally (and especially in Scotland) the Kittiwake population has undergone a steep and well-documented decline since the mid-1980s. This has been most dramatic in Scotland with the index in 2018 being 69% below the 1986 baseline. Wales' and Skomer's population has shown more stability followed by a slower decline over this period, and Kittiwake numbers on Skomer have fallen by 33.01% since 1986 (Figure 20).

Figure 20 Black-legged Kittiwake breeding numbers 1960-2021

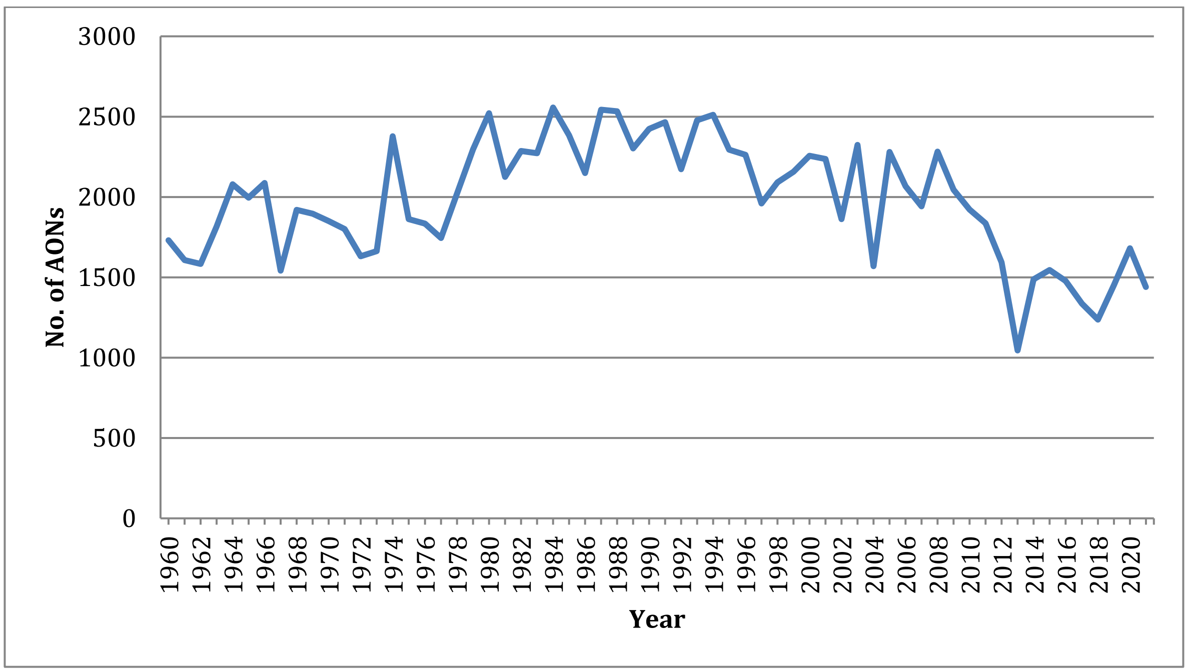


Table 13 **Black-legged Kittiwake whole island count details 2009-2021**

Year	Total	% change from previous year	5 year % change
2009	2046	-10.3	-10.3
2010	1992	-6.06	-7.01
2011	1837	-4.02	-5.41
2012	1594	-13.23	-30.15
2013	1045	-34.44	-48.93
2014	1488	+42.40	-22.58
2015	1546	+3.90	-20.74
2016	1477	-4.46	-7.34
2017	1336	-9.55	-6.57
2018	1236	-7.49	-10.30
2019	1451	+17.39	+2.43
2020	1681	+15.81	+19.30
2021	1439	-14.40	+0.21

11.2 Breeding success

11.2.1 Methods

The breeding success of Kittiwake apparently occupied nests (AONs) was monitored at the same three sub-colonies studied since 1989: South Stream (plot 1 and 2), High Cliff (plot 2) and the Wick (plot 3, 4, 5 and 6).

Nests were mapped out on photographs during a visit in late May and another in mid-June. These nests were monitored throughout the breeding season, with visits carried out every 14 days initially, increasing to every 5 days once chicks reached a 'medium' size. This increase in the number of visits during the chick rearing period has been carried out since 2015. A total of 10-11 checks were done at each study plot, with the last plots being monitored until 8th August. All chicks that were large on the final visit (class 'e' in Walsh et al (1995)) were assumed to have fledged.

The final productivity for the island is given as the total number of large/fledged chicks divided by the number of AONs across all plots.

11.2.2 Results

A total of 520 nests were started in the study plots, resulting in 463 apparently occupied nests (AON's). These AONs produced a minimum of 527 chicks, although this is likely to be an underestimate due to the difficulty of recording small chicks. A total of 366 chicks reached a 'large' size and were therefore considered to have successfully fledged.

The productivity for 2021 was 0.79 (Table 14). This is the highest productivity seen on the island since 2010 and is above both the historical average of 0.69 (1989-2020) the past five-year average (0.59) (Figure 21, Table 15).

Table 14 Black-legged Kittiwake productivity per AON on Skomer Island for 2021

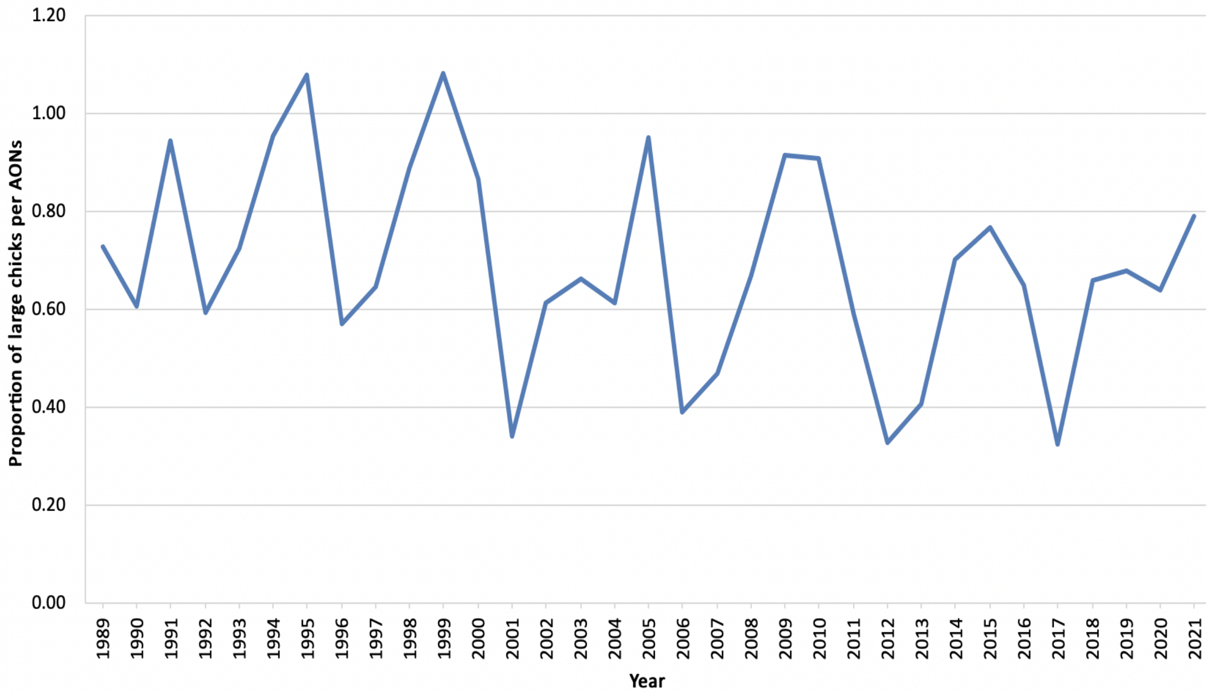
Site	Nests started	AON'S	Incubating Pairs	Nest with chicks	Total chicks	Large chicks	Productivity per site
S. Stream 1	110	100	98	84	133	97	0.97
S. Stream 2	73	62	62	41	59	37	0.60
High Cliff	98	87	84	76	137	85	0.98
The Wick 3	35	31	31	25	41	36	1.16
The Wick 4	75	70	70	46	72	66	0.94
The Wick 5	95	85	74	49	69	44	0.52
The Wick 6	34	28	22	10	16	1	0.04
Totals	**520**	**463**	**441**	**331**	**527**	**366**	**0.79**

Table 15 Black-legged Kittiwake productivity on Skomer Island 2016 – 2021

Year	Nest started	AON's	Large chicks	Productivity
2016	424	399	260	0.65
2017	433	381	124	0.33
2018	450	386	255	0.66
2019	507	438	298	0.68
2020	572	511	325	0.64
2021	520	463	366	0.79
			Mean*	**0.59**
			SD*	**0.15**
			SE*	**0.07**

* Mean, SD and SE excludes results from 2021.

Figure 21 **Black-legged Kittiwake productivity on Skomer Island 1989 – 2021**



11.3 Timing of breeding

Nest building was first noted on 4th May and the first eggs were seen at the Wick and South Stream on 17th May. The first chick was recorded on 8th June and first fledglings were seen on 22nd July, both at South Stream (Table 16).

