Skomer Seabird Report 2014

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Summary

This document reports upon the 2014 breeding season for seabirds on Skomer Island, drawing together the work of The Wildlife Trust of South and West Wales (WTSWW) staff, volunteers, and research institutions including the University of Gloucestershire. The report includes whole island population counts, study plot counts and 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 (part of the UK Government's Department for the Environment, Farming and Rural Affairs) for the monitoring of Skomer's seabird populations as a key site for the Seabird Monitoring Programme.

The table below summarises population counts for ten species in 2014 and makes comparison with the previous year as well as giving a five year percentage change. The gaps in the data are the total number of Shags nests on the main part of Skomer in 2014 and a whole island population count for Herring Gulls in 2013.

Early indications suggest the winter storms of 2013/14 negatively affected the survival of several species of seabird (particularly Puffin, Guillemot and Razorbill), although data from at least one more year are required for a definitive result.

Whole island seabird population counts for 2014.
Counts are compared with 2013 and giving a five year percentage change

Species and count units	Totals for 2014	Totals for 2013	% Change from 2013	5 Year % Change
Fulmar (AOS)	556	503	+10.54	+4.91
Cormorant (AON)	6	7	-14.30	+100.00
Shag (AON)	-	5		
Lesser Black Backed Gull (AON)	8432	8132	+3.6	-11.2
Herring Gull (AON)	440			+2.09
Greater Black Backed Gull (AON)	107	84	+27.40	-9.32
Black-legged Kittiwake (AON)	1488	1045	+42.40	-22.58
Guillemot (IND)	23493	20862	+12.61	+17.69
Razorbill (IND)	6541	6663	-1.83	+21.33
Puffin (IND)	18237	19280	-5.41	+45.00

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

Fulmar: The whole island count was up by 10.54% on 2013. There was, however, a drop in numbers within the study plot areas from 147 AOS to 112 AOS. Productivity was higher than any of the last six years at 0.45 chicks per AOS, slightly below the average productivity over the period 1986 to 2011 (0.48).

Manx Shearwater: The breeding study plot census was completed by students from the University of Gloucestershire. Breeding success was the highest since 1998 at 0.71 fledged young per egg laid.

Lesser Black-backed Gull: A much better year in 2014, with just a small population increase of 3.6% on the previous year but a considerable increase in productivity from 0.076 in 2013 (a very poor year) to 0.57 in 2014 – higher than average for the last 20 years.

Herring Gull: Better coverage in 2014 with an island population of 440 and productivity of 0.52 chicks fledged per AON.

Black-legged Kittiwake: Productivity was up on 2013 (0.33) at 0.64 and was the highest since 2010. The Whole island population count was also up by 42.40%.

Guillemot: The whole island count was up by 12.61% on 2013. Although the whole island count and study plot counts were both up on the previous year it is important to note that this is a common effect of a seabird wreck, where young birds occupy gaps in the breeding colonies, and the true effect of the winter storms may not be felt for several years. Productivity in the study plots monitored by the Field Worker (A Wilson) was the same as in the previous two years at 0.63 (this is just below the overall mean of 0.68). Students working under Professor Tim Birkhead from Sheffield University also reported lower than average breeding success in 2014.

Razorbill. The whole island count was down by 1.83% on 2013, and the study plots were down by 12.4%. Productivity was 0.27 chicks per active and regularly occupied site which is considerably lower than the mean of 0.49.

Atlantic Puffins: The maximum whole island spring count was down by 5.41% on 2013. Productivity was 0.53 chicks fledged per burrow, which is 25% lower than 2013. Only 59.5% of 2013’s breeding adults returned to Skomer in 2014, a 25% drop compared with 2012-2013 (84.2%), although accurate survival estimates require at least one more year’s data to put 2014 into context with the average adult survival of 91.1% since 1972.

The last two years have seen two of the latest breeding seasons on record, bucking the recent trend for earlier breeding.

1 Introduction

Seabirds are a significant component of the marine environment and Britain has internationally important populations of several species. A recent census (Perrins *et al*. 2011) of the Manx Shearwater population on Skomer estimated 316,070 breeding pairs. This affords Britain's (and Skomer's) seabird populations even greater importance and probably makes Britain's Manx Shearwater population(s) a higher proportion of a world population than is the case for any other bird species breeding in the Britain and Ireland. Skomer is believed to hold the largest Manx Shearwater colony in the world. Other seabird species that breed on Skomer in important numbers include Fulmar, Lesser Black-backed Gull, Kittiwake, Common Guillemot, Razorbill and 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 have been designated a Marine Nature Reserve. 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 of particular species, annual adult survival rates, breeding success and other aspects of seabird ecology have been carried out for many years by other bodies, including South Pembrokeshire Ringing Group, Prof. Tim Birkhead's long-term study of guillemot population dynamics, and Prof. Tim Guilford's studies of the migration strategies of seabirds.

During the 2013/14 winter there were some severe back to back storms in the north east Atlantic which affected the over winter survival of several species of seabird (mostly Puffins, Razorbills and Guillemots) that were wintering in the area. Around 40,000 birds washed up dead in an area covering the Atlantic coasts of Portugal, Spain, France and Britain. Long-term monitoring on Skomer and other British and European seabird colonies is therefore of upmost importance in tracking and understanding the dynamics of these populations.

In 2014, the whole island counts and study plot counts of Common Guillemot and Razorbill, the whole island counts of Northern Fulmar and all breeding gulls (including Kittiwake) and breeding success rates of Fulmar, Herring Gull, Great Black-backed Gull, Kittiwake and Common Guillemot were funded by JNCC. This work is carried out by the island Wardens and a contract Field Worker with additional help in some areas by the island Assistant Warden and volunteers. Alastair Wilson was the JNCC-WTSWW Field Worker in 2014.

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 funded by JNCC (the JNCC-UoG Field Assistant in 2014 was Ros Green).

The studies of Lesser Black-backed Gulls require significant coordination between both JNCC Field Assistants, the Island staff and volunteers. Systematic nest count areas were rotated again in 2014 to build up a picture of correction factors across at sub-colonies across the island, to improve the accuracy and efficiency of this work while minimising disturbance.

A review of the Great Black-backed Gull diet study was carried out in 2012 and can be read in Appendix 7. The new tried and tested method was used in 2014 and can be read about in Section 10.3.

1.1 Introduction to 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 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, e.g. a reliable 2013-14 estimate can only be obtained after observations in both 2014 and 2015. Hence the survival estimate for the last year of the study (2013-14) is not comparable with the others and produces an unreliable estimate, and is 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 1. For those species where a trend is apparent, this is highlighted in the text. Field observations were made from April – August 2014 by Ros Green 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, we can control for variation between individuals and sites. In other words, it makes the survival estimates much more accurate if we follow the same birds, 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 doesn't mean it has died: we may not have been able 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 we see a trend that concerns us from a conservation perspective or a pattern that might enable us to find out 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

2.1 Whole island counts

Whole island counts of the cliff nesting species were carried out in June (1st-26th June) and two complete counts were made.

The Lesser Black-backed Gull *Larus fuscus* colonies were counted by eye from established vantage points between the 3rd and 6th of May. An attempt was then made to ground truth a sample of colonies (between the 19th and 26th of May) to produce a correction factor (for missed nests) with which to calculate an island population.

In mid-June 1999, black-and-white photographs were taken of all study count sections and these are filed on the island. In 2013 and 2014 new photographs of some of the sections were taken in order to update the existing ones, as vegetation and the cliffs themselves have changed over the years.

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. General trends can nonetheless be identified with some confidence.

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

Counts were made during the first three weeks of June of the same study plots used in previous years, using methods outlined in Walsh *et al.* (1995). 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 to 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. Only one of these images is now in use, at Wick Corner ledge, with all others having been replaced by new photographs when required. All occupied Guillemot, Razorbill and Kittiwake breeding plots were re-photographed in 2014 as vegetation and the cliffs themselves have change over the years. Of particular note is a large cliff collapse at South Stream cliff over the winter of 2013-2014.

2.4 Weather

The effects of the winter storms were still being felt in spring with damage to coastlines and the loss of thousands of seabirds between Portugal and Scotland (with the highest numbers in Spain) including birds Skomer. However, it was a generally mild and settled spring and summer with few dramatic weather events. There was some extremely warm and dry autumn weather.

March – Temperatures slightly above average, generally dry and sunny, some blustery and breezy weather.
April – Temperatures again slightly above average, unsettled to start with but high pressure dominated through the middle of the month with plenty of dry and warm weather, month ended with more showers but interspersed with sunny spells.
May – Average maximum temperatures, generally dry, sunny and warm, heavy thunderstorms and rain between the 19th and 24th, ending more settled, only two days with wind force 6 or above.
June – Showery start, settled mid-month, returning to slightly more unsettled weather towards end of month although last two days were fine.
July – First week slightly unsettled with rain on the 4th and fairly low temperatures, mid-month much warmer and settled with maximum of 27°C on the 23rd, no strong winds.
August – Temperatures slightly below average or average for time of year, twelve days with rain, some unsettled weather and a stormy period around the 10th
September – Dominated by high pressure and easterly winds, maximum temperatures well above average, driest September since 1910.

Despite a mild spring it was again an extremely late breeding season. It is thought that this may have been caused by the extreme winter storms of 2013/14.

3 Northern Fulmar *Fulmaris glacialis*

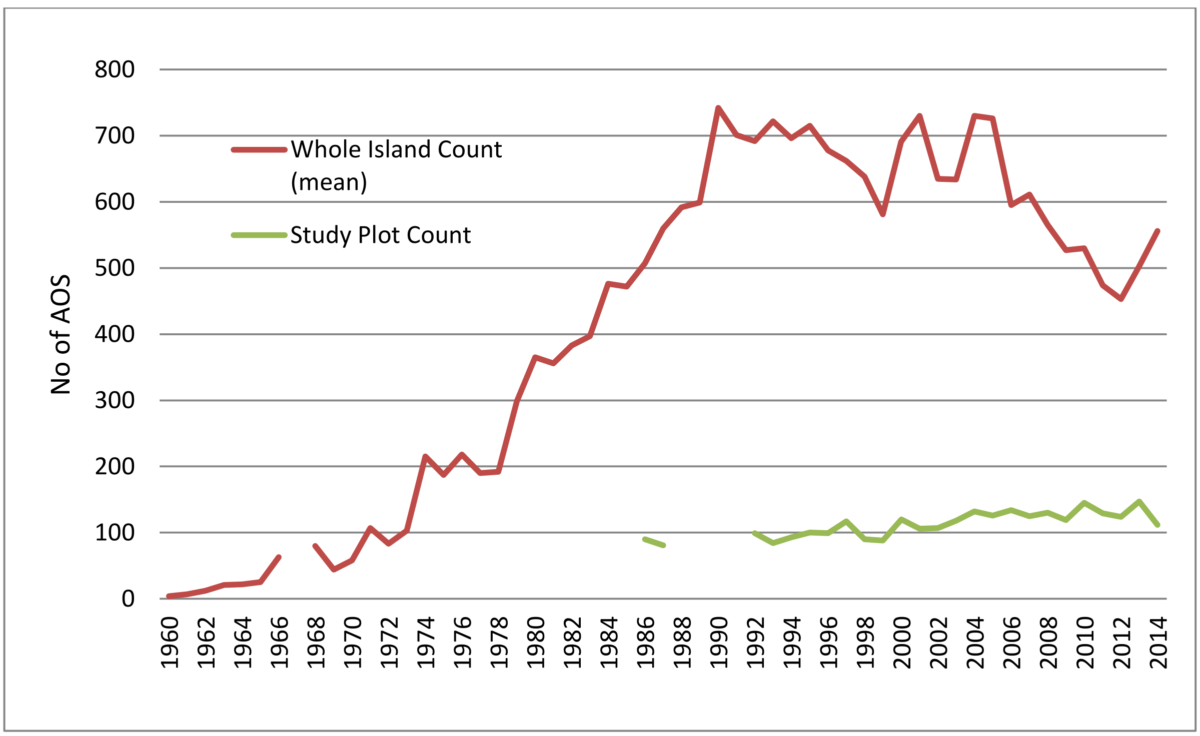
3.1 Breeding numbers - whole island counts

Two whole island counts were conducted in June. The mean of the two counts was 556 (Range: 579 – 532) which is 10.54% up on 2013. Study plot counts and whole island counts suggest a decline in population since 1990. However, since 1998 there has been a gradual increase in productivity, suggesting the population may have stabilised with regards to food availability and competition for both nest sites and food.

Table 1 Northern Fulmar whole island counts 2004-2014

Year	Total	% Change on previous year	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

Figure 1 Northern Fulmar breeding numbers 1963-2014



3.2 Breeding success

3.2.1 Methods

Three visits were made to each of the seven fulmar study plots between 22nd May and 14th June to observe site occupancy. As described in Walsh *et al.* (1995) productivity-monitoring method 1 (nest-site mapping), the sample size for breeding success is sites where an egg is seen or a bird appeared to be incubating on two consecutive checks when visits are made 5-10 days apart. A last visit was made on the 5th and 6th August to determine the presence or absence of large chicks on the sites. All large chicks were assumed to have fledged.

The Fulmar nests identified in plot "North Haven East" show a large amount of overlap with those in plot "North Haven Centre". It is recommended that "North Haven East" be removed from the study plots, and that "North Haven Centre" monitored from the visitor sales point where there is a good view of the whole cliff face. Alternatively the area of "North Haven East" should be clearly delineated and excluded from the "North Haven Centre" plot.

3.2.2 Results

112 AOSs were identified in late May/early June. The overall breeding success was 0.45, higher than any of the last 6 years, and only slightly below the average productivity over the period 1986 to 2011 (0.48), and rolling 5 year mean of 0.336 (Figure 2). However by taking the mean of each sites' productivity, small sites can have a disproportionate effect on the overall result. In order to combat this, JNCC guidelines state that results from small plots may have to be combined. In this case Tom's House and South Haven are both small plots and have been combined to give the final productivity figure. It appears that in the past this consideration may have been overlooked or tackled in a different manner. For example, in 2013 one nest which was successful raised the overall productivity mean from 0.16 to 0.29. Productivity was very similar for all sites this year, resulting in a particularly small SE.

Table 2 Northern Fulmar breeding success 2014

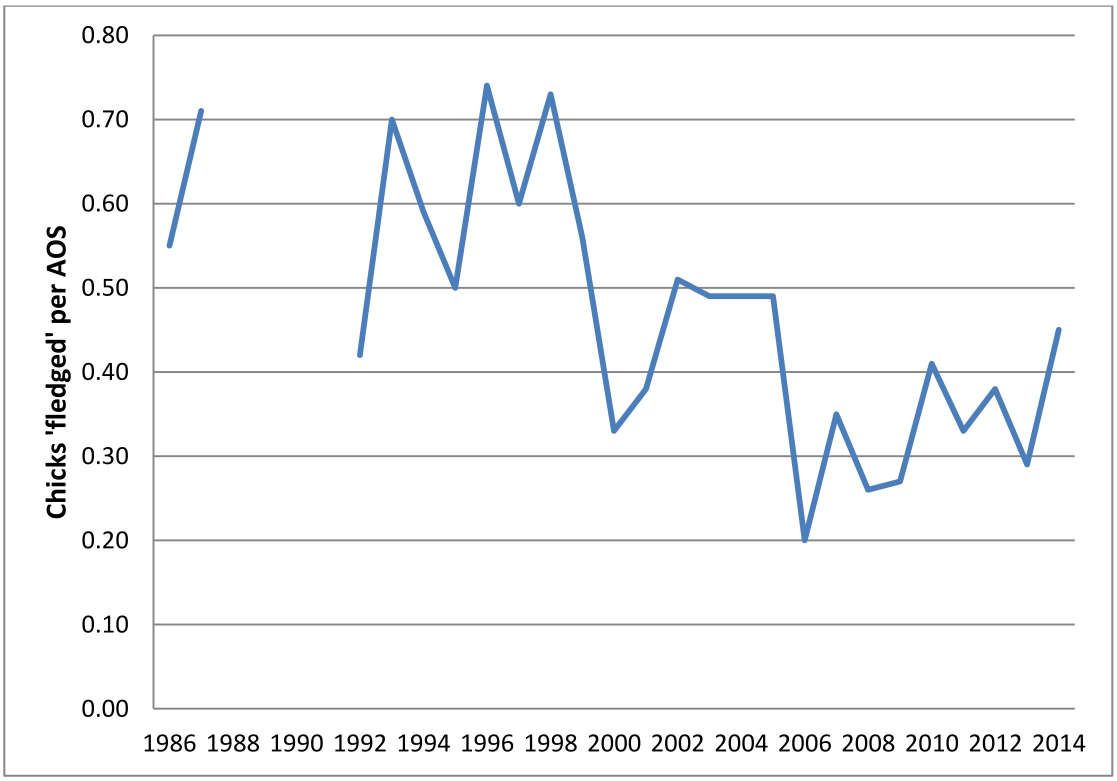
	No. site monitored	No. sites occupied	Chicks fledged	Breeding success
Tom's House	6	2	1	n/a
Basin (West)	35	25	12	0.48
Basin (East)	19	15	6	0.40
North Haven	47	31	15	0.48
South Haven	14	9	4	n/a
Castle Bay	20	13	5	0.38
Matthew's Wick	24	17	8	0.47
S.H. + T.H.	20	11	5	0.45
Total	**165**	**112**	**51**	
Mean				**0.45**
SD				**0.04**
SE				**0.02**

Table 3 **Northern Fulmar breeding success 2008-2014**

	2008	2009	2010	2011	2012	2013	2014
Tom's House	0.00	0.25	0.43	0.00	0.00	1.00	0.50*
Basin (West)	0.21	0.32	0.38	0.38	0.31	0.27	0.48
Basin (East)	0.25	0.33	0.64	0.43	0.43	0.41	0.40
North Haven	0.37	0.34	0.39	0.25	0.42	0.26	0.48
South Haven	0.32	0.11	0.24	0.23	0.33	0.24	0.44*
Castle Bay	0.38	0.25	0.33	0.44	0.35	0.33	0.38
Matthew's Wick	0.29	0.32	0.45	0.56	0.48	0.55	0.47
Mean	**0.26**	**0.27**	**0.41**	**0.33**	**0.38**	**0.29**	**0.45**
SE	**0.05**	**0.03**	**0.05**	**0.06**	**0.06**	**0.09**	**0.02**

* Site figures have been combined to produce the final productivity estimate, as suggested by JNCC, in order to combat the influence of very small plot sizes.

Figure 2 **Northern Fulmar breeding success 1986-2014**



3.3 Timing of breeding

The time of egg laying was specifically monitored in 2014, this may explain why it is five days earlier than any other year since 2008. Hatching dates were not monitored and are always difficult to detect.

Table 4 Northern fulmar timing of breeding 2008-2014

	2008	**2009**	**2010**	**2012**	**2013**	**2014**
First egg	23rd May	20th May	22nd May	20th May	3rd June	15th May
First chick	14th July	8th July	6th July	13th July	10th June	10th July

4 European Storm-petrel *Hydrobates pelagicus*

As part of a continuing project to estimate survival of breeding adult Storm Petrels on Skomer, 47 individuals were encountered in four ringing visits to the breeding colony at Tom's House in July and August (after the incubation period when storm petrels are less prone to disturbance). 19 individuals were retraps from previous years, and 28 new birds were ringed.

Preliminary analyses of ringing data from 2006-14 indicate a low recapture probability of birds known to be alive (less than 20%), and a large number of birds encountered once and never recaptured (nearly 87% of individuals are 'transient', most likely non-breeding birds prospecting for nesting sites). These factors hinder the estimation of annual survival rates, but survival estimates averaged over longer time periods (e.g. five years) will remain valuable, especially if combined with periodic census of apparently occupied breeding sites in this colony. The value of this project will increase as it becomes more long-term (only seven years of data are available), therefore the continued ringing of adult Storm Petrels at Tom's House is recommended, to further understanding of their ecology in corrdination with efforts on Skokholm Island's much larger population.

Project coordination and data analysis was carried out by Matt Wood, fieldwork by Ros Green with invaluable assistance from qualified ringers working on the island, including the Wardens.

5 Manx Shearwater *Puffinus puffinus*

5.1 Breeding study plots census

The breeding plots around Skomer have been studied since 1998 with help from University of Oxford MSc students, but this course ceased in 2011 and took with it the field workers and funding for accommodation at the peak of the seabird season. Volunteers from the Edward Grey Institute completed the survey in 2012, but were unable to do so in 2013. Two students from the University of Gloucestershire completed the census in 2014, but a more sustainable basis is required to safeguard the future of this census project.

Table 5 Manx shearwater burrows in census plots 1998-2012

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

Table 6 **Shearwater responses to playback in census plots 1998-2012**

Site/Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
A	12	15	17	12	20	15	16	12	28	10	23	20	9	13	17		24
B	19	35	18	19	32	28	32	15	21	30	12	15	9	18	19		20
C	56	45	27	35	36	45	52	41	53	66	69	82	30	66	41		102
D	81	65	61	51	71	55	52	64	64	73	61	57	31	80	97		112
E	17	14	17	15	14	7	9	9	10	5	8	3	5	5	5		5
F	3	3	2	5	5	6	4	7	8	6	6	3	4	3	9		9
G	2	6	4	3	9	7	5	8	9	2	9	12	6	7	9		16
H	23	17	10	15	16	10	14	16	13	17	14	22	12	18	32		12
I	72	88	74	117	75	67	102	134	111	116	83	169	110	135	144		134
J	77	75	107	67	54	66	81	73	42	70	72	80	46	95	93		118
L	147	132	186	131	142	164	185	244	150	157	156	222	123	159	179		215
M	85	80	67	62	79	94	71	75	66	73	65	81	33	95	89		85
N	51	67	39	49	52	44	40	63	75	23	37	70	41	82	62		77
O	27	29	38	34	30	36	84	34	40	29	25	38	30	51	45		47
P	30	60	57	67	78	77	32	67	95	72	117	93	80	107	127		98
Q	34	26	17	17	29	26	32	32	32	31	20	65	20	25	28		27
R	48	44	65	39	56	83	91	92	72	65	62	53	65	79	65		77
S	37	67	45	51	63	75	63	65	55	73	69	96	87	75	56		80
TOTAL	821	868	851	789	861	905	965	1052	944	918	908	1181	767	1113	1117		1258

5.1 Breeding Success

After an extremely poor breeding year in 2012 (0.55 fledged young per egg laid), followed by a better year in 2013 (0.60), 2014 has been a better year still (0.71), well above the five-year average of 0.65 and the 1995-2014 average of 0.62. This is also the highest productivity recorded since 1998 (0.76; see Figure 3).

Manx Shearwater breeding success in The Isthmus study plot in 2014 is detailed in Table 6; Figure 3 shows annual variation in breeding success since 1995.

Table 7 Manx Shearwater breeding success in The Isthmus study plot in 2014

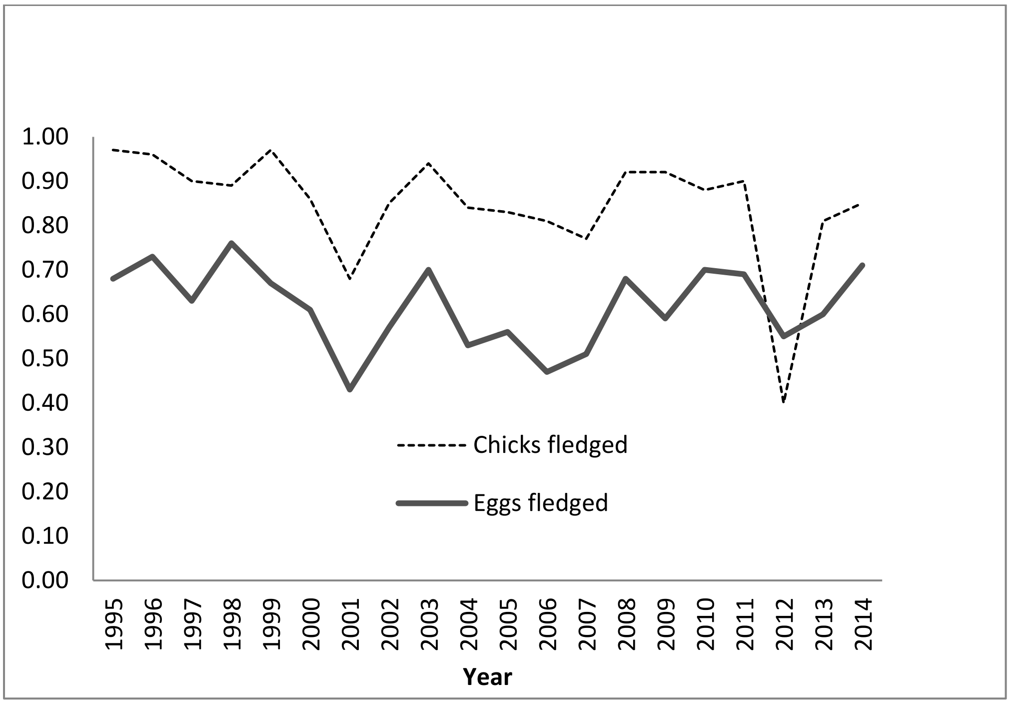
Total Number of eggs laid	85
Number of eggs known or assumed to have failed[1]	14
Number of eggs known or assumed to have hatched[2]	71
Number of chicks known or assumed to have died[3]	11
Number of chicks surviving to ringing age	60
Hatching success[4]	84%
Fledging success[5]	85%
Number of fledged young per egg laid	**0.71**

Notes:

1. Thirteen eggs are known to have failed, having been found abandoned or broken, or having disappeared before they could possibly have hatched. One more was assumed to have failed at the egg stage, the burrow being completely empty when checked on 12th July. Interestingly, both of these adults were present in the burrow one week later, without an egg, when it was double checked.
2. Seventy-one chicks were found between 24th June and 29th July. 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 found dead inside the burrows, but eight are only assumed to have failed. These eight burrows were found empty when checked in early August. It is remotely conceivable that three of these could have fledged normally, but at this early time in the season it is improbable.
4. Hatching success = % of eggs known or assumed to have hatched.
5. Fledging success = % of chicks surviving to a large size.

In Figure 3, a clear parallel can be seen between the two datasets. The weather in 2012 meant that many burrows were flooded and so very few of the hatchlings survived to fledging age.