Table 16 **Black-legged Kittiwake phenology records 2013 – 2021**

	2013	2014	2015	2016	2017	2018	2019	2020	2021
Nest building start	10 May	23 April	4 May	2 May	6 May	11 May	8 May	12 May	4 May
First egg	28 May	22 May	19 May	20 May	23 May	25 May	19 May	21 May	17 May
First chick	23 June	24 June	20 June	14 Jun	14 June	20 June	15 June	16 June	8 June
First fledgling	—	27 July	24 July	25 July	25 July	28 July	17 July	20 July	22 July

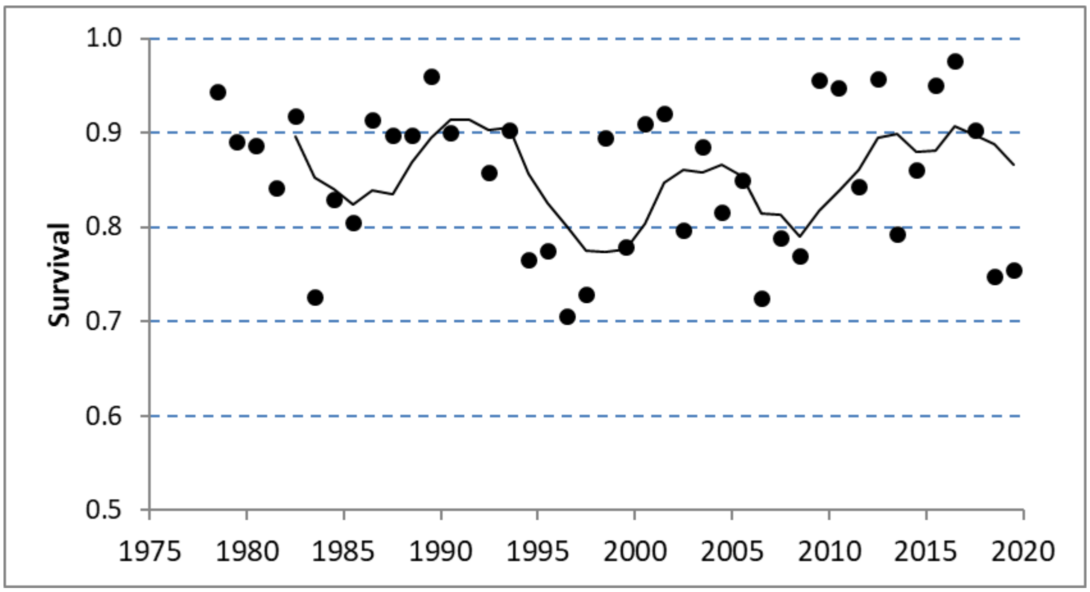
11.4 Breeding adult survival

These analyses are based on colour-ringed birds nesting at the South Stream Cliff study plot, as well as any others found around the island that have moved from that site.

Over the period 1978-2020, survival of breeding adults averaged 0.85 (Figure 22). There continues to be a cyclic fluctuation in adult breeding survival over the course of the study, and indications of a long-term decline in survival rate. The survival rate of breeding adult Kittiwakes in 2019-20 remained low at 0.75.

Given the difficulties faced by Kittiwake populations further north in the UK, and the declining numbers on Skomer, we remain concerned for the status of the Skomer population (Horswill et al 2022).

Figure 22 Survival rates of breeding adult Kittiwakes 1978-2020 (includes encounter data to 2021)



Notes:

1. Fitted line shows the five-year moving average
2. Survival was non-estimable in 1991-2
3. The final transition in the series is not estimable, requiring one further year's data (see Section 1.1)
4. Appendix 2 gives the estimated survival rates for 1978-2020
5. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

12 Common Guillemot *Uria aalge*

12.1 Breeding numbers - whole island counts

Two whole island counts of Common Guillemots (hereafter Guillemot) were made between 1st and 20th June. A mean of 27,269 Guillemots we counted (range: 26,983-27,555) which is a decrease of 5.31% from the last whole island count of Guillemots in 2019.

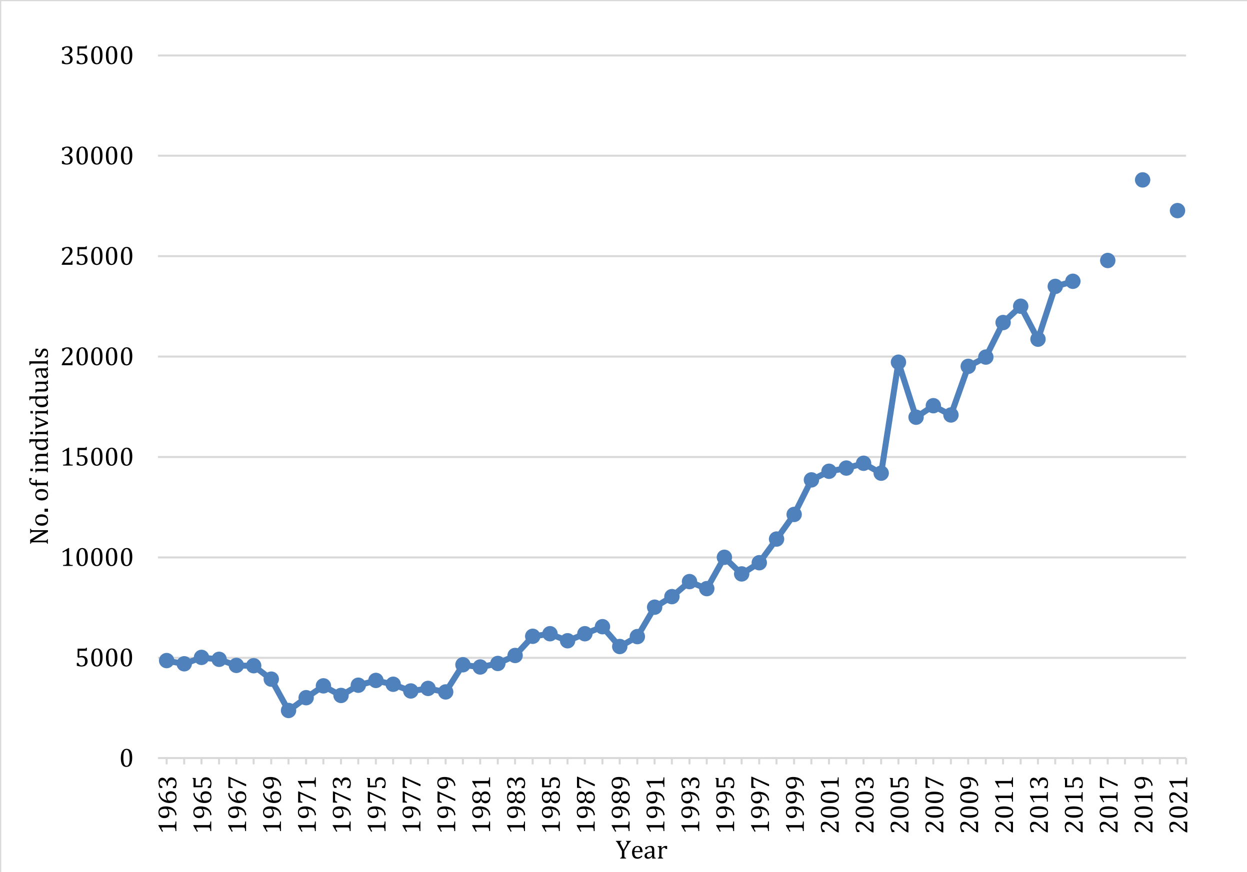
The national trend, since 1986, has been one of an increasing population. However, trends in each country are markedly different with losses in Scotland and increases in England, Wales and Northern Ireland. Moreover, recent years of poor productivity and lower return rates may well lead to future declines in the national population. Skomer's population has shown a steady increase during the same time period; 2021 is the first time the population has decreased since 2013.

Table 17 Common Guillemot whole-island counts 2008-2015; 2017; 2019 and 2021

Year	Land count	% change	Sea count	% change	Total count	% change from previous year	5-year % change
2008	11579	-23.6	5509	+56.5	17088	-2.60	+20.45
2009	14339	+23.8	5173	-6.10	19512	+14.19	-1.01
2010	15643	+9.09	4319	-16.51	19962	+2.31	+17.58
2011	15064	-3.70	6624	+53.37	21688	+8.65	+23.62
2012	16557	+3.78	5951	-10.17	22508	+3.78	+31.72
2013	15025	-9.25	5837	-1.92	20862	-7.31	+6.92
2014	12437	-17.22	11056	+89.41	23493	+12.61	+17.69
2015	12822	+3.10	10924	-1.06	23746	+1.08	+9.49
2016*							
2017	13547	+5.65	11241	+2.90	24788	+4.39	+9.43
2018*							
2019	19580	+44.53	9218	-18.0	28798	+16.18	+24.78
2020*							
2021	18021	-7.96	9036	-1.97	27269	-5.31	+12.05

*Not censused in these years

Figure 23 **Common Guillemot numbers (whole island) 1963-2015; 2017; 2019 and 2021**



12.2 Breeding numbers - study plot counts

The study plots are thought to be representative of the whole island population (Wilson 1992) and may reflect any population change more accurately than the whole island counts, as repeated counts take account of variations in attendance that is thought to occur within colonies. For details of counts refer to Appendix 4.

Breeding population counts for Guillemots were continued at the four study plots established at the Wick (Wick A; Wick B; Wick C; Wick D) by the Wildlife Trust of South and West Wales, Sheffield University and JNCC in 2016.

A total of ten counts were made at four study plots at the Wick during the first three weeks of June. All study plots were completed on the same day and every individual plot was done by the same observer to reduce variation between repeat counts.

There were significantly fewer Guillemots counted at the Wick study plots this year compared to 2020, with a 20% decrease in the mean total counted across all plots (Table 18). However, numbers were up 2% from the number counted in 2019. Comparison of counts prior to 2016 are not possible due to the change of study plots. See Appendix 4 for details of the study plot counts prior to 2016.

Table 18 **Common Guillemot study plot count totals at the Wick 2016-2021**

Study Plot	Year	Mean	SD	SE	Sign.	% Change
Wick A	2016	102	4.77	1.51	—	—
	2017	104	8.87	2.80	NS	+1.86
	2018	104	8.99	2.84	NS	0.00
	2019	124	6.36	2.01	**	+19.17
	2020	161	7.30	3.26	**	+29.83
	2021	140	7.04	2.23	**	-12.83
Wick B	2016	81	4.84	1.53	—	—
	2017	77	6.51	2.06	NS	-4.94
	2018	85	6.64	2.10	*	+9.88
	2019	95	6.92	2.19	**	+12.19
	2020	105	13.04	5.83	NS	+10.76
	2021	65	5.17	1.63	**	-37.81
Wick C	2016	85	7.37	2.33	—	—
	2017	77	10.36	3.28	NS	-8.64
	2018	84	8.53	2.70	NS	+9.33
	2019	96	12.32	3.90	*	+13.51
	2020	128	13.57	6.07	**	+33.82
	2021	112	10.12	3.20	*	-12.79
Wick D	2016	44	5.90	1.86	—	—
	2017	42	7.41	2.34	NS	-5.44
	2018	34	4.81	1.52	*	-17.75
	2019	51	12.93	4.01	**	+48.04
	2020	72	12.74	5.70	*	+40.67
	2021	55	11.89	3.76	*	-22.63
Total	**2016**	**311**	**14.27**	**4.51**	**—**	**—**
	2017	**300**	**24.76**	**7.83**	**NS**	**-3.7**
	2018	**307**	**25.17**	**7.96**	**NS**	**+2.47**
	2019	**365**	**29.40**	**9.30**	******	**+18.96**
	2020	**465**	**33.59**	**15.02**	******	**+27.40**
	2021	**373**	**22.93**	**7.25**	******	**-19.96**

Note: Significance between years established using the t-test for comparing the means of two small samples (two-tailed test, df=n-1). NS Not significant, * Statistically significant ($P<0.05$), * * Statistically highly significant ($P<0.01$). See Appendix 4 for count details.