Figure 3 Annual variation in Manx Shearwater breeding success 1995-2014



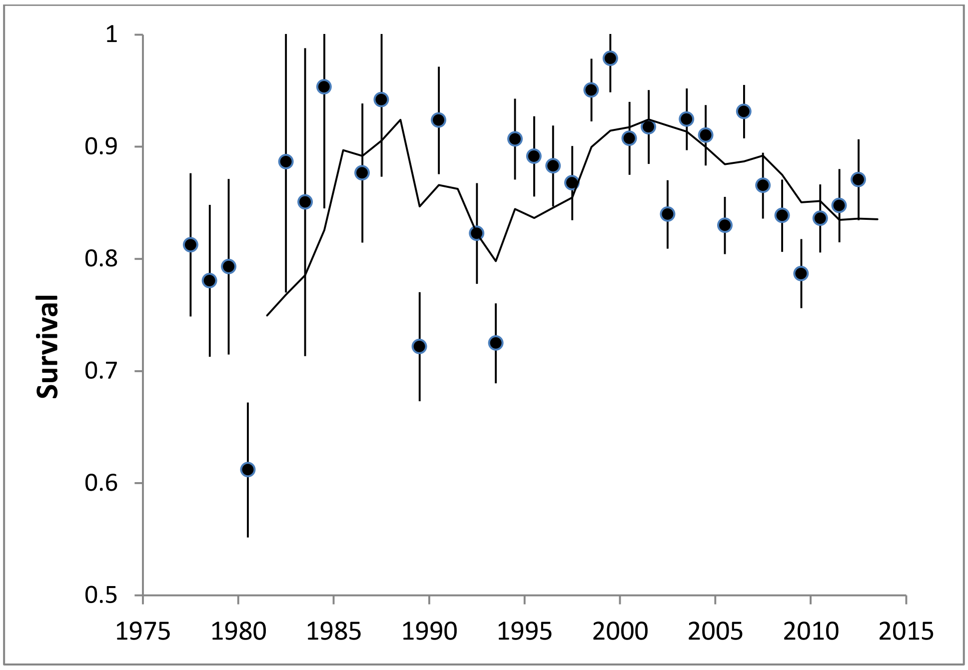
Productivity varies markedly between years, with signs of a gradual increase over the last 10-15 years. The potential effects of temporal variation in productivity and survival (Section 1.1.2) on the demography of shearwaters warrant further study, in relation to the annual breeding census undertaken at sites across Skomer island since 1998 – the only annual index of population available and with uncertain future.

5.2 Adult survival

The shearwater survival estimates are based on birds that are marked in burrows on The Isthmus. All but a few of the nests are reached every year and the majority of the birds breeding in them are caught. In recent seasons, night searches for adults in the vicinity have turned up a few "missing" birds - birds that had survived, but were not breeding in the study burrows; presumably they were living nearby.

Figure 4 shows annual variation in breeding survival estimates for Manx Shearwaters. Recent analyses indicate that the data set is most robust for the analysis of trends in survival since 1992 (M.J. Wood *et al*. in prep). Although there is no significant time-associated variation in adult breeding survival since 1992, there is a clear decline in adult breeding survival since 1994, which may be a potential concern for Manx Shearwaters on Skomer Island. As reported previously, these survival estimates remain low, both in comparison with more detailed studies carried out in the 1960s and 70s on Skokholm and with what might be expected for a bird with such a low reproductive rate. The effects of this recent decline require further analysis, ideally incorporated with annual census of breeding population changes (see Section 5.1) in sixteen plots of breeding burrows around Skomer into population modelling.

Figure 4 **Survival rates of adult breeding Manx Shearwaters 1978-2013**



Notes:

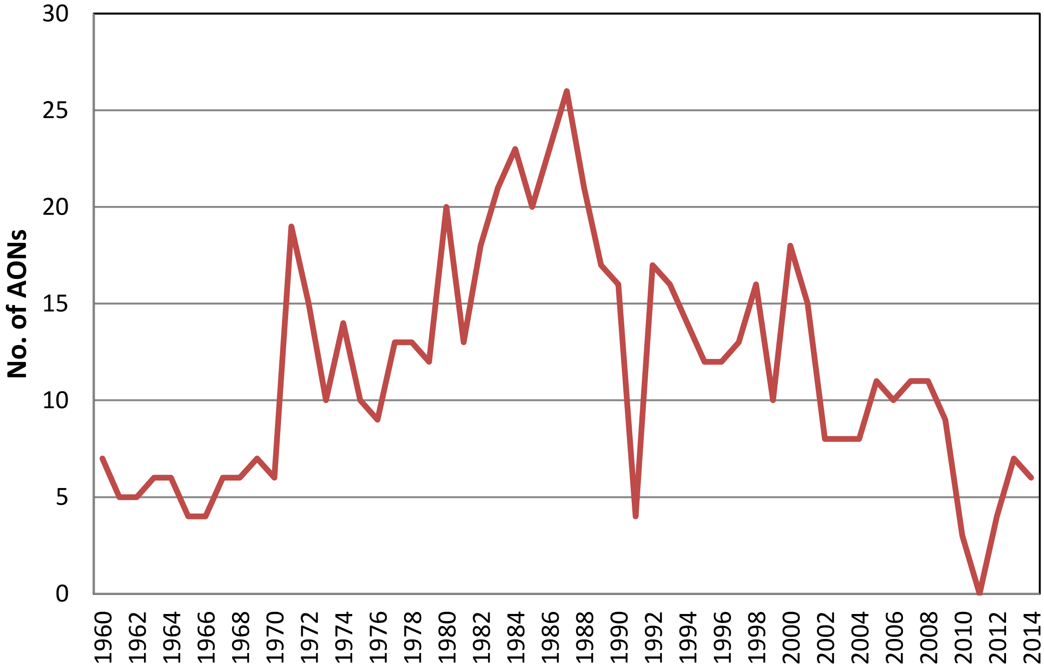
1. Fitted line shows the five-year moving average, error bars ± 1 standard error
2. Survival was non-estimable in 1981-2, 1988-9, 1991-2 and 2013-14 (the last transition in such analyses is non-estimable, requiring at least on further year's data. See Section 1.1)
3. Appendix 1 gives the estimated survival rates for 1978-2013.

6 Great Cormorant *Phalacrocorax carbo*

6.1 Breeding numbers

All nests were again located on the southern face of the Mew Stone and there was a slight drop from seven nests (or AONs) in 2013 to six in 2014.

Figure 5 Great cormorant breeding numbers 1960-2014



6.2 Breeding success

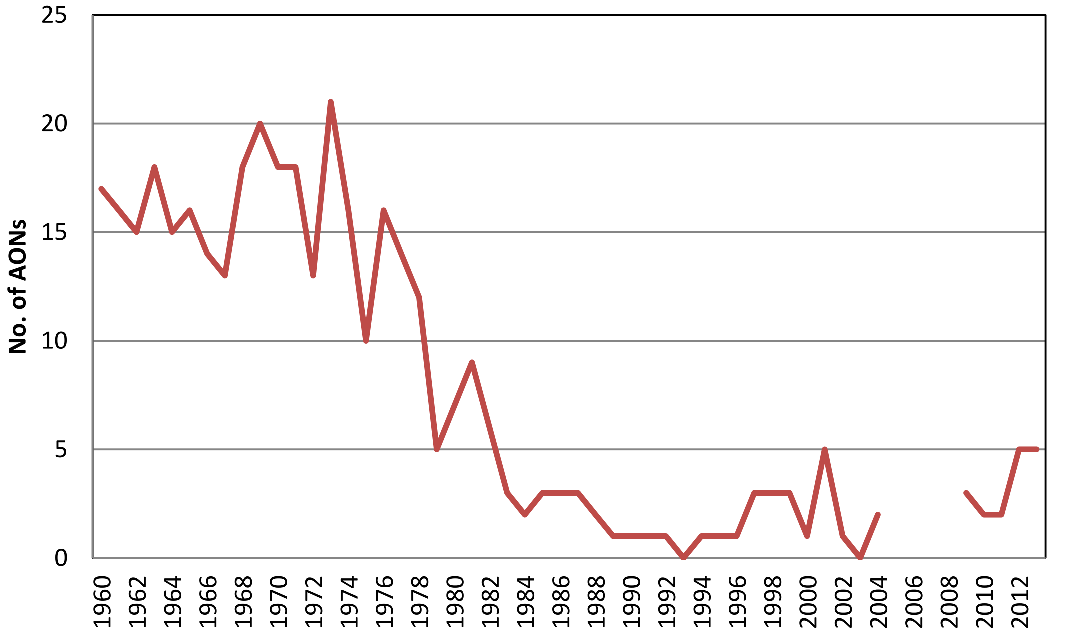
Three visits were made to the colony between 5th and the 18th of June to count nests and young. Nine chicks fledged from six nests giving a productivity figure of 1.5 chicks fledged per AON. However, one nest may have been missed and if so this would give the slightly lower productivity figure of 1.3 chicks fledged per AON.

7 European Shag *Phalacrocorax aristotelis*

7.1 Breeding numbers

Several visits were made to the colony near Double Cliff in June and July but nests were too well hidden to locate from a boat. A single nest on the Garland Stone was monitored and fledged three chicks.

Figure 6 **European Shag breeding numbers 1960-2013**



7.2 Breeding success

An accurate productivity figure for Skomer (excluding Middleholm) is difficult to give, as the single visible nest at the Garland Stone gives a productivity figure of 3 chicks fledged per AON, which is surely too high if there were an unknown number of nests (AONs) at Double cliff. On the 18th of July five recently fledged chicks were seen at the Double Cliff colony as well as the three chicks at the Garland Stone. This Highlights the fact that there probably were an unknown number of AONs at Double Cliff and the difficulty in arriving at accurate population and productivity figures for 2014.

Shags breeding on Middleholm were monitored by South Pembrokeshire Ringing Group on a visit on the 30th of June to monitor nests and ring chicks. 23 were nest sites located of which five were built and occupied but probably fledged no chicks, six were innaccessible and contained large chicks (4 x 3 chicks and 2 x 2 or 3 chicks), one with two late eggs, two where chicks had almost certainly fledged and nine with chicks ringed. A total of 25 chicks were ringed from nine nests equating to 2.78 chicks fledged per pair. This is a high productivity level and one of the best since monitoring began, although the number of nests has fallen. Taking into account the other six sites with chicks and those where probably no chicks fledged the minimum productivity level is 2.1 chicks per pair. It was also a rather late breeding season for Shags on Middleholm with the chicks being ringed at least a month later than two years ago.

8 Lesser Black-backed Gull *Larus fuscus*

8.1 Methods for estimating breeding numbers

The Lesser Black-backed Gull *Larus fuscus* colonies were counted by eye (eye counts) from established vantage points between the 3rd and 6th of May. Mike Wallen, a volunteer, has been doing these eye counts for many years and, to keep the counts consistent, this was continued in 2014. In addition Eye Counts, Mike also made an assessment of vegetation height and burrow density which he recorded for each sub-colony to build up a picture of the detectability of nests, suitability for systematic walk-through counts and a choice of sub-colonies that reflects vegetation across the island.

Systematic Counts of a subsample of colonies (Table 8) were then made between the 19th and 26th of May. Nests, including empty nests, in selected sub-colonies were systematically searched for and counted by fieldworkers. The method assumes that each pair builds one nest. Systematic counts usually detect more nests than eye counts, so a correction factor (ratio of systematic counts to eye counts) was used to scale up whole-island eye counts to the number of AONs.

Since 2011, at the request of JNCC, the sub-colonies selected for systematic counts have been rotated each year to avoid subjecting the same areas to the inevitable disturbance of census work that may have an adverse impact on the accuracy of survey results. The aim is to build up a rolling picture of the correction factors for specific sections over the course of several years. The rationale is as follows:

- Four sub-colonies were checked by doing walk through counts in 2014 (4,6,B,P)
- Where correction factors have been obtained in 2014, and other sub-colonies since 2011, these are used to calculate the number of AONs per sub-colony from eye counts (Table 9)
- Where more than one correction factor exists, the average is used (2011-2014 average = 2.17)
- Where no correction factor exists, the average correction factor over all sub-colonies is used

There are limitations of this approach. (i) it is assumed that the detectability of nests remains constant between years when vegetation height that may obscure both eye and systematic counts is known to vary, and (ii) it is assumed that correction factors remains constant in space when local features such as habitat type and breeding density are known to vary. Applying mean correction factors to sub-colonies not systematically surveyed, and carrying over correction factors between years is unlikely to be entirely accurate, but not using a correction factor would greatly under-estimate the number of AONs and it is hoped that the accuracy of this method will improve as systematic counts are rotated through more sub-colonies on the island.

8.2 Breeding numbers – results

In eye counts, a total of 3812 Apparently Occupied Nests (AON) and Apparently Occupied Territories (AOT) were identified from standardised viewpoints around the island (Table 9). The number of Apparently Occupied Nests, including empty (but active) nests, in selected sub-colonies was systematically counted by walking through the colony in 2014 (also Table 9, see Section 8.1 for methods).

Of 43 sub-colonies, 15 have been counted systematically since 2011 Correction factors (ratios of systematic counts to eye counts) are used to calculate the number of AONs for these sub-colonies, and the mean correction factor (2.17±0.19) used for sub-colonies not yet systematically counted.

This gives a population estimate of 8432 breeding pairs, which is 3.6% higher than 2013 but still an 11.2% decline compared to the five year average 2009-2013 (Figure 7). The population remained at a historically low level in 2014, a 58.3% decrease since 1993 when the population was at its peak.

Poor adult survival is implicated as one of the drivers of this long term decline (see Section 8.4) but it is not known how many of these 'missing' birds die over the winter and how many simply move to another colony. A good breeding season in 2014, with increases in population and productivity, was welcome after an extremely poor one in 2013.