The old study plots (Bull Hole, South Stream and High Cliff) were counted twice during the first three weeks of June, with the aim to look at whether the new plots are representative of the whole island population. Bull Hole showed the greatest increase, up 20% since it was last counted in 2016. High Cliff showed a 9% increase, and South Stream just 2% (Table 19). The overall increase across all three plots was 14%.

Table 19 Old Guillemot plot counts 2016 and 2021.

	2016	2021	% Change
Bull Hole	3662	4407	+20.34
South Stream	1034	1054	+1.93
High Cliff	2402	2628	+9.41
Total	**7098**	**8089**	**+13.96**

12.3 Breeding success

12.3.1 Methods

The number of active and regularly occupied sites was established at the Wick Corner study plot and their histories followed, using the methodology outlined in Walsh *et al*. (1995). Visits to the study plot were made from late April to begin mapping the location of pairs. Monitoring was conducted from 25th April until 19th July.

The study plot was visited every day where possible, with the greatest time effort made during egg laying, hatching and fledging periods. The number of visits was 81, comparable with the 85 visits made in 2020.

Productivity is given as the total number of fledged or apparently fledged chicks (last seen at 15 or more days old) divided by the number of active and regularly occupied sites and active sites only at the Wick Corner study plot.

12.3.2 Results

A total of 127 occupied sites were monitored at the Wick Corner study plot. The productivity for active and regularly occupied sites was 0.60 chicks per breeding pair, and the productivity for active only occupied sites was 0.61 (Table 20). The productivity results for this year are much lower than last year (0.76).

Guillemots breeding in sparse groups have lower breeding success than those breeding in dense groups, such as on a breeding ledge (Birkhead 1977). The inclusion of the eight isolated breeding sites from the top section of the Wick Corner study plot would bias results by reducing the productivity of the study plot and therefore were excluded from the reported results for 2021, as they were in 2020. However, if these eight isolated breeding sites are included, the productivity for active and regularly occupied sites at the Wick Corner study plot would be reduced to 0.56, and the productivity for active only occupied sites would be reduced to 0.57.

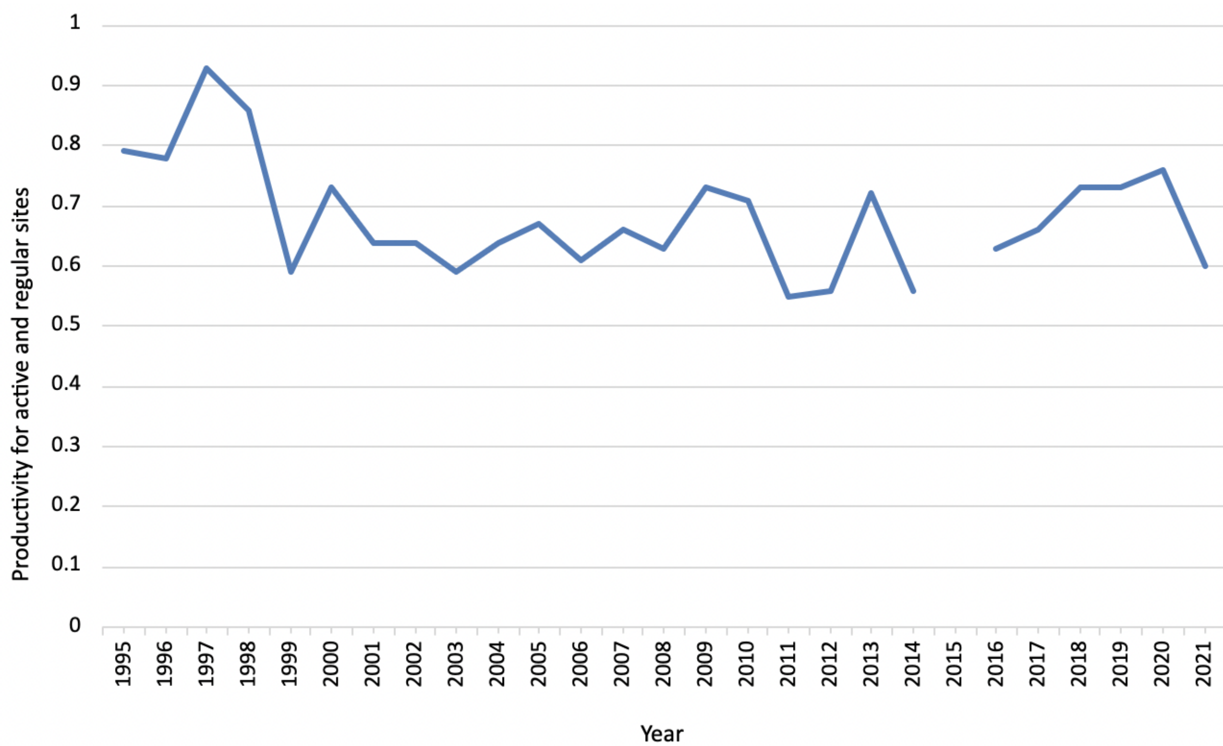
Table 20 shows the productivity of Guillemots on Skomer Island since 1989. The productivity for 2021 is the lowest recorded since 2011 and therefore also lower than the average productivity of the active and regular sites (0.68) and active only sites (0.72) since 1989. A large number of active nest sites failed at the egg stage, which could be the result of two storms early in the incubation period. It should be noted that these results include monitoring from plots other than the Wick Corner. Comparisons of only the Wick Corner study plot since 1995 show that the average productivity for active and regular sites is also 0.68. (Figure 25; Appendix 4).

Table 20 **Common Guillemot productivity on Skomer Island 1989 – 2021**

Year	Number of sites, active + regular.	Number of sites, active only.	Number of chicks fledged	Productivity per active + regular site	Productivity per active site only
1989	120	—	96	0.80	—
1990	112	—	80	0.71	—
1991	140	—	107	0.76	—
1992	171	—	121	0.71	—
1993	198	—	141	0.71	—
1994	187	—	135	0.72	—
1995	198	190	151	0.76	0.79
1996	210	195	161	0.77	0.83
1997	211	205	174	0.82	0.85
1998	199	191	154	0.77	0.81
1999	242	190	147	0.61	0.77
2000	227	212	143	0.63	0.67
2001	259	232	160	0.62	0.69
2002	259	236	170	0.66	0.72
2003	262	234	179	0.68	0.76
2004	292	257	184	0.63	0.72
2005	297	267	200	0.67	0.75
2006	287	264	142	0.49	0.54
2007	258	243	164	0.64	0.67
2008	283	249	164	0.58	0.66
2009	254	241	185	0.73	0.77
2010	315	285	211	0.67	0.74
2011	292	260	153	0.52	0.59
2012	318	283	185	0.58	0.65
2013	328	283	212	0.63	0.75
2014	300	293	183	0.61	0.62
2015*	63	63	48	0.76	0.76
2016**	123	122	77	0.63	0.63
2017**	103	99	69	0.66	0.69
2018**	106	101	77	0.73	0.76
2019**	124	123	91	0.73	0.74
2020**	119	116	91	0.76	0.76
2021**	127	125	76	0.60	0.61
			Mean***	**0.68**	**0.72**
			SD***	**0.08**	**0.07**
			SE***	**0.01**	**0.01**

*In 2015 only plot Wick 1G was monitored
**Only the Wick Corner was monitored (Wick 1G, Wick 2G and Bull Hole were dropped in 2016).
*** Mean, SD and SE excludes results from 2021.

Figure 24 **Common Guillemot productivity at the Wick Corner Study plot 1995 – 2021**



12.4 Timing of breeding

The first egg on the island was noted on 27th April and the first chicks on 30th May, at the Amos. The first 'jumpling' was recorded on 21st June at the Wick Corner study plot. The median fledging date at the Wick Corner study plot was 28th June, with 49% of chicks fledging around this date (26th to 30th June).

Table 21 **Common Guillemot phenology records 2014-2021**

	2014	2015	2016	2017	2018	2019	2020	2021
First egg	12 May	30 April	27 April+	2 May	5 May	22 April	23 April	27 April
First chick	10 June	3 June	2 June	2 June	4 June	19 May	25 May	30 May
First 'jumpling'	28 June	23 June	22 June	22 June	28 June	17 June	22 June	21 June
Median fledge date	11 July	3 July*	5 July	2 July **	6 July**	22 June**	22 June**	28 June**

+ Guillemot egg seen being carried by a Raven, first egg seen on a ledge on the 29th April at the Amos.
* Records came only from one plot, the Wick 1G.
** Records came only from one plot, the Wick Corner

12.5 Adult and juvenile survival

These and other Common Guillemot studies were undertaken by The University of Sheffield, under the supervision of Prof. Tim Birkhead, for over 40 years. Unfortunately, in 2014, funding from Natural Resources Wales (NRW) was withdrawn from this study and it is currently being supported by private fundraising efforts. The project is now managed by Prof. Steve Votier (Heriot Watt University).

Results from fieldwork in 2021 suggest that survival of adult Guillemots were (as in 2020) similar overall to the average. A summary of these studies can be found in Appendix 1.

13 Razorbill *Alca torda*

13.1 Breeding numbers - whole island counts

Two whole island counts of Razorbills were made between the 1st and 20th June. A mean of 8,168 individual Razorbills were counted (range: 7,724-8,612) which is 8.49% higher than the 7,529 individuals counted in 2018, the last time there was a whole island count.

Due to difficulties in censusing this species (being less concentrated than Guillemots and often breeding in hidden sites amongst boulders and in burrows), the pattern of Razorbill numbers on Skomer is probably a less accurate reflection of population variation (Figure 25). However, it has been measured in a consistent way for over 50 years. Numbers have more than doubled since the early 1960s when records began and, although there has been some variation between years (when compared with the increase of Guillemot on Skomer), the trend has been upwards.

Table 22 Razorbill whole island count details 2006-2021

Year	Land count	% change	Sea count	% change	Total count	% change	% 5-yr change
2006	2955	-22.5	1606	-17.6	4561	-20.8	-10.5
2007	3588	+21.4	1259	-21.6	4847	+6.3	+14.3
2008	2336	-34.9	2637	+109.5	4973	+2.6	+ 2.6
2009	2970	+27.1	2292	-13.1	5262	+5.8	-8.6
2010	2835	-4.55	2556	+11.6	5391	+2.5	+18.2
2011	2141	-24.48	2977	+16.47	5118	-5.06	5.59
2012	2428	+13.40	2543	-14.58	4971	-2.87	-0.04
2013	2719	+11.99	3944	+55.10	6663	+34.04	+26.63
2014	2016	-25.86	4525	+14.73	6541	-1.83	+21.33
2015	2813	+6.41	4676	+1.21	7489	+14.49	+46.33
2016	2760	-1.88	4490	-3.98	7250	-3.19	+45.85
2017*							
2018	2861	+3.66	4668	+3.96	7529	+3.85	+14.37
2019*							
2020*							
2021	3409	+19.15	4759	+1.95	8168	+8.49	+15.14

*Not censused in these years

13.2 Breeding numbers - study plot counts

A study in 1992 (Wilson 1992) suggested that the Razorbill study plot counts were not thought to be representative of the whole island population. Changes in the plot counts between years, however, still provide useful information. In particular, ten land-based counts provide a more valid representation of population change than two land/sea-based counts. For details of counts refer to Appendix 4.

A total of ten counts were made at each study plot this year during the third week of June. All study plots were completed on the same day and every individual plot was done by the same observer to reduce variation between repeat counts.

In 2021 there was a decrease of 13% in the total number of Razorbills counted across all the study plots compared to 2020, but an increase of 6% compared to 2019 and 4.9% from the five-year average (2016-2020). Caution is suggested when comparing count data with years prior to 2018 due to the change in the study plot size of High Cliff.

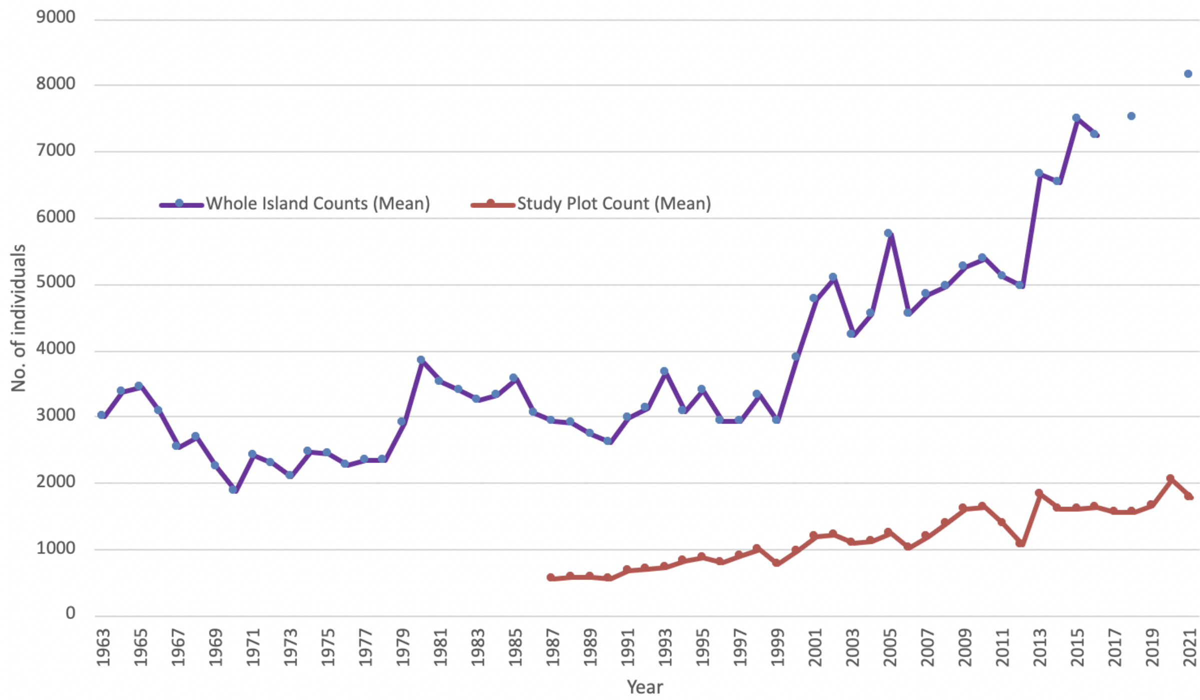
Table 23 Razorbill study plot totals from 2011 – 2021

Study Plot	Year	Mean	SD	SE	Sign.	%Change	5Yr %Change
Bull Hole	2011	304	45.4	14.3	*	-29.7	-4.7
	2012	317	77.8	29.4	NS	+4.1	+3.0
	2013	451	31.2	11.8	**	+42.6	+28.9
	2014	386	52.1	16.5	**	-14.5	-1.8
	2015	348	69.6	22.0	NS	-10.0	-8.1
	2016	342	45.8	0.83	NS	-1.6	-5.3
	2017	401	47.4	15.0	*	+17.4	+8.9
	2018	487	31.5	9.9	**	+21.4	+26.4
	2019	500	63.7	20.1	NS	+2.7	+27.4
	2020	630	39.3	17.6	**	+25.9	+51.6
	2021	588	68.0	21.5	*	-11.9	+18.2
High Cliff	2011	292	54.8	17.3	*	-23.2	+16.1
	2012	310	68.0	25.7	NS	+6.1	+12.2
	2013	360	29.8	11.3	NS	+16.0	-8.8
	2014	392	62.1	19.6	NS	+9.1	+13.0
	2015	432	54.5	17.2	NS	+10.1	+24.5
	2016	437	68.1	21.5	NS	+1.2	+22.4
	2017	336	46.0	14.5	**	-23.2	-13.1
	2018^	214	34.7	11.0	**	-36.1	-45.2
	2019	237	22.6	7.1	**	+10.7	-34.5
	2020	297	17.0	7.6	**	+25.2	-10.3
	2021	213	26.3	8.3	**	-28.1	-29.8
S.Stream	2011	72	24.7	7.8	NS	-35.4	-23.4
	2012	78	46.7	17.6	NS	+8.3	+5.7
	2013	127	16.5	6.2	*	+63.3	+47.2
	2014	135	42.9	13.6	NS	+5.7	+38.4

	2015	116	14.4	4.6	NS	-14.0	+10.5
	2016	140	27.8	8.8	*	+20.6	+32.2
	2017	112	25.0	7.9	*	-19.6	-5.7
	2018	136	12.3	3.9	*	+20.8	+2.6
	2019	130	20.4	6.5	NS	-4.4	+1.6
	2020	151	16.9	7.6	NS	+16.5	+19.4
	2021	129	15.8	5.0	*	-14.9	-3.8
The Wick	2011	718	19.8	6.26	NS	-0.8	+33.9
	2012	568	29.9	11.3	**	-20.9	-21.9
	2013	891	42.6	16.1	**	+56.9	+28.1
	2014	690	35.9	11.4	**	-22.6	-5.3
	2015	706	44.2	14.0	NS	+2.4	-1.7
	2016	707	53.0	16.8	NS	0.0	-1.1
	2017	715	26.8	8.5	NS	+1.1	+0.3
	2018	724	35.0	11.1	NS	+1.3	-2.4
	2019	804	57.5	18.2	**	+11.1	+13.5
	2020	969	25.2	11.3	**	+20.6	+32.6
	2021	875	72.8	23.0	**	-9.7	+11.7
All Plots	2011	1386	101.7	36.0	*	-15.9	+15.4
	2012	1227	168.0	63.5	*	-11.5	-11.4
	2013	1829	68.6	25.9	**	+49.1	+25.9
	2014	1603	93.6	29.6	**	-12.4	+3.9
	2015	1601	136.7	43.2	NS	-0.1	+4.1
	2016	1625	174.2	55.1	NS	+ 1.5	+ 6.2
	2017	1564	68.2	27.2	NS	-3.8	-0.8
	2018	1561	44.4	14.0	NS	-0.2^	-5.1
	2019	1671	106.1	33.6	**	+7.0	+5.0
	2020	2047	17.8	8.0	**	+22.5	+27.6
	2021	1775	69.2	21.9	NS	-13.3	+4.8

Note: ^ denotes calculations where the High Cliff study plot was reduced in 2018. Significance between years established using the t-test for comparing the means of two small samples (two-tailed test, df=n-1). NS Not significant, * Statistically significant (P<0.05), * * Statistically highly significant (P<0.01). See Appendix 4 for count details.

Figure 25 **Razorbill numbers 1963-2021**



13.3 Breeding success

13.3.1 Methods

The number of active and regularly occupied sites was established at three study plots (Bull Hole, Wick 3A and Wick 3B) and their histories followed using the methodology outlined in Walsh *et al.* (1995). Visits to the study plots were made from late April to map the location of pairs. Monitoring was conducted from 24th April until 4th August.

Sites were visited every one to two days, with the greatest effort made during the egg laying, hatching and fledging periods. The number of visits ranged between 66 and 85, comparable to 2020 where the number of visits ranged from 70 to 76.

The final productivity is given as the total number of fledged or apparently fledged chicks (last seen at 15 or more days old) divided by the number of active and regularly occupied sites and active sites only across all plots.