Figure 7 **Lesser Black-backed Gull breeding numbers 1961-2014.**

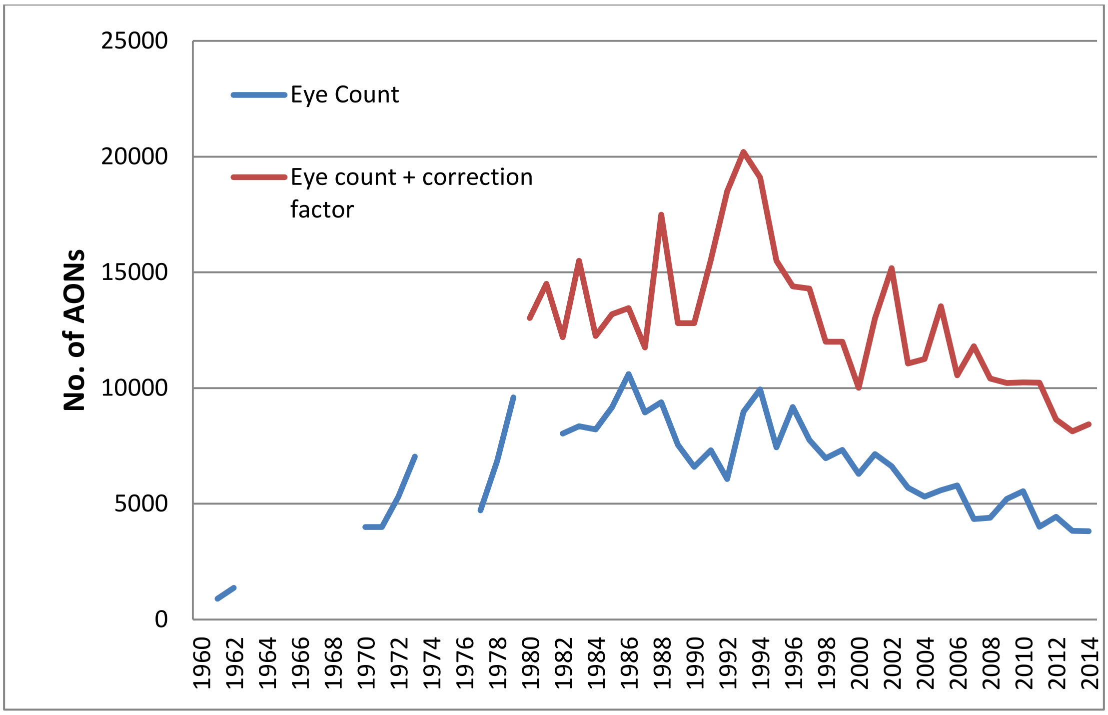


Table 8 Record of Lesser Black-backed Gull systematic counts in sub-colonies. Systematic walk-through counts are carried out by careful searching for Apparently Occupied Nests (AONs). These systematic counts enable the calculation of a whole-island estimate of AONs

	2011 & previous years	2012	2013	2014
1 South Old Wall				
2 Marble Rocks				
3 Abyssinia + 24				
4 Anvil Rock				
5 Bull Hole				
6 Pyramid Rock				
7 North Plain				
8 Sheer Face West				
9 Sheer Face East				
10 The Hill				
11 Double Cliff				
12 North slopes				
13 North Valley Rise				
14 Green Plain				
15 South Neck - Thorn Rock				
16 W/S Field				
17 Saunders Fist				
18 Harold Stone				
19 Wick Cliff				
20 Tom's House-Skomer Head				
21 colony now joined with X				
22 Garland Stone				
23 North West Neck				
24 East of West Pond – see 3				
25 Toms House to Wick				
26 Mew Stone				
A Lantern				
B Neck East				
C Neck main ridge				
D South Castle				
E Neck South West Coast				
F South Haven				
G South Stream Cliff				
H Welsh Way				
I High Cliff				
J South Wick Ridge				
K Wick				
L Welsh Way Ridge				
M Wick Ridge North				
N Wick Ridge North				
O Moorey Meadow				
P South Stream				
Q Bramble				
R Lower Shearing Hays				
S New Park				
T Shearing Hays				
U Captain Kites				
V Wick Basin				
W The Basin				
X / 21 (see 21)				
Y Field 11				
Z Basin-South Pond				

Table 9 Lesser Black-backed Gull counts of Apparently Occupied Nests

Sub-colony	Mean eye count	Number of correction factors 2011-2014	Correction factor	AONs
1 South Old Wall	67	1	3.59	241
2 Marble Rocks	67	1	1.87	125
3 Abyssinia + 24	90	1	1.74	156
4 Anvil Rock	119	1	2.85	339
5 Bull Hole	65	2	3.36	219
6 Pyramid Rock	42	0		91
7 North Plain	240	1	2.24	538
8,9,10 Sheer Face	157	2	1.97	309
11 Double Cliff	17	1	2.37	40
12 North slopes	22	0		48
13 N Valley Rise	303	0		659
14 Green Plain	601	0		1307
16 W/S Field	31	1	0.42	13
18 Harold Stone	0	0		0
19 Wick Cliff	2	0		4
20 Tom's House-Sk Head	5	0		11
21 colony now joined with X	60	0		130
22 Garland Stone	17	0		37
23 NW Neck	31	0		67
25 Toms House to Wick	0	0		0
B Neck E	103	1	2.67	275
C Neck main ridge	131	0		285
D South Castle	122	0		265
E Neck SW coast	18	0		39
F South Haven	105	0		228
G S Stream Cliff	51	0		111
H Welsh Way	51	0		111
I High Cliff	48	1	1.63	78
J S Wick Ridge	30	1	1.55	47
L Welsh Way Ridge	94	0		204
M N Wick Ridges	174	0		378
O Moory Meadow	83	0		180
P South Stream	74	1	2.19	162
Q Bramble	3	0		7
R Lower Shearing Hays	192	0		417
S New Park	110	0		239
T Shearing Hays	54	0		117
U Captain Kites	109	0		237
V Wick Basin	0	0		0
W The Basin	34	1	1.71	58
Y Field 11	124	2	2.60	322
Z Basin-South Pond	166	1	2.02	335
Extra coastal	0	0		0
TOTAL	**3812**			**8432**

Tables 10 & 11 and Figure 8 indicate an increase of empty nests on previous records, for the fifth year in a row.

Table 10 Percentage of empty Lesser Black-backed Gull nests counted in May 2014

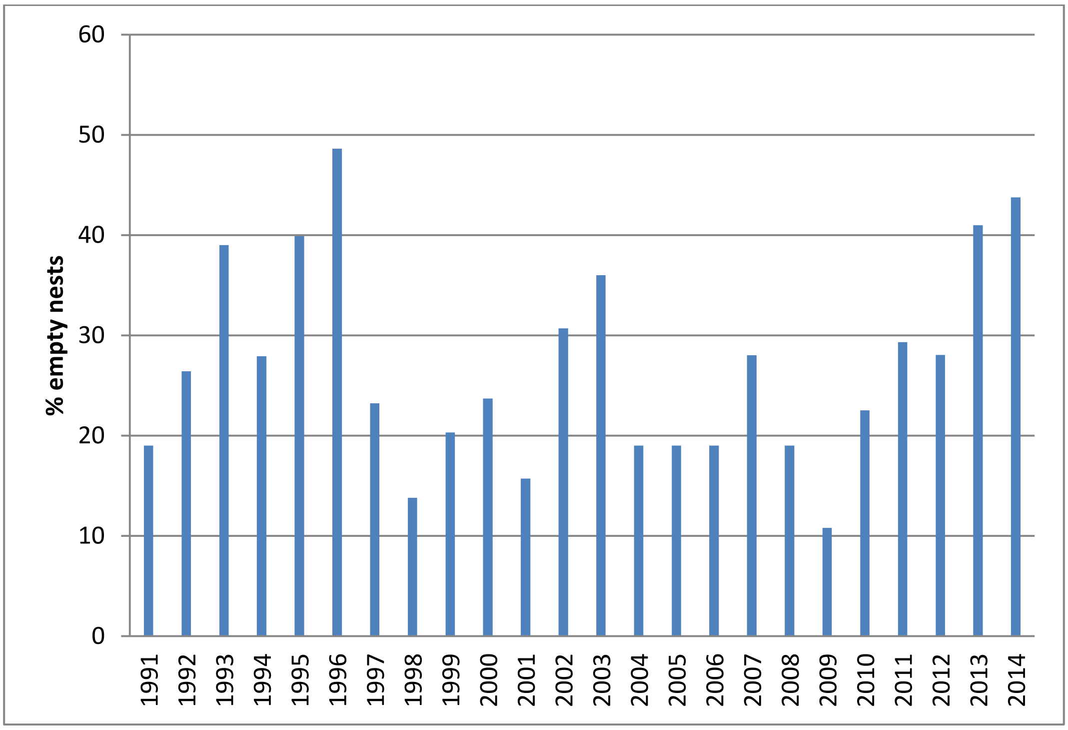
	Sub-colony	TOTAL	Empty total	% empty
4	Anvil Rock	339	135	40
6	Pyramid Rock	250	164	66
B	Neck East	275	106	39
P	South Stream	162	44	27
Mean		257	112	44

Table 11 Lesser Black-backed Gull empty nests 1998–2014

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2001
% Empty nests	19	26	39	28	40	49	23	14	20	24	16	31

2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
36	19	19	19	28	19	10.8	22.5	25.3	28	41	44

Figure 8 Percentage of empty Lesser Black-backed Gull nests 1991–2014



8.3 Breeding success

The estimated number of fledglings of Lesser Black-backed Gulls in 2014 (4264 fledglings) was much greater than that of the poor season in 2013 (579 fledglings). This 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, although in the last few years it has been difficult to find this number, due to successive poor breeding seasons.

In 2014, 279 chicks were ringed, a considerable increase on 2013 (59). The ringed/resighting estimates based on these are shown in Table 12 and the productivity in Table 13.

Table 12 Estimated number of Lesser Black-back Backed Gull fledglings in 2014

Date	No. ringed fledglings seen	No. unringed fledglings seen	Total no. fledglings seen	Est. No. of fledglings
31/07	19	362	381	5595
04/08	40	410	450	3139
06/08	34	486	520	4267
08/08	34	460	494	4054
Mean	32	430	461	4264

Note: Estimated number of fledglings = (total fledglings seen x number of fledglings ringed, i.e. 279) / number of ringed fledglings seen.

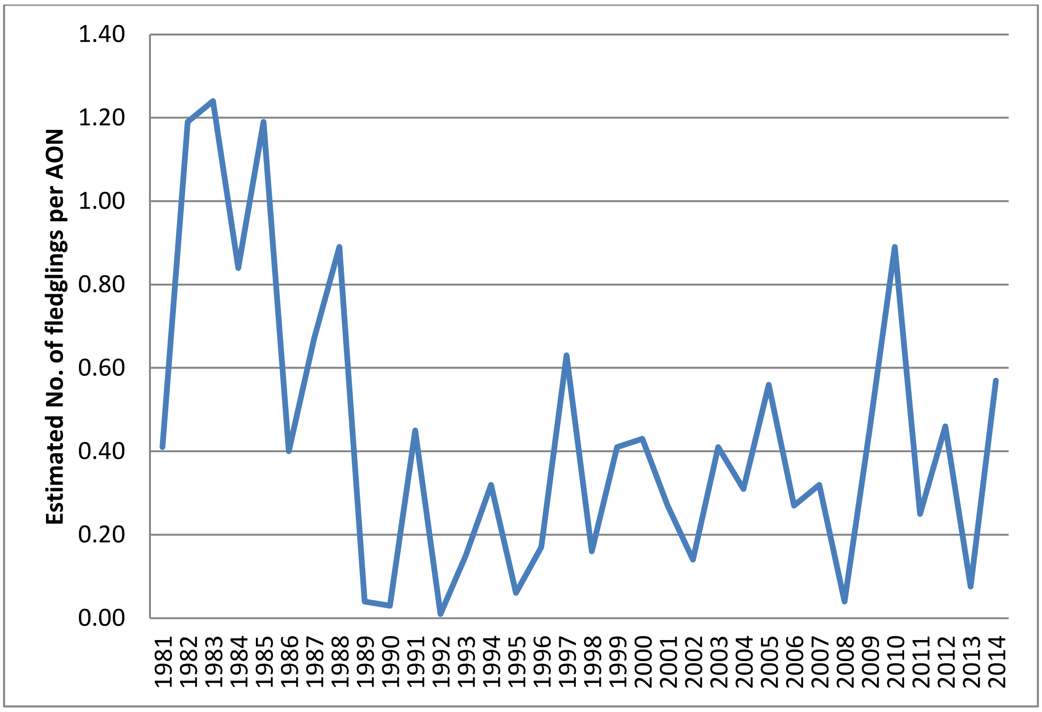
Table 13 Estimated productivity of Lesser Black-back Backed Gulls in 2014

	Number of fledglings	Productivity (AON=7501)
Maximum estimate	5595	0.76
Minimum estimate	3139	0.42
Mean estimate	4264	0.57

Note: Productivity is calculated as the number of fledglings (from mark-recapture of fledglings) per Apparently Occupied Nests on Skomer Island, excluding The Neck (from corrected eye-counts). See Section 8.1 for methods.

Figure 9 shows the estimated productivity of Lesser Black-backed Gulls on Skomer since 1981. After a sharp decline in the 1980s, average productivity has since remained low with frequent years of very low productivity. 2014 productivity appears to have been higher than the 20 year average (0.33), and a considerable increase after the very poor year seen in 2013.