Due to their nesting behaviour, Razorbill productivity can be particularly difficult to monitor. Some nests within a plot boundary may be hidden in a crevice and therefore never visible. Even visible nests are often partially obscured in cracks or by rocks making identification of nest contents very difficult or impossible until chicks are larger. The scattered nature of the nest sites also means that more time is needed to watch individuals in order to catch a glimpse of an egg or chick.

The final productivity is given as the total number of fledged or apparently fledged chicks (last seen at 15 or more days old) divided by the number of active and regularly occupied sites and active sites only across all plots.

In 2018, productivity study plots for Razorbills were changed in consultation with The Wildlife Trust of South and West Wales and JNCC. The High Cliff and Bull Hole study plots were determined to be very large and unmanageable to provide reliable productivity assessment of Razorbills. As a result, the High Cliff study plot was dropped and the Bull Hole study plot was split in half with the more difficult half abandoned. The new plot boundaries of Bull Hole have been identified on the study plot map for future reference. These changes were continued in 2021.

13.3.2 Results

A total of 246 occupied sites were monitored in 2021. The productivity for active and regularly occupied sites was 0.50, and the productivity for active only occupied sites is 0.54 (Table 24). These productivity estimates are slightly higher than those observed in 2020 and the historical average of 0.48 (1993-2020).

Table 24 Razorbill productivity on Skomer Island in 2021

Site	No. active + regular sites	No. active sites	Large chicks	Productivity per site (a + r)	Productivity per site (a only)
Wick 1A	—	—	—	—	—
Wick 3A	118	108	62	0.53	0.57
Wick 3B	40	36	13	0.33	0.36
Bull Hole	88	83	48	0.55	0.58
Total	**246**	**227**	**123**	**0.50**	**0.54**

Note: Data shown for active (a) and regular (r) sites.

Table 25 Razorbill productivity from 1993 – 2021

Year	Number of sites, active + regular.	Number of sites, active only.	Number of chicks fledged	Productivity per active + regular site	Productivity per active site only
1993	—	—	—	0.58	—
1994	—	—	—	0.54	—
1995	177	163	126	0.71	0.77
1996	—	—	—	0.65	0.71
1997	—	—	—	0.75	0.73
1998	—	—	—	0.66	0.71
1999	—	—	—	0.56	0.74
2000	—	—	—	0.50	0.54
2001	299	272	173	0.58	0.64
2002	310	286	114	0.37	0.40
2003	357	282	181	0.51	0.64
2004	406	357	206	0.51	0.58
2005	328	293	191	0.58	0.65
2006	418	389	129	0.31	0.33
2007	374	333	209	0.56	0.63
2008	486	305	94	0.19	0.22

2009	395	327	145	0.37	0.44
2010	466	353	171	0.37	0.48
2012	357	294	66	0.19	0.23
2013*	294	240	100	0.34	0.42
2014	360	353	98	0.27	0.28
2015	323	306	120	0.37	0.39
2016	306	298	125	0.41	0.42
2017	295	277	143	0.48	0.52
2018***	160	153	98	0.61	0.64
2019	175	164	110	0.63	0.67
2020****	104	97	48	0.46	0.49
2021	246	227	122	0.50	0.54
			Mean****	**0.48**	**0.53**
			SD****	**0.15**	**0.16**
			SE****	**0.03**	**0.03**

* From 2013, the methodology changed to only monitoring one site out of three in rotation at the Wick each year.
** 5-year average, SD and SE excluded results from 2021.
*** High Cliff drop and Bull Hole halved from this year on
**** Bull Hole not monitored

13.4 Timing of breeding

The first egg was recorded on 24th April, the first chick on 30th May, and the first jumpling on 17th June, all at the Bull Hole study plot.

The median fledging date of the study plots was 27th June, with 37% of chicks fledging around this date (25th to 29th June) (Table 26).

Table 26 **Razorbill phenology records from 2014 – 2021**

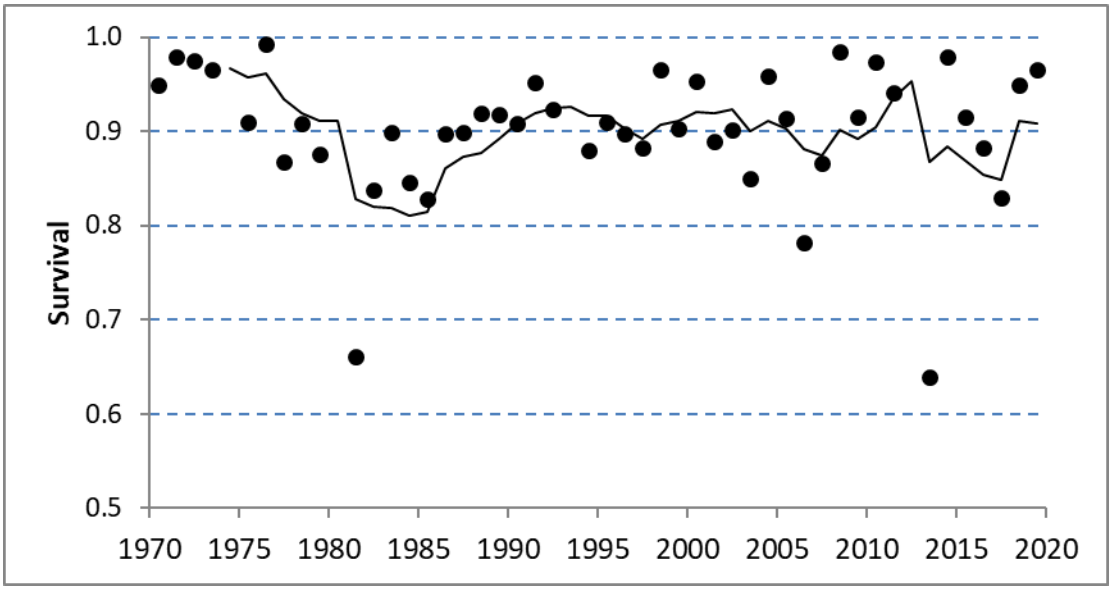
	2014	2015	2016	2017	2018	2019	2020	2021
First egg	12 May	25 April	26 April	26 April	22 April	19 April	29 April	24 April
First chick	16 June	31 May	29 May	28 May	3 June	20 May	7 June	30 May
First 'jumpling'	29 June	18 June	15 June	14 June	23 June	16 June	23 June	17 June
Median fledge date	14 July	2 July	1 July	29 June	4 July	24 June	27 June	27th June

13.5 Breeding adult survival

Survival across the long-term-study (1970-2020) averages 0.90, and in 2019-20 was 0.97.

Poor years have been associated with winter seabird wrecks (e.g. 2013-14; Morley et al 2015). After relative stability in the 1980s and 90s, survival rates appear more variable since 2000. Recent years show survival declining, which may be a cause for concern.

Figure 26 **Survival rates of adult breeding Razorbills 1970-2020 (includes encounter data to 2021)**



Notes:

1. Fitted line shows the five-year moving average,
2. Survival was non-estimable in 1974-5, 1976-7, 1980-82, 1993-4, and 2012-13. The final transition in the series is not estimable (Section 1.1) and requires at least one further year of data.
3. Appendix 2 gives the estimated survival rates for 1970-2020
4. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

14 Atlantic Puffin *Fratercula arctica*

14.1 Breeding numbers

The first Atlantic Puffins (hereafter Puffin) of the year was seen on the 7th of March, seven days earlier than in 2020. One whole island counts of Puffins was made on 8th April (Table 28 and Figure 28). Counts were also conducted in North Haven on twelve dates between the 21st of March and 13th of April to assess Puffin attendance (Table 27 and Figure 27). When conditions and numbers of Puffins seemed right a whole island count was conducted. Whole island counts were all made in the afternoon between 17.00 and 19.00 and in favourable weather conditions. The maximum count of 34,813 was made on the 8th of April. This is 17 more than were counted in 2020.

Assessing the Puffins UK population size is complicated by many factors, including: the remoteness of many colonies, some colonies being shared with Manx Shearwaters (including Skomer) and the count units involved. Where possible Apparently Occupied Burrows (AOBs) have been used and the main source of error here is the misclassification or overlooking of burrows and birds nesting under boulders. Where this is not possible (as on Skomer) the number of Individuals (INDs) attending the colony in spring are counted. This second method is similarly imperfect, complicated by the variability of numbers within and between days and the difficulty in predicting when to count (as well as the ability to count at the best times). The practice of assuming that one individual corresponded to one Apparently Occupied Burrow (AOB) was applied to counts from all three national censuses, potentially resulting in a serious underestimate of the population. Therefore, uncertainty remains as to current trends and population size in the UK (post 2000).

Despite this uncertainty, the UK's Puffin population was thought to have increased between 1969 and the early 2000s, however, the decline has been suggested since then, albeit with regional increases (JNCC). Declines have been most severe in the north of Britain, especially at sites like Fair Isle and St Kilda. On a wider scale, the Puffin has recently been classified by the IUCN as Endangered (IUCN A2abcde+4abcde) in Europe, and Near Threatened in the EU27 mostly due to declining populations in Iceland and Norway caused by the combined impact of predation by invasive species, pollution, food shortages caused by the depletion of fisheries and adult mortality in fishing nets.

Skomer's increasing numbers are therefore at odds with trends at UK and continental scales and deserve scrutiny to understand the reasons for this.