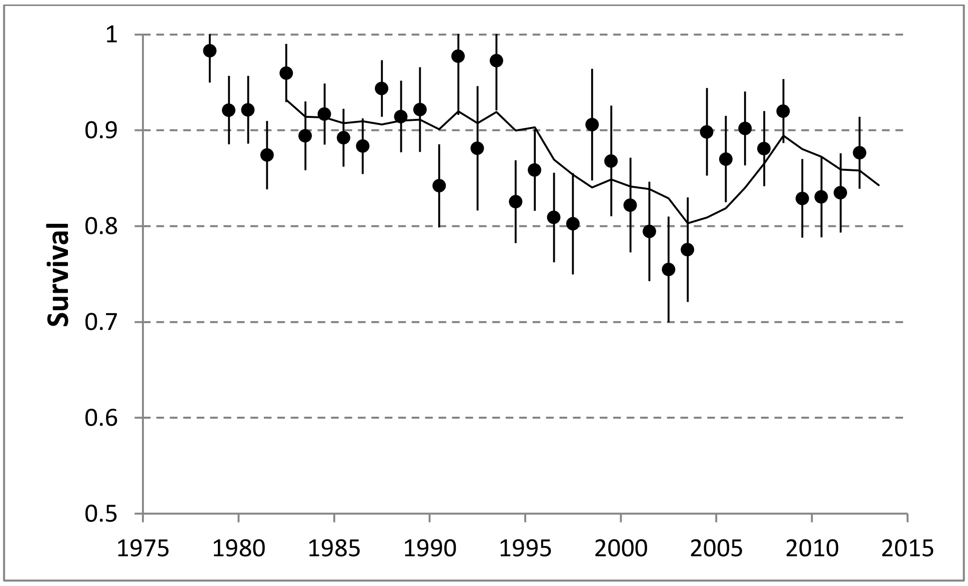
Figure 9 Productivity of Lesser Black-backed Gulls per AON 1981-2014



8.4 Adult survival

These birds are all from the study area in Lower Shearing Hays. Previously, it has been noted that there has been a decline in the breeding population, presumably due to the very poor breeding success. Overall survival 1978-2014 has averaged 0.88, but there has been considerable variation over time (Figure 10). The steady decline in survival from the late 1970s to the early 2000s appears to have recovered somewhat in recent years, but remains lower than the 1970s and 80s.

Figure 10 Survival rates of adult breeding Lesser Black Backed Gulls 1978-2013



Notes:

1. Fitted line shows the five-year moving average, error bars ± 1 standard error

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 1 gives the estimated survival rates for 1978-2014

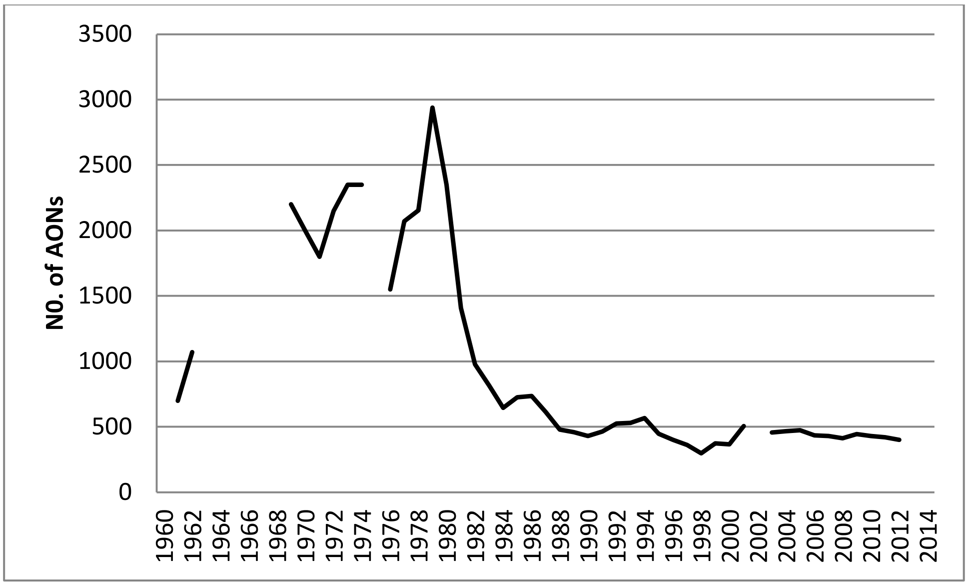
9 Herring Gull *Larus argentatus*

9.1 Breeding numbers

A total of 440 Apparently Occupied Nests (AON) was counted in 2014. 307 of these were coastal nesting with the remainder nesting inland (133). Therefore 70% of Herring Gulls nested on the coast which is very similar to the percentage of coastal nesting birds in 2012 (68%).

Skomer's Herring Gulls fell into heavy decline in the 1980's but have stabilised at a lower level since then (Figure 11). 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 11 Herring Gull: Number of AONs 1961-2014



9.2 Breeding success

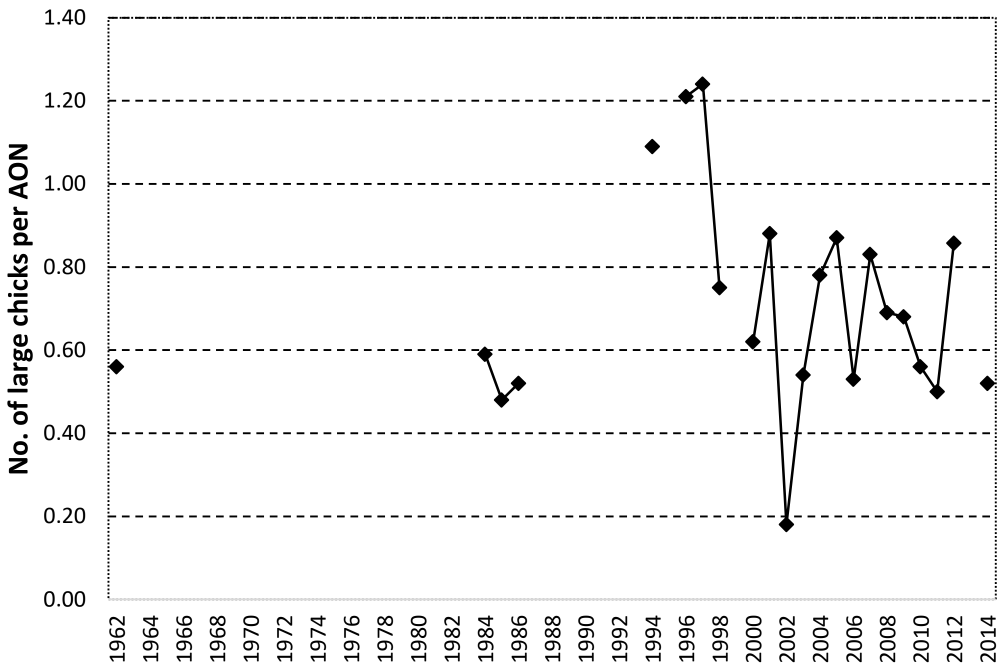
The average breeding success for all years monitored between 1962 and 2013 is 0.71 large chicks per AON. Productivity for 2014 was 0.52, a figure somewhat lower than the island average and lower than the most recent value obtained in 2012, which was 0.86.

Sites were visited on 19th May to identify and map Apparently Occupied Nests (AON), with a further nine visits made between 23rd May and 9th July to monitor chick development and record large chicks/fledglings.

Table 14 Estimated productivity of Herring Gulls on Skomer, 2014

	AON	Large Chicks	Productivity
Tom's House	23	12	0.52
Waybench	Not recorded in 2014		

Figure 12 Breeding success of coast-nesting Herring Gulls, 1962-2014.

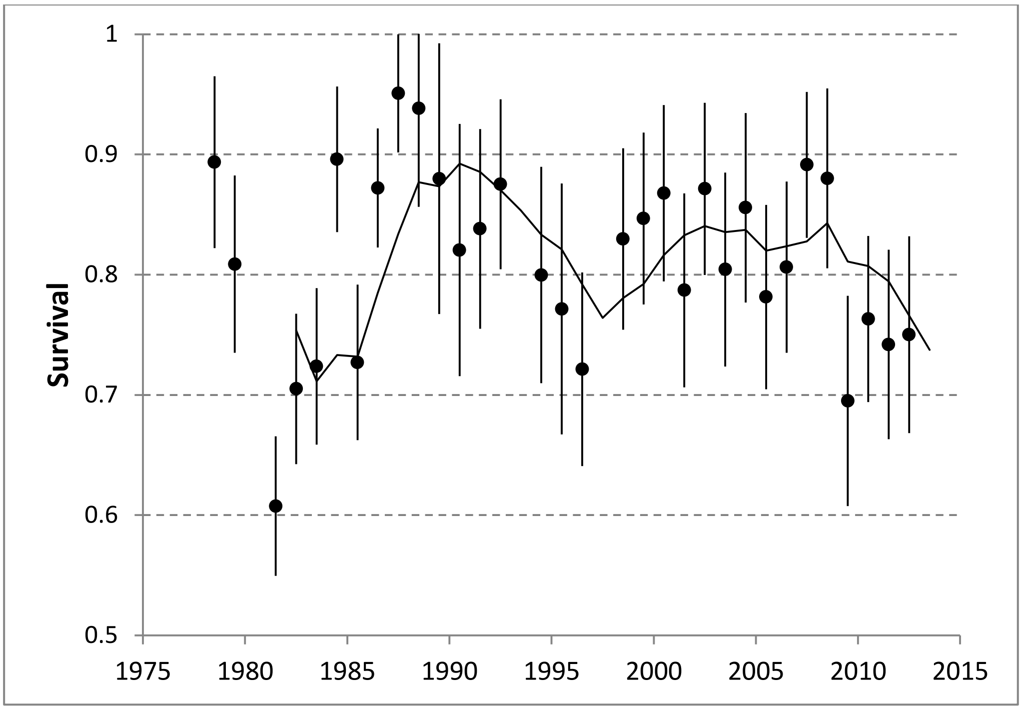


3.1 Adult survival

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. However, the samples are still smaller than desirable.

Adult breeding survival has declined steadily in recent years, mirroring the sharp declines seen in the years up to 1980-1 and 1997-8. Again, this may be cause for concern and warrants further analysis.

Figure 13 Survival rates of adult breeding Herring Gulls 1978-2013



Notes:

1. Fitted line shows the five-year moving average, error bars ± 1 standard error
2. Survival was non-estimable in 1980-81, 1993-4, 1997-8 and 2013-14 (the final transition in the series in such analyses is not estimable, Section 1.1)
3. Average survival 1978-2014 = 0.812, (excluding estimates from the years mentioned above)
4. Appendix 1 gives the estimated survival rates for 1978-2013

10 Great Black-backed Gull *Larus marinus*

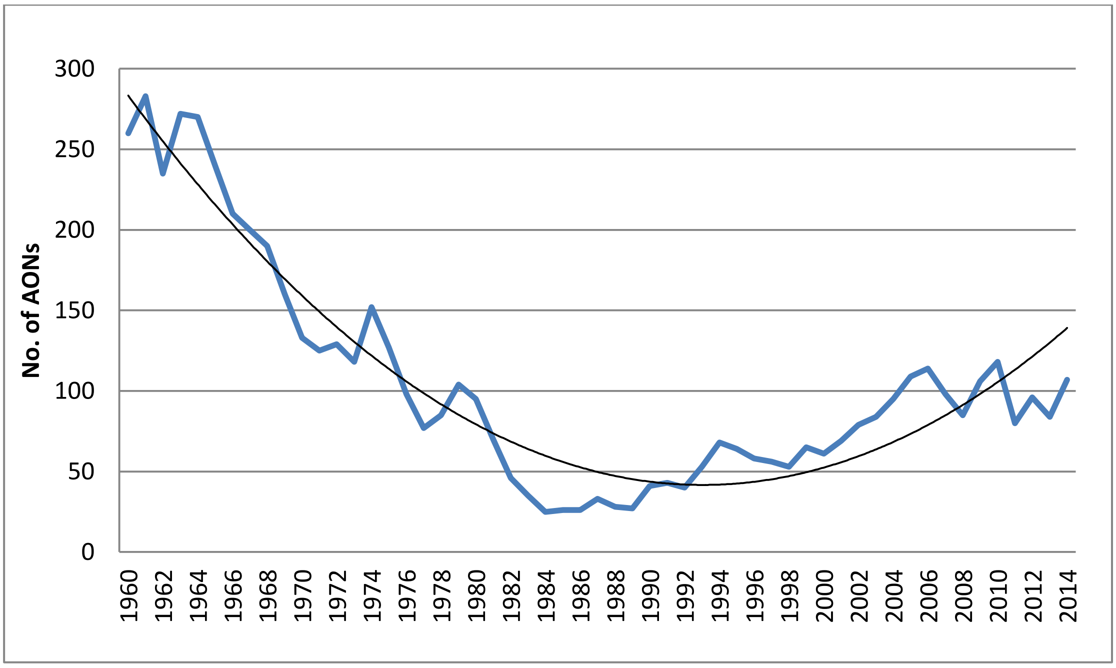
10.1 Breeding numbers

After a dip in 2013 (84 AON) Great Black-backed Gull (GBBGU) numbers were back up to 107 Apparently Occupied Nests (AON) in 2014. This is 7% higher than the ten year mean (100 AON) and the highest figure since 2010.

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 has shown a slow decline since 1999. Although the Skomer population has Recent data suggests that the population may be recovering from earlier setbacks from the 1960s to 1980s (see Figure 14).