Table 27 Spring counts of individual Puffins in 2021: North Haven

Date	No. individual puffins in North Haven
21-Mar	5130
04-Apr	1071
07-Apr	2300
08-Apr	6601*
13-Apr	5000

Note:
* = whole island count

Figure 27 Spring counts of individual Puffins in 2021: North Haven

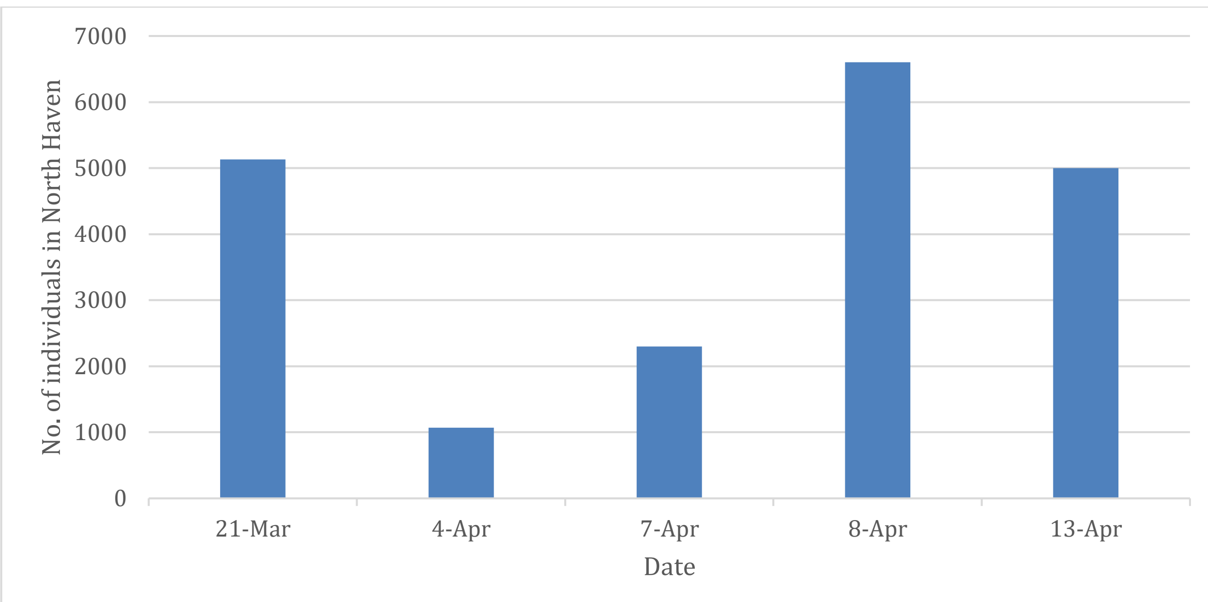
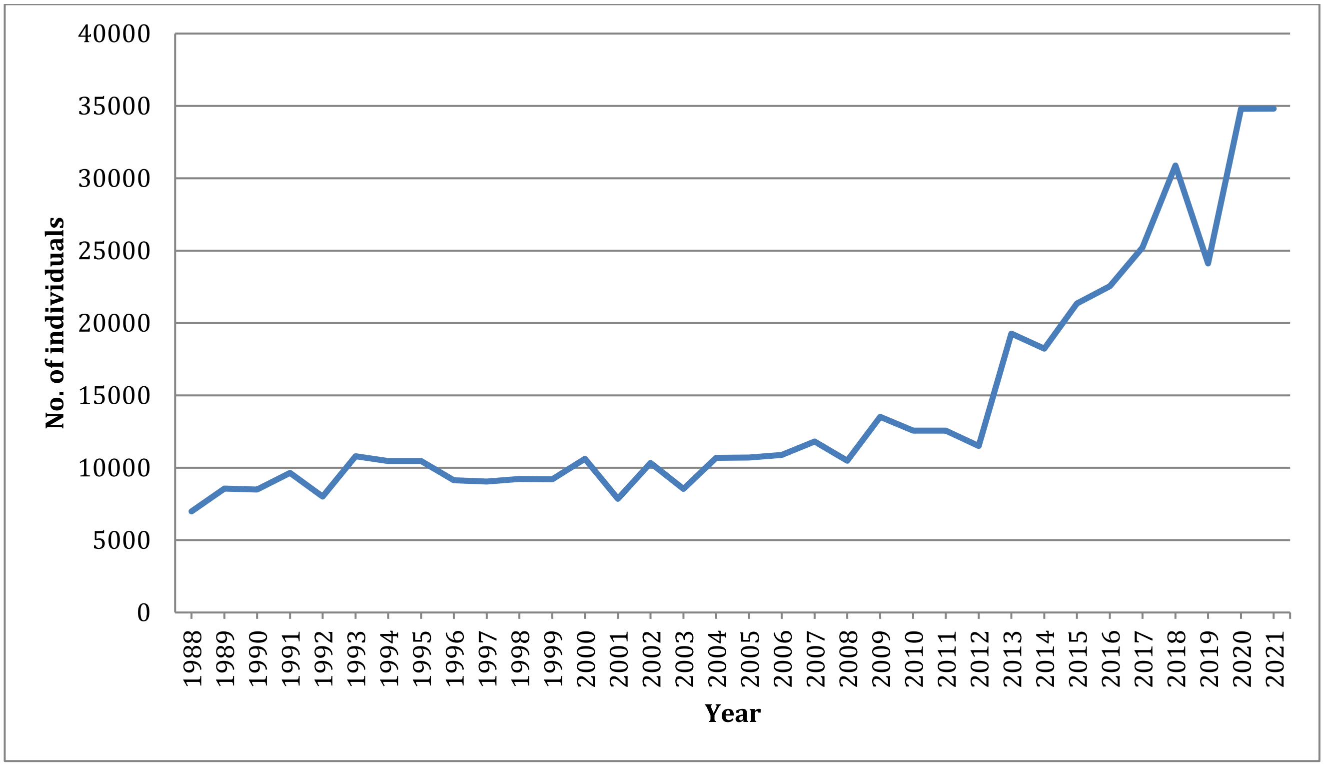


Table 28 **Maximum spring Puffin counts: Skomer 2004-2021**

Year	No. individual puffins	% change	5 year % change
2004	10688	+25.2	+0.7
2005	10717	+0.3	+36.5
2006	10876	+1.5	+5.5
2007	11821	+8.7	+38.5
2008	10487	-11.3	-1.9
2009	13508	+28.8	+26
2010	12577	-6.89	+15.64
2011*	-	-	-
2012	11497	-8.59	+9.63
2013	19280	+67.7	+42.73
2014	18237	-5.41	+45
2015	21349	+17.06	+69.75
2016	22539	+5.57	+96.04
2017	25227	+11.93	+35.77
2018	30895	+22.47	+44.87
2019	24108	-21.97	+1.94
2020	34796	+43.33	+40.17
2021	34813	+0.05	+26.53

* 2011 – No Puffin count was possible due to timings/weather/availability of counters.

Figure 28 Maximum spring counts of Puffins: Skomer 1989-2021



14.2 Puffin burrow occupancy and breeding success

Puffin burrow occupancy and breeding success in the South East Isthmus study plot for 2021 is shown in Table 29 below.

Table 29 Burrow occupancy and breeding success of Atlantic Puffins, 2021

Total no. of burrows	No. occupied burrows	% Occupied	No. chicks based on 2+ feeds	Productivity based on 2+ feeds
227	171	0.75	119	0.70

Burrow occupancy was established during evening watches conducted during the incubation period, in mid-May. Burrows were considered active if they were attended on 2 or more occasions. The first confirmed adult Puffins carrying fish were seen coming ashore at North Haven on 22nd May, this being five days later than the first of 2020. Activity at the South-east Isthmus plot showed a clear reduction by the 16th July.

Breeding success was based on 24-hour feeding watches. Before 2013, two watches were carried out, one timed for mid-feeding and the second just before the first chicks fledge. However, getting the timing right is challenging – too late and early chicks can fledge before the second watch, too early and late chicks have not hatched by the first watch. Therefore, as recommended in the 2012 report, feeding watches are now carried out every two weeks from the first date adults were seen bringing in fish, until few or no adults were seen on land regularly.

Three watches were completed in 2021: the first watch on the 5th June ran from 04:30 – 21:30, two weeks after the first fish had been seen coming into the Isthmus plot. On the 19th June, a watch ran from 04:30 – 21:30, covering peak provisioning of any chicks that were hatched at the first watch still being fed, and any younger chicks (if they survived) would probably still be being fed by the final watch. The final watch on the 2nd July ran from 04:20 – 21:30 and saw a marked decrease in activity with most chicks having probably fledged from the first wave but capturing the activity of later burrows. Two weeks after this on 16th July, there did not appear to be enough activity in the plot to justify another watch.

For occupied burrows to be considered successful, the burrow had to be provisioned on at least two of the watches. This gives a productivity estimate of 0.70 (chicks fledged per active burrow). This is the same as the productivity in 2020, which was itself a decrease of 0.03 from 2019.

14.3 Feeding rates

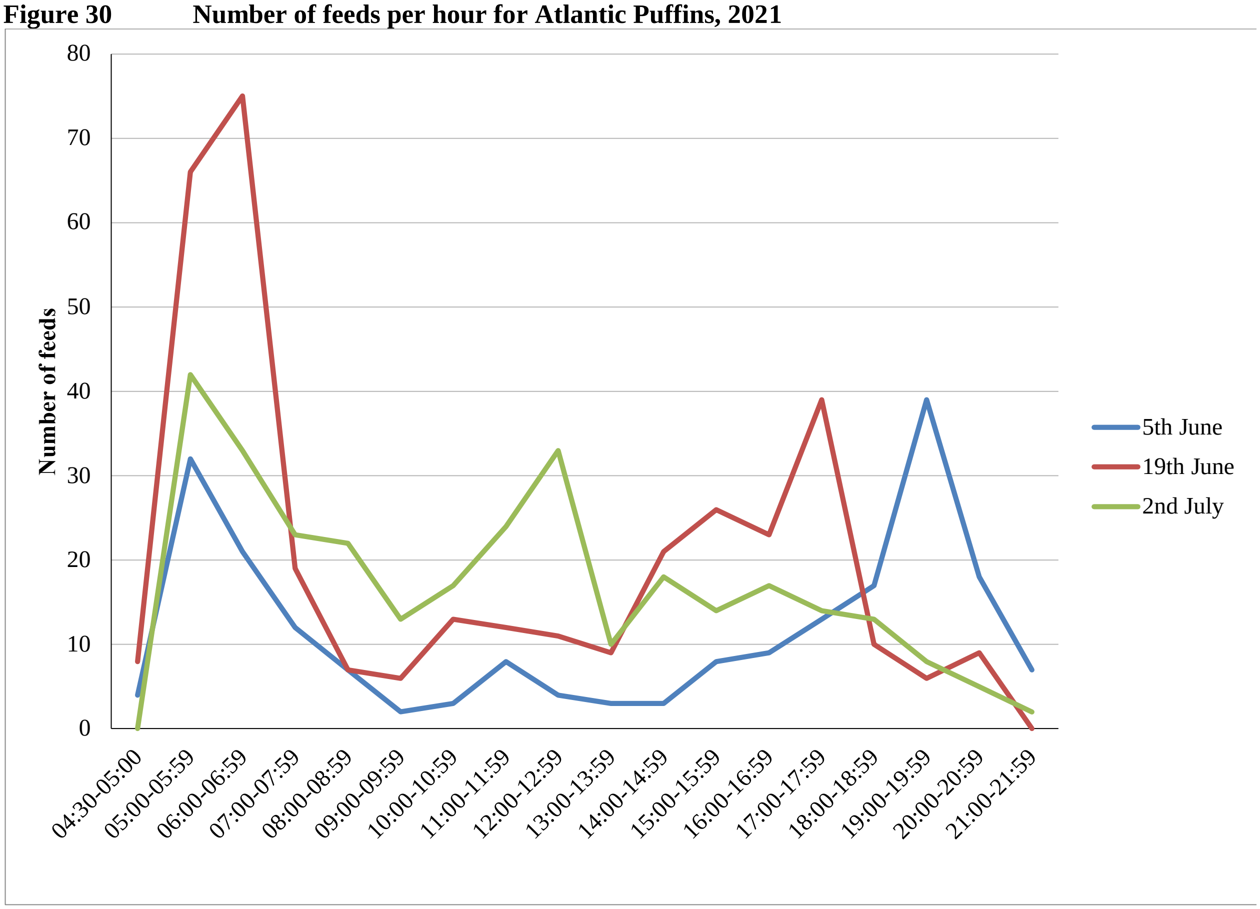
Details of feeding rates in occupied burrows were as follows:

Table 30 Feeding rates of Atlantic Puffins, 2021

	5th June	19th June	2nd July
No. of burrows to which feeds were recorded	112	133	126
Total No. recorded feeds	210	360	306
Mean No. feeds per burrow	1.88	2.71	2.43

A total of 171 active burrows were followed in 2021, higher than in recent years: 92 in 2020, 141 in 2019, 138 in 2018 and 142 in 2017. In 2021, low rainfall in the spring meant that the lower half of the study plot was almost entirely bare of grass, while the upper half had just a short covering. This made seeing burrow entrances much easier than in years with greater grass growth, and it may also have provided birds with greater opportunities to excavate new burrows in the loose soil.

Figure 30 Number of feeds per hour for Atlantic Puffins, 2021



Feeding rates are given for occupied burrows only. Feeding peaked in the morning and mostly showed a second, smaller peak in the evening, this reflects the pattern in feeding rate shown in most years.

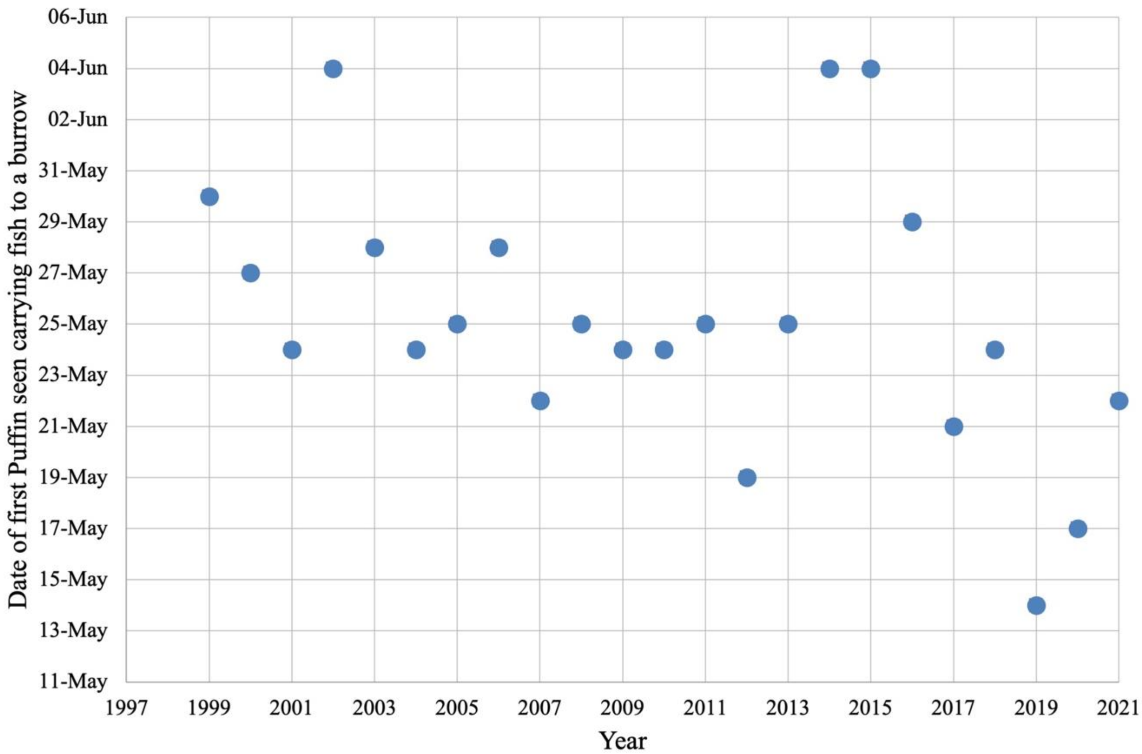
14.4 Timing of breeding

As was the case for most other species, the timing of breeding for Puffins was on the early side, but still around the long-term average. The first Puffins were seen on the 7th March, seven days earlier than in 2020, and the first arrival of over 100 was on the 17th (one days earlier than 2020). The first Puffins recorded on land were on the 22nd. Burrow checks on 24th April by Dr. Annette Fayet found 50% of burrows contained an egg. However, when calculating back from the first Puffin seen carrying fish (22nd May in North Haven) the first eggs would have been laid around the 23rd to the 30th of April.

Table 31 Dates of first Puffins seen carrying fish to a burrow 1999-2021

Year	First fish
1999	30-May
2000	27-May
2001	24-May
2002	04-Jun
2003	28-May
2004	24-May
2005	25-May
2006	28-May
2007	22-May
2008	25-May
2009	24-May
2010	24-May
2011	25-May
2012	19-May
2013	25-May
2014	04-Jun
2015	04-Jun
2016	29-May
2017	21-May
2018	24-May
2019	14-May
2020	17-May
2021	22-May

Figure 30 **Dates of first Puffins seen carrying fish to a burrow 1999-2021**

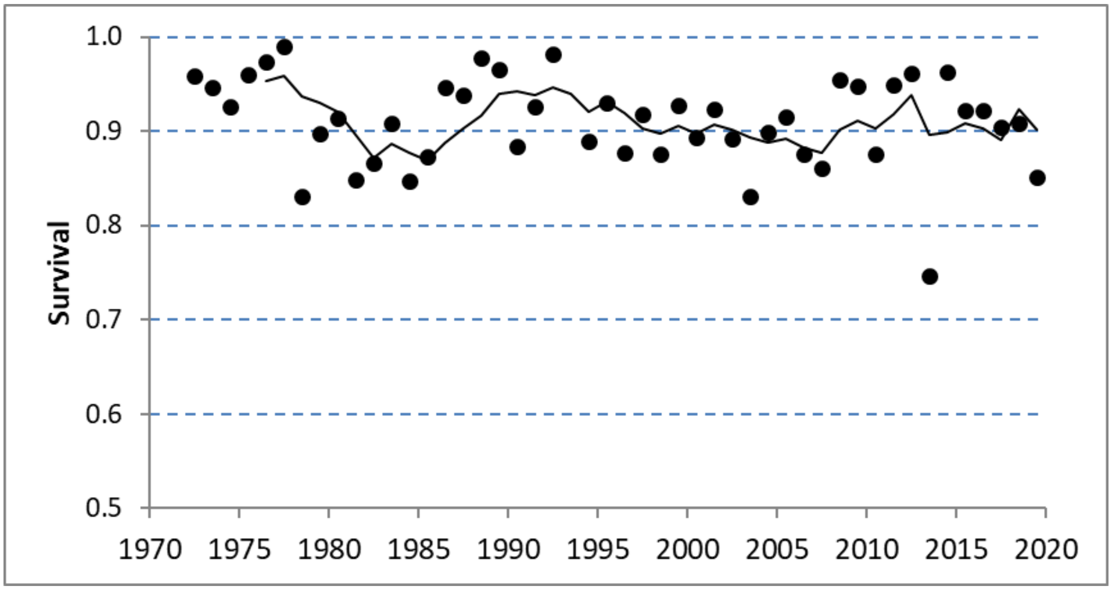


14.5 Breeding adult survival

The breeding adult survival rate in 2019-20 was 0.85. The study average (1972 to 2020) was 0.91.

The effects of the 2013-14 storms remain apparent, with a marked drop in adult survival after tens of thousands of auks were washed up dead on the Atlantic coast of NW Europe (Morley et al. 2015). The long-term impacts of severe climatic events on seabird populations remain poorly understood.

Figure 31 Survival rates of adult breeding Puffins 1972-2020 (includes encounter data to 2021)



Notes:

1. Fitted line shows the five-year moving average
2. Survival was non-estimable in 1993-4. The final transition in the series in such analyses is inestimable (Section 1.1)
3. Appendix 2 gives the estimated survival rates for 1972-2020
4. Survival estimates are the result of capture-mark-recapture analysis (see 1.1.1)

15 Acknowledgements

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17 Appendices

Appendix 1 **Skomer Guillemot Report 2021 for WTSWW**

T R Birkhead (TRB)

TRB/Steve Votier (SV) employed Julie Riordan as field assistant to conduct the population monitoring that forms part of TRB and SV's long-term guillemot population study on Skomer Island. This is a summary of the main findings from the 2021 season.