Figure 14 Great Black-backed Gull breeding numbers 1960-2014



10.2 Breeding success

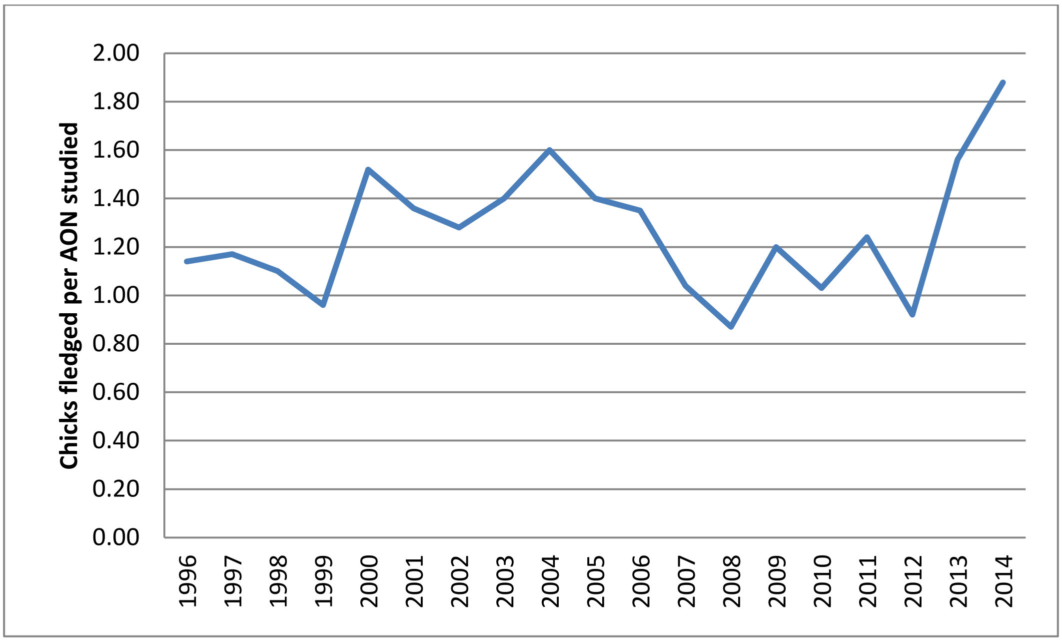
Monitoring of the breeding success of Great Black-backed Gulls has been included in the JNCC contract since 1999.

25 Great Black-backed Gull AON were identified during May across the island. These were visited between the 21st June and 14th July resulting in a total of 47 large chicks being recorded. Of these, three nests had no chicks, one had only one chick, 17 nests had two chicks, and four had three chicks. This gives a productivity of 1.88 chicks per AON, a

significant increase in breeding success compared to the last few years (Figure 15). Moreover, it is the highest productivity figure since records began in 1996.

Whilst carrying out the diet monitoring on this species one nest that appeared to have fledged no chicks contained evidence to the contrary. This may have been the result of early fledging, and the tendency for the chicks to roam around the area around the nest. If this is the case then the productivity may be even higher than 1.88 chicks per AON.

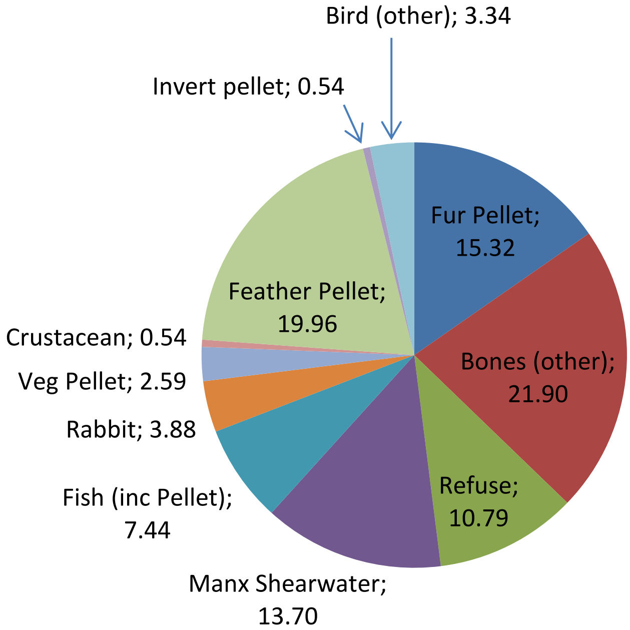
Figure 15 Great Black-backed Gull breeding success 1996-2014



10.3 Diet Study

A trial study to monitor the diet of GBBGUs was initiated in 2008 then continued in 2013 and 2014. The prey remains around a sample of 25 nests were recorded. The sample represented nests from differing habitats and shearwater densities. The survey was carried out after chicks fledged (from late July to early August).

Figure 16 Great Blacked-backed Gull diet remains

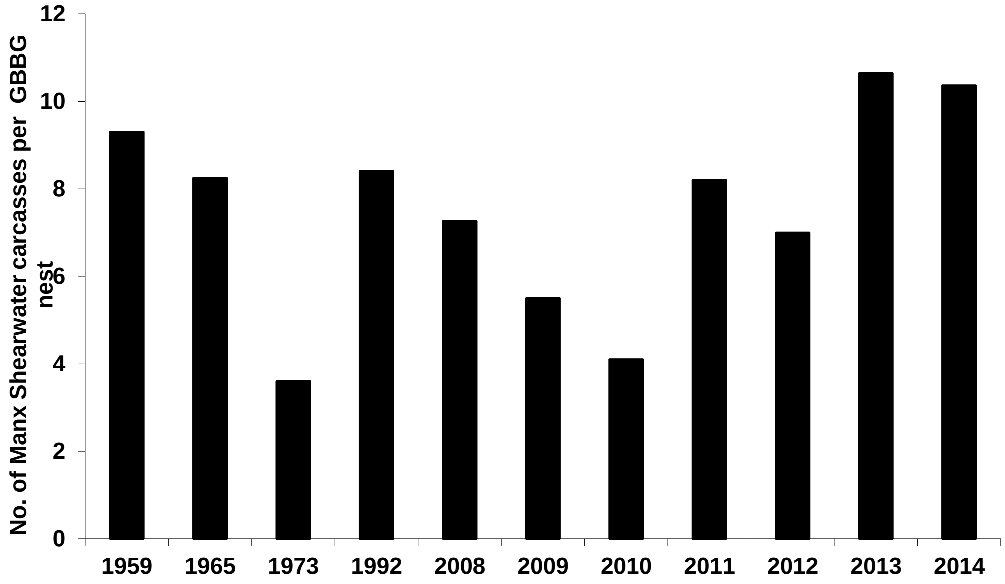


The modified method used in 2013 was used again during 2014. Prey items within a five metre radius cross-shaped transect centred on each nest were recorded. Additionally the number of Manx Shearwater and Rabbit carcasses within a 10m radius search area around the nests was recorded for comparison with historic records of Manx Shearwater predation levels.

Roughly 14% of the prey items recorded were Manx Shearwaters (Figure 16), compared to 20% in 2013. Manx Shearwater remains were recorded at 92% of the nests studied. The bones (other) category was the most prevalent prey items category, being found at 100% of the nests. Refuse was found at 88% of the nests, compared to 76% in 2013. Other birds were found at 44% of nests in 2014, compared to 60% of nests in 2013, and included Puffin, Guillemot, Razorbill and Lesser Black Backed Gull.

In 2014 a total of 259 Shearwater carcasses were found at the sample of 25 nest sites, giving a mean of 10.36 carcasses per nest (Figure 17). This is the second highest rate recorded, and is almost identical to the 2013 level of 10.64 carcasses per nest. The number of rabbit carcasses discovered this year was 2.76 rabbit carcasses per nest compared to 3.12 in 2013.

Figure 17 Shearwater carcasses per Greater Black-backed Gull nest 1959-2014



11 Black-legged Kittiwake *Rissa tridactyla*

11.1 Breeding numbers

After a record low in 2013 (1045 AON) a slight recovery in numbers was apparent in 2014. Birds were obviously more able to build nests at the 'normal' time and two whole island counts were once again possible (only one was possible in 2013). A mean of 1488 Apparently Occupied Nests (AON) were counted in June (1st-26th). This represents a 42% increase on 2013 but is still a -23% five year change and is 20% lower than the ten year mean (1850 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 a 77% decline since 1986. 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 only 31% since 1986. This decline has likely been caused by low productivity coupled with low survival, and looks likely to continue.

Figure 18 Black-legged Kittiwake breeding numbers 1960-2014

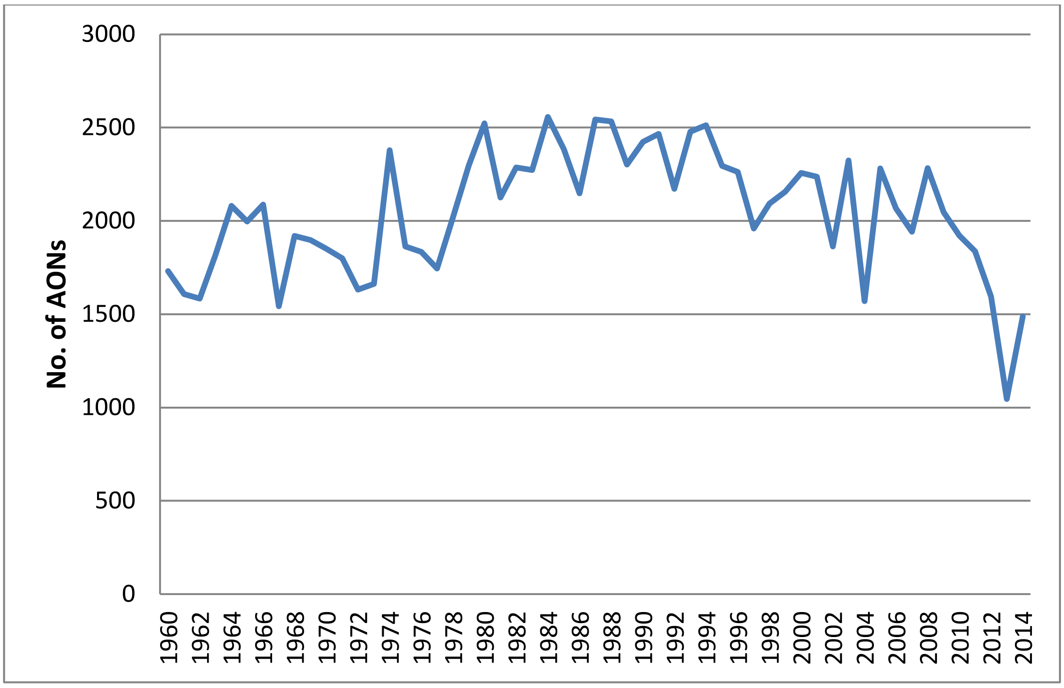


Table 15 Black-legged Kittiwake whole island count details 2007-2014

	Total	% change	5 year % change
2007	1942	-6	-16.1
2008	2282	+17.5	+45.4
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

11.2 Breeding success

11.2.1 Methods

The breeding success of 491 kittiwake AONs was monitored at the same three sub-colonies studied since 1989 (note: some areas within the sub-colonies have been dropped since 1989) using the same methods as in previous years from Walsh *et al.* (1995). New photographs were taken this year with each nest being marked on a transparent overlay. Visits were made to each sub-colony to monitor progress from nest construction to fledging. All chicks that were large (class 'e' in Walsh *et al* (1995)) were assumed to have fledged. On the last visit any chicks of medium/large size (class 'd') were also assumed to have fledged. Standard recording sheets from the Seabird Monitoring Handbook Walsh *et al.* (1995) were used for data collection.

11.2.2 Results

This year 544 nests were started in the study areas, an increase from 500 nests in 2013. Study sites Wick 8 A+B contained no nests (there was one nest in these plots in 2011, and none in 2012 or 2013). Breeding success per nest was double that of 2012 and 2013.

The 491 AONs produced a minimum of 455 chicks. Because of the difficulty of recording small chicks in some of the plots this is likely to be an underestimate. Last year only 166 chicks survived to a 'large' size class, this year however a total of 345 reached a 'large' size and were considered to have fledged successfully.

During the egg incubation stage a Carrion Crow was seen at South Stream predating nests. Out of 189 fully built nests only 23 were recorded as having chicks (12%), compared to 402 nests producing 420 chicks (104%) at High Cliff and the Wick combined. High Cliff and the Wick combined had a productivity of 0.80 chicks per AON, if there had been a similar success rate at South Stream there would have been 151 chicks fledging rather than just 23. In 2013 South Stream also did particularly badly, although there is no mention of the Carrion Crow, it may be the case that one particular individual is targeting the South Stream colony, such predation events should be recorded and noted each year.

In 2014, 88% of AONs went on to apparently incubate eggs (79% in 2013), with 72% of these producing chicks (73% in 2013). 10% of pairs did not complete nests (‘trace’ nests only) compared to 21% in 2013.