Covid was still an issue. Nonetheless, Julie Riordan was present continuously between 12 April and 10 July 2021. However, TRB, Ben Hatchwell and SV were limited to a single visit of 36 hours between 30 June and 2 July to undertake the necessary ringing of adult guillemots and chicks. This was later than anticipated, but the weather was wet at the most appropriate time. Fortunately, on 1 July the weather cooperated and the ringing was successfully completed, with a total of 50 adults and 240 chicks ringed.

Adult survival seemed to be about average, but detailed analysis will be conducted later.

The timing of breeding: the median laying date was 4 May which was fairly early compared with recent years.

Breeding success: Two major storms in May (likely due to climate change) on 3-4 May and 20-21 May resulted in the lowest guillemot breeding success (0.64 chicks/pair) recorded on Skomer for many years.

Feeding observations; The majority of chick-feeds comprised clupeids, with smaller numbers of sandeels and gadids. 11 fish obtained during ringing comprised three gadids and 8 sprats.

Appendix 2 Breeding adult survival rates from capture-recapture analyses 1970-2019

* Capture-mark-recapture analyses are carried on long-term individual encounter histories using programs ESURGE. Some parameters are inestimable (and left blank); others relate to the last transition in the encounter history (the survival of birds in the last year of the study) which cannot be estimated reliably and awaits at re-sighting data from at least one further year (see Section 1.1). Key to abbreviated seabird species: MX = Manx Shearwater, LB = Lesser Black-Backed Gull, HG = Herring Gull, KI = Kittiwake, RZ = Razorbill, PU = Atlantic Puffin

Year		Species					
From	To	MX	LB	HG	KI	RZ	PU
1970	1971					0.949	
1971	1972					0.979	
1972	1973					0.974	0.959
1973	1974					0.966	0.946
1974	1975						0.927
1975	1976					0.909	0.961
1976	1977					0.993	0.973
1977	1978	0.749				0.867	0.990
1978	1979	0.780	0.983	0.894	0.944	0.909	0.831
1979	1980	0.793	0.921	0.809	0.891	0.876	0.897
1980	1981	0.612	0.921	0.982	0.886		0.914
1981	1982		0.874	0.608	0.842	0.661	0.849
1982	1983	0.887	0.960	0.705	0.918	0.837	0.866
1983	1984	0.851	0.894	0.724	0.726	0.898	0.909
1984	1985	0.953	0.917	0.896	0.830	0.846	0.847
1985	1986		0.892	0.727	0.805	0.828	0.873
1986	1987	0.876	0.883	0.872	0.914	0.897	0.947
1987	1988	0.942	0.944	0.951	0.898	0.899	0.938
1988	1989		0.914	0.938	0.897	0.919	0.978

1989	1990	0.722	0.922	0.880	0.959	0.918	0.965
1990	1991	0.924	0.842	0.820	0.900	0.909	0.884
1991	1992		0.977	0.838		0.952	0.926
1992	1993	0.823	0.881	0.875	0.857	0.924	0.981
1993	1994	0.725	0.973		0.903		
1994	1995	0.907	0.825	0.800	0.766	0.880	0.889
1995	1996	0.889	0.859	0.771	0.774	0.910	0.930
1996	1997	0.890	0.809	0.721	0.706	0.897	0.877
1997	1998	0.868	0.803	0.993	0.729	0.883	0.918
1998	1999	0.951	0.906	0.830	0.895	0.965	0.875
1999	2000	0.979	0.868	0.847	0.779	0.904	0.927
2000	2001	0.906	0.822	0.868	0.910	0.953	0.893
2001	2002	0.919	0.794	0.787	0.921	0.889	0.923
2002	2003	0.849	0.755	0.871	0.797	0.902	0.893
2003	2004	0.923	0.772	0.804	0.885	0.850	0.832
2004	2005	0.926	0.918	0.856	0.817	0.959	0.899
2005	2006	0.843	0.871	0.781	0.849	0.914	0.916
2006	2007	0.935	0.903	0.806	0.725	0.782	0.876
2007	2008	0.889	0.896	0.891	0.789	0.866	0.861
2008	2009	0.852	0.924	0.880	0.770	0.984	0.954
2009	2010	0.838	0.846	0.692	0.956	0.916	0.947
2010	2011	0.883	0.848	0.798	0.948	0.973	0.876
2011	2012	0.883	0.866	0.752	0.843	0.941	0.950
2012	2013	0.944	0.904	0.751	0.957		0.961
2013	2014	0.904	0.943	0.971	0.793	0.639	0.746

2014	2015	0.851	0.839	0.800	0.861	0.979	0.962
2015	2016	0.795	0.918	0.773	0.951	0.915	0.922
2016	2017	0.929	0.827	0.752	0.976	0.882	0.922
2017	2018	0.856	0.915	0.955	0.903	0.830	0.904
2018	2019	0.963	0.585	0.815	0.749	0.950	0.908
2019	2020	0.846	0.825	0.720	0.755	0.966	0.851

Appendix 3 Mean seabird counts by section in 2021

Plot No	counted from		Kittiwake			Guillemot		
			count 1	count 2	mean	count 1	count 2	mean
1		sea	0	0	0	1756	1783	1769.5
2		sea	17	22	19.5	401	568	484.5
3		sea	105	114	109.5	221	318	269.5
4		sea	1	1	1	263	320	291.5
5		sea	49	43	46	755	725	740
6		sea	52	58	55	197	228	212.5
7		sea	0	0	0	19	41	30
8	land		0	0	0	206	217	211.5
9	land		0	0	0	95	116	105.5
10		sea	0	0	0	0	0	0
11		sea	0	0	0	343	331	337
12	land		0	0	0	23	23	23
13	land		28	24	26	6		3
14	land		229	213	221	1147	1224	1185.5
15		sea	53	38	45.5	11	3	7
16	land		109	102	105.5	2665	2715	2690
17		sea	0	0	0	0	0	0
18		sea	0	0	0	0	0	0
19	land		0	0	0	441	453	447
20		sea	0	0	0	0	0	0
21		sea	0	0	0	0	0	0
22	land		433	403	418	4261	4546	4403.5
23	land		7	7	7	32	39	35.5
24		sea	0	0	0	56	81	68.5
25		sea	0	0	0	0	0	0
26	land		0	3	1.5	371	448	409.5
27	land		92	114	103	3381	2996	3188.5
28	land		0	0	0	28	33	30.5
29		sea	0	0	0	0	0	0
30	land		0	0	0	142	253	197.5
31	land		0	0	0	289	343	316
32	land		0	0	0	82	72	77
33	land		36	29	32.5	435	343	389
34	land		0	0	0	776	774	775
35		sea	0	1	0.5	356	279	317.5
36		sea	27	33	30	301	221	261
37	land		136	129	132.5	4185	4199	4192

38		**sea**	**87**	**79**	**83**	**686**	**446**	**566**
39		**sea**	**0**	**3**	**1.5**	**881**	**967**	**924**
40		**sea**	**0**	**0**	**0**	**802**	**785**	**793.5**
41		**sea**	**0**	**0**	**0**	**187**	**208**	**197.5**
42		**sea**	**0**	**0**	**0**	**504**	**504**	**504**
43		**sea**	**0**	**0**	**0**	**123**	**147**	**135**
44		**sea**	**0**	**0**	**0**	**322**	**463**	**392.5**
45		**sea**	**0**	**0**	**0**	**234**	**343**	**288.5**
TOTAL			**1461**	**1416**	**1438.5**	**26983**	**27555**	**27269**

Appendix 4 Study plot counts

Number of individual Common Guillemots counted in the Wick study plots in 2021

Date	Weather	A	B	C	D	All
01/06/2021	SE 4	132	70	117	55	374
04/06/2021	SW 3	138	65	118	70	391
06/06/2021	N 3	140	59	105	64	368
07/06/2021	SW 3	144	71	112	64	391
12/06/2021	NW 3	145	64	119	65	393
13/06/2021	S 2	132	66	119	56	373
14/06/2021	NW 2	148	69	113	52	382
16/06/2021	W 2	133	62	92	33	320
17/06/2021	NW 4	136	56	99	57	348
19/06/2021	SE 2	152	71	124	38	385
	Mean	**140**	**65**	**112**	**55**	**373**
	SD	7.04	5.17	10.12	11.89	22.93
	SE	2.23	1.63	3.20	3.76	7.25
	T-TEST p value	0.00	0.00	0.05	0.05	0.00

Number of individual Common Guillemots counted at the old study plots in 2021

Date	Weather	High Cliff	South Stream	Bull Hole	Total
06/06/2021	N 3	2665	-	-	-
07/06/2021	SW 3	-	1055	4394	-
14/06/2021	N 3	2591	-	-	-
19/06/2021	SE 3	-	1053	4420	-
	Mean	**2628**	**1054**	**4407**	**8089**

Number of individual Razorbills counted in the study plots in 2021

Date	Weather	High Cliff	Wick	Bull Hole	S.Stream	All
01/06/2021	SE 4	236	932	484	140	1792
03/06/2021	SW4	245	937	608	134	1924
06/06/2021	N 3	248	755	622	135	1760
07/06/2021	SW 3	240	802	546	146	1734
12/06/2021	NW 3	204	852	582	135	1773
13/06/2021	SE 2	178	995	475	111	1759
14/06/2021	S 3	190	934	487	147	1758
16/06/2021	W 2	193	844	597	99	1733
17/06/2021	N 4	192	864	671	121	1848
19/06/2021	SE 1	208	838	507	117	1670
	Mean	**213**	**875**	**558**	**129**	**1775**
	SD	26.3	72.79	68.00	15.85	69.17
	SE	8.30	23.02	21.50	5.01	21.87
	TTEST p value	0.00	0.00	-0.02	-0.04	-0.06

Appendix 5 Seabird ringing totals for 2021 (excluding re-sightings)

Skomer Island

	New	Full grown	Pulli	Retrap/recovery	TOTAL
Guillemot	290	50	240	0	250
Herring Gull	31	2	29	1	32
Kittiwake	15	15	0	0	15
Lesser Black-backed Gull	266	14	252	11	277
Manx Shearwater	498	342	156	73	571
Puffin	89	45	44	3	92
Razorbill	38	13	25	11	49
Storm Petrel	46	46	0	38	84
Grand Total	983	477	506	137	1120