Table 16 Black-legged Kittiwake breeding success 2014

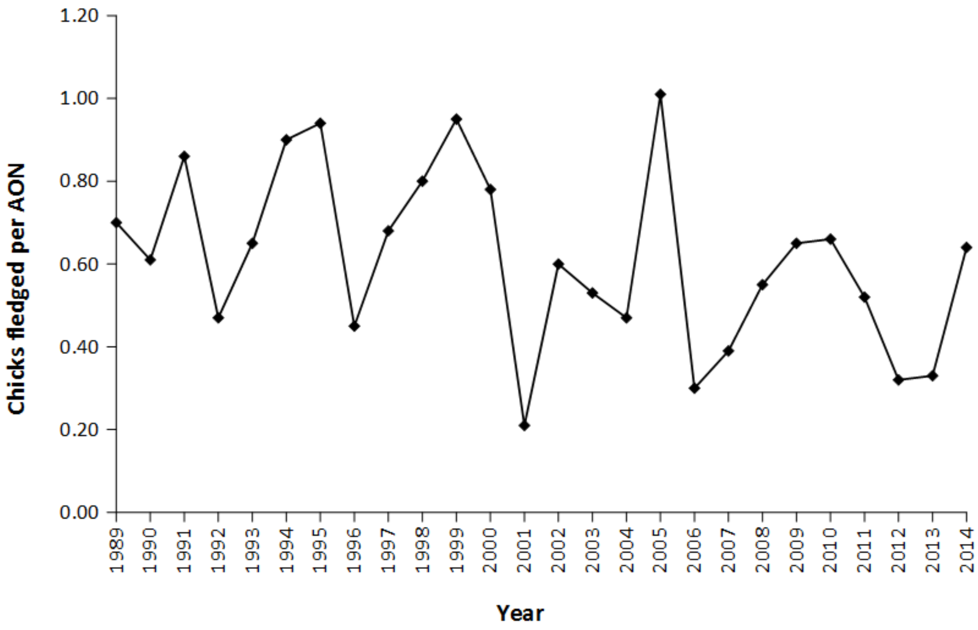
	Nests started	AON'S	Incubating Pairs	Nests with chicks	Total chicks	Large chicks		Breeding Success
S.Stream	113	89	59	23	35	23		0.26
High Cliff	122	111	97	92	130	95		0.86
The Wick	309	291	277	197	290	227		0.78
Totals	544	491	433	312	455	345	**Mean**	**0.64** (0.93)*
							SD	**0.28**
							SE	**0.09**

* figure in brackets is total number of chicks divided by the total number of AON's

Table 17 **Black-legged Kittiwake breeding success 1989-2014**

Year	Mean breeding success	Standard Error
1989	0.70	0.04
1990	0.60	0.07
1991	0.86	0.07
1992	0.47	0.12
1993	0.65	0.08
1994	0.90	0.14
1995	0.94	0.11
1996	0.45	0.06
1997	0.68	0.06
1998	0.79	0.09
1999	0.95	0.06
2000	0.78	0.08
2001	0.21	0.08
2002	0.61	0.07
2003	0.60	0.06
2004	0.53	0.08
2005	0.47	0.08
2006	1.01	0.16
2007	0.30	0.07
2008	0.39	0.13
2009	0.55	0.09
2010	0.65	0.06
2011	0.52	0.10
2012	0.32	0.06
2013	0.33	0.13
2014	0.64	0.09
Mean	**0.63**	**0.08**

Figure 19 **Black-legged Kittiwake breeding success 1989-2014**



Current instructions suggest visiting the Kittiwake plots every 2 weeks, however this is not particularly useful as the chicks fledge from 35 days, within the space of just 2 visits. This year monitoring took place every 10 days once there were chicks present, and then every 5-7 days once the first chicks had reached a large size in order not to miss any potential fledglings. Kittiwake productivity monitoring will be reviewed for 2015.

In previous years, the relationship between breeding success and number of eggs and chicks hatched was examined. However, this instruction is not contained within the monitoring guide or management plan. Walsh *et al.* (1995) even makes the note not to spend a lot of time trying to estimate clutch size or confirming nest contents for standing birds, so this study was not carried out in 2014. It is recommended that this information should not be analysed in future years unless a large amount of effort is put into acquiring this information, the current sample size for known clutch sizes is usually so small that it would give unreliable results.

11.3 Timing of breeding

Nest building was first noted on the 23rd of April, with the first egg seen on the 22nd of May, and the first chick on the 24th June. These dates are very rough as Kittiwake monitoring only occurs every 14 days (Table 18) according to the methodology in Walsh *et al.* (1995).

Table 18 Black-legged Kittiwake - timing of breeding 2008-2014

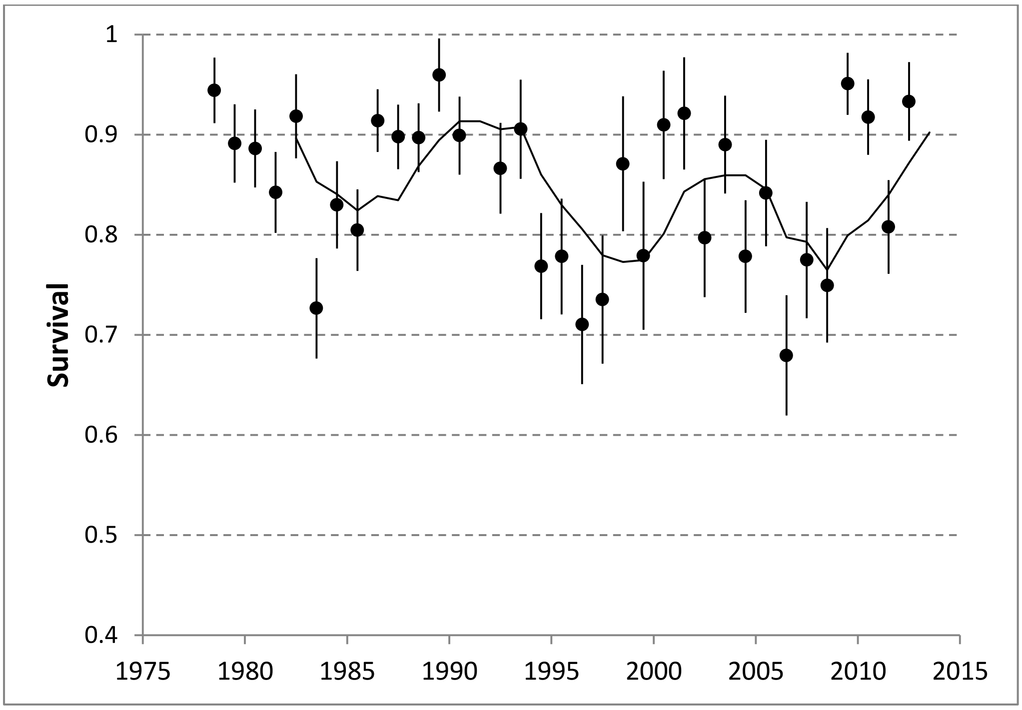
	2008	2009	2010	2011	2012	2013	2014
Nest building start	8th May	30th April	30th April	7th May	7th May	10th May	23rd April
First egg	24th May	11th May	21st May	13th May	20th May	28th May	22nd May
First chick	20th June	11th June	8th June	10th June	11th June	23rd June	24th June
First fledgling							27th 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. In 2014, no breeding birds remain at the previous study plot location in Tom's House.

Over the period 1978-2014, survival of breeding adults averages 0.85 (Figure 20). There continues to be wide fluctuation in adult breeding survival between years, despite a high probability of re-sighting live birds (>90% encounter probability in the last ten years). There appears to be a long-term decline in survival rate, but this requires further analysis as part of a demographic study that draws together the population parameters measured on Skomer.

Figure 20 Survival rates of breeding adult Kittiwakes 1978-2013



Notes:

1. Fitted line shows the five-year moving average, error bars ±1 standard error
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 1 gives the estimated survival rates for 1978-2013

12 Common Guillemot *Uria aalge*

12.1 Breeding numbers - whole island counts

Two whole island counts were conducted in the first three weeks of June, 2014. There were two spells of northerlies during this period but the weather was sufficiently benign to complete all land and boat based counts within the allotted time. A mean of 23,493 Individuals (IND) were counted, with a range of 23141 – 23844. This represents a 12.61% increase on the previous year. This increase may however be an effect of young birds moving into spaces on the cliffs made vacant by breeding adults which died in the winter storms, thus masking the storms true effects. There was some indication that this change in demographics had a negative effect on productivity but this was more pronounced in Razorbills and Puffins. This, coupled with the fact that one of our longest running studies on Guillemots led by Prof. Tim Birkhead of Sheffield University had its funding from Natural Resources Wales withdrawn in 2014, has given us considerable cause for concern.

Table 19 Common Guillemot whole-island counts 2004-2014

Year	Land count	% change	Sea count	% change	Total count	% change	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

12.2 Breeding numbers - study plot counts

The study plots are thought to be representative of the whole colony (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 2.

The number of common guillemots within the study plots as a whole has changed little over the last five years, with a small increase of 6.4% on 2009 numbers. In general there does still seem to be a slow increase taking place with this year's population being 4.5% higher than the 2008-2012 five-year mean (Table 20).

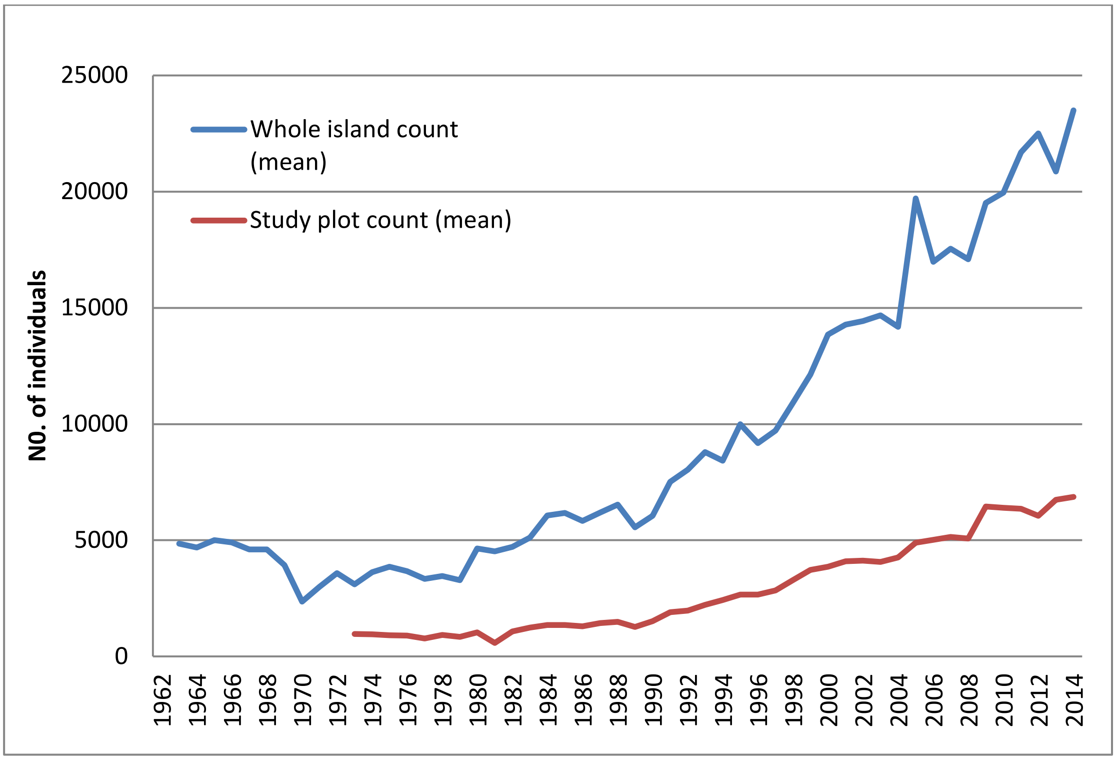
A total of 10 counts were made at each study plot this year by the seabird fieldworker during the first three weeks of June, none being on consecutive days, with one day being abandoned due to extreme heat haze preventing accurate counting. As in 2013 this led to a lower standard deviation and standard error than was achieved in 2011/12 where varying timings and observers was used due to time restrictions placed upon staff.

Table 20 Common Guillemot study plot totals 2010-2014

Study Plot	Year	Mean	SD	SE	Signif	%change	5yr %change
Bull Hole	2010	3493.9	287.2	90.8	NS	-0.26	+23.7
	2011	3569.1	348.1	110.1	NS	+2.2	+21.4
	2012	4201.3	214.1	80.9	* *	+17.7	+43.8
	2013	3553.9	144.6	54.6	* *	-15.4	+0.5
	2014	**3607.9**	**136.5**	**43.2**	NS	**+1.5**	**-1.5**
High Cliff	2010	2024.1	158.6	50.2	NS	-1.6	+34.8
	2011	2006.5	124.1	39.2	NS	-0.9	+31.6
	2012	1801.7	346.6	131.0	*	-10.2	+19.3
	2013	2161.4	106.0	40.5	*	+20.0	+15.0
	2014	**2290.4**	**79.3**	**25.1**	* *	**+6.0**	**+13.9**
S.Stream	2010	882.4	98.3	31.1	NS	-1.7	+23.7
	2011	804.1	47.3	15.0	*	-8.8	+19.3
	2012	908.1	100.6	38.0	*	+12.9	+40.6
	2013	1021.3	41.5	15.7	*	+12.5	+23.4
	2014	**972.4**	**71.4**	**22.6**	NS	**-4.8**	**+7.7**
All	2010	6400.4	446.2	141.1	NS	-0.9	+27.5
	2011	6360.5	419.2	148.2	NS	-0.62	+23.7
	2012	6911.1	416.5	157.4	*	+8.66	+36.1
	2013	6736.6	282.2	106.7	NS	-2.5	+7.9
	2014	**6870.7**	**213.5**	**67.5**	*	**+2.0**	**+4.5**

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 3 for count details.

Figure 21 Numbers of Common Guillemots 1962-2012



12.3 Breeding success

12.3.1 Methods

The number of active and regularly occupied sites was established at study plots and their histories were followed, using the methodology outlined in Walsh *et al.* (1995). Visits were made from mid-April to begin mapping the location of pairs. Full monitoring began on the 6th May although this was interrupted by bad weather which led to most birds heading out to sea for a few days. The last visit was made on the 27th July (21st July in 2013)

Sites were visited every one or two days, with the greatest effort made during egg laying, hatching and fledging periods. The number of visits ranged between 59 and 64, a significantly higher effort than in previous years. (26 to 44 in 2013, 45-51 in 2012)

12.3.2 Results

2014 saw a mean productivity of 0.63 fledged birds per active and regularly occupied site, which is the same figure as in 2013 and 2012 (Tables 23 and 24, Fig 22), and is slightly lower than the overall mean of 0.68 (1989 – 2014). Three hundred active and regular sites were recorded this year, 28 fewer than last year. 98% of sites were considered active this year (86% in 2013). The definition of 'active' versus 'regular' sites is discussed further shortly.

Current study plots result in monitoring over 300 nest sites, a 50% increase from 1996 when these plots were set up. Walsh *et al.* (1995) suggests using 5 plots of 50 nest sites (250 sites total).

Table 21 Common Guillemot breeding success 1989-2014

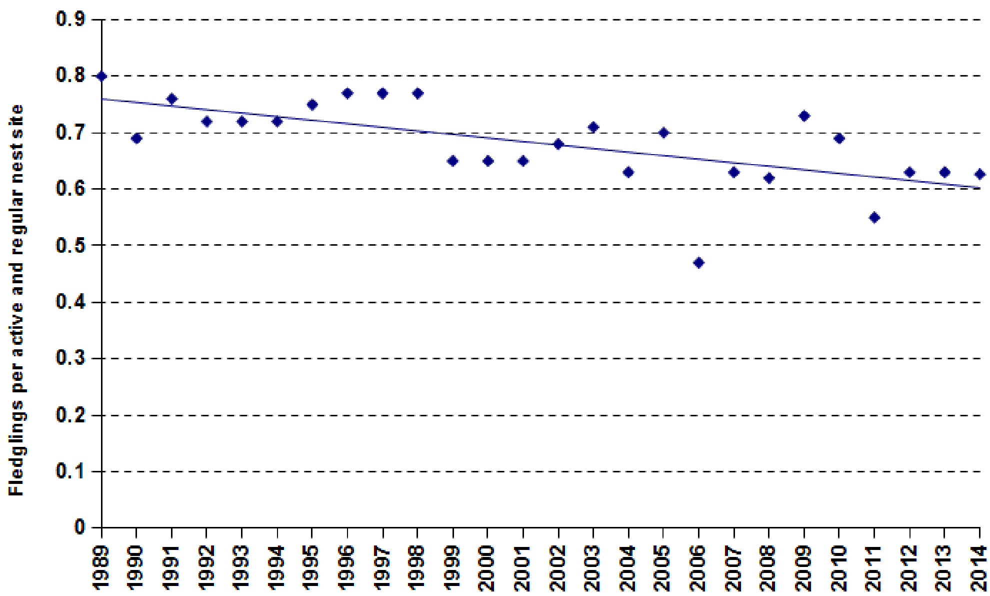
Year	No. Sites	Large Chicks	Mean Productivity across sites	SE
1989	120	96	0.80	0.05
1990	112	80	0.69	0.05
1991	117	89	0.76	0.05
1992	169	121	0.72	0.04
1993	198	141	0.72	0.05
1994	187	131	0.72	0.03
1995	198	151	0.75	0.04
1996	210	161	0.77	0.02
1997	226	174	0.77	0.33
1998	201	154	0.77	0.04
1999	242	147	0.65	0.05
2000	227	143	0.65	0.08
2001	259	160	0.65	0.08
2002	259	170	0.68	0.03
2003	268	179	0.71	0.05
2004	292	184	0.63	0.01
2005	297	200	0.70	0.03
2006	287	142	0.47	0.07
2007	258	164	0.63	0.02
2008	269	164	0.62	0.06
2009	254	185	0.73	0.05
2010	315	211	0.69	0.04
2011	292	149	0.55	0.06
2012	318	185	0.63	0.08
2013	328	212	0.63	0.05
2014	300	183	0.63	0.03
		Mean (1989-2014)	0.68	0.06

Table 22 Common Guillemot breeding success 2014

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
Wick 1G	63	62	42	0.67	0.68
Wick 2G	88	88	53	0.60	0.60
Wick Corner	112	106	63	0.56	0.59
Bull Hole	37	37	25	0.68	0.68
			Mean	0.63	0.64
			SD	0.05	0.05
			SE	0.03	0.02

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

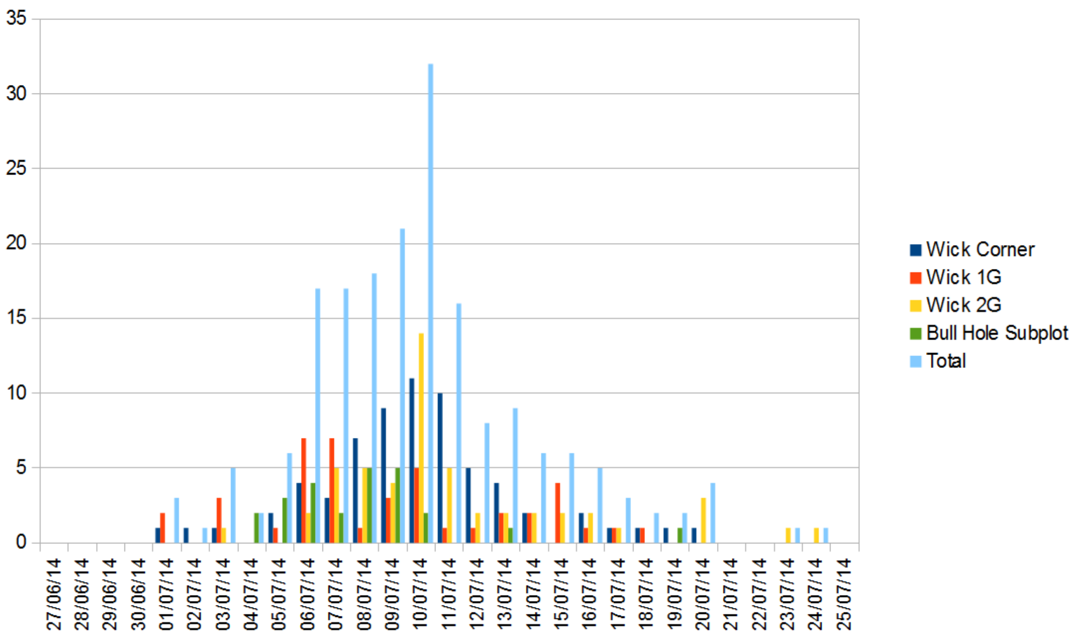
Figure 22 Common Guillemot breeding success 1989-2014



Whilst inspecting historic records it has become evident that the guidelines used to define active sites and regular sites have not always followed Walsh *et al's*. (1995) instructions. The criteria therein state that active sites include birds 'apparently incubating' on two consecutive visits, where a regular site requires a pair of birds to be in attendance on three consecutive visits. The former is relatively easy to achieve, whereas the latter is an infrequent occurrence. Any attempt to calculate breeding success based solely on 'active sites' will therefore need to inspect original data carefully.

The median fledge date was 11th July (10th July in 2013). During the five days centred on the median fledging date (9th to 13th July) 47% (53% in 2013) of chicks "fledged".

Figure 23 Common Guillemot fledging numbers each day



12.4 Timing of breeding

The first egg was noted on the 12th May at Bull Hole, the first chicks on the 10th June, at Bull Hole and the Amos, and the first 'jumpling' on the 28th June at the Amos. The last study plot chick left Wick 2G on the 24th July, although fledgling sized chicks were present on the Wick until at least the 4th August.

Table 23 Common Guillemot timing of breeding 2008-2014

	2008	2009	2010	2011	2012	2013	2014
First egg	11th May	25th April	29th April	21st April	23rd April	7th May	12th May
First chick	14th June	26th May	31st May	26th May	27th May	9th June	10th June
First 'jumpling'	25th June	11th June	23rd June	15th June	18th June	1st July	28th June

12.5 Adult and juvenile survival

This and other Common Guillemot studies are undertaken by Sheffield University. However, in 2014, funding from Natural Resources Wales (NRW) was withdrawn from this study, therefore these data are not available for this report.

13 Razorbill *Alca torda*

13.1 Breeding numbers - whole island counts

Due to difficulties in censusing this species (being less concentrated than Common Guillemots and often breeding in hidden sites amongst boulders and in burrows), the pattern of Razorbill numbers on Skomer is probably not a true reflection of the true population trends (Figure 24). Having said this, numbers have doubled since the early 1960s when records began and, although there has been some variation between years (when compared with the increase of Common Guillemot on Skomer), the trend is upwards.

Two whole island counts were carried out in June 2014 producing a mean of 6541 Individuals (IND). The range was 6550 – 6777. This is a 1.83% decrease on the previous year but a 21.33% increase over a five year period.

Table 24 Razorbill whole island count details 2006-2014

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

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 as representative of the whole island population as those of Guillemots. Changes in the plot counts between years however is still useful information, follows similar trends (Figure 24), and presents a more thorough method, using 10 land based counts versus two counts from the sea. The importance of carrying out as many counts as possible was highlighted in particular at South Stream which on a hot day returned only 63 individuals, whereas the following count, two days later resulted in 189 being sighted.

The 2014 total count identified a marked decrease of 12.4% compared to 2013 figures (Table 24), however numbers this year are also 3.9% higher than the 5-year mean. Bull Hole and The Wick suffered significant decreases of 14.5% and 22.6% respectively, whilst South Stream and High Cliff showed non-significant increases of 5.7% and 9.1% respectively.

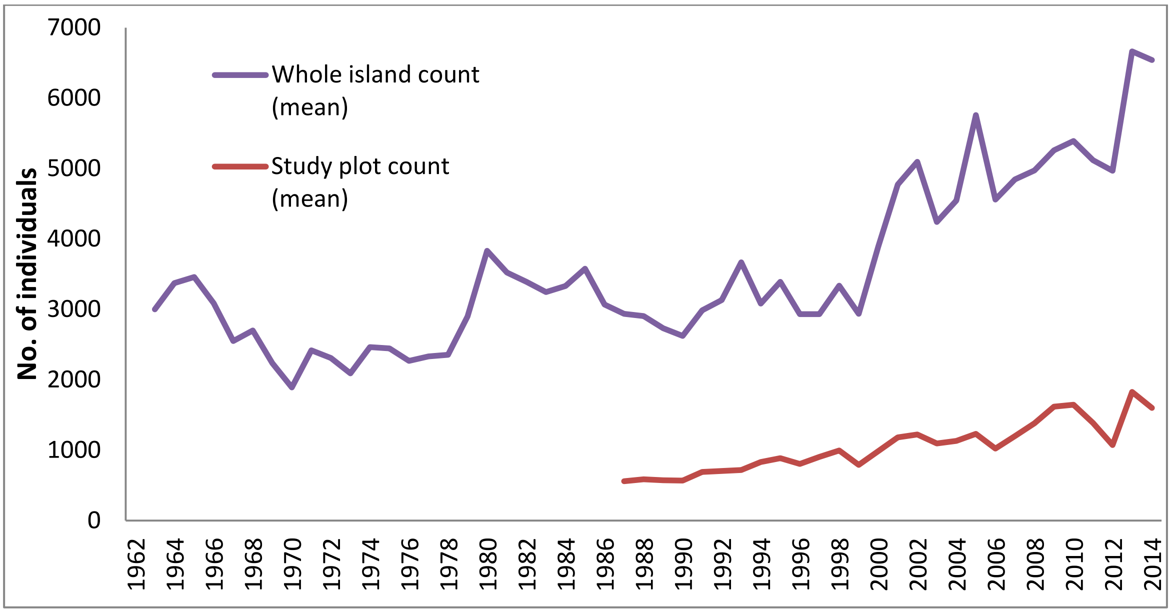
A total of 10 counts were made at each study plot this year by the seabird fieldworker during the first three weeks of June, none being on consecutive days, with one day being abandoned due to extreme heat haze preventing accurate counting. As in 2013 this led to a lower standard deviation and standard error than was achieved in 2011/12 (Table 25) where varying timings and observers was used due to time restrictions placed upon staff.

Table 25 Razorbill study plot totals 2010-2014

Study Plot	Year	Mean	SD	SE	Signif	%Change	5Yr %Change
Bull Hole	2010	432.5	88.0	27.8	NS	+10.9	+87.3
	2011	304.3	45.4	14.3	*	-29.7	-4.71
	2012	316.6	77.8	29.4	NS	+4	+3
	2013	451.3	31.2	11.8	* *	+42.5	+28.9
	2014	**385.9**	**52.1**	**16.5**	* *	**-14.5**	**-1.8**
High Cliff	2010	380.2	63.4	20.0	NS	-3.4	+102.8
	2011	292.1	54.8	17.3	*	-23.2	16.1
	2012	309.9	68	25.7	NS	+6.1	+12.2
	2013	359.6	29.8	11.3	NS	+16.0	-8.8
	2014	**392.3**	**62.1**	**19.6**	NS	**+9.1**	**+13.0**
S.Stream	2010	111.4	26.3	8.3	NS	+14.4	+23.8
	2011	72.0	24.7	7.8	NS	-35.4	-23.4
	2012	78	46.7	17.6	NS	+8.3	+5.7
	2013	127.4	16.5	6.2	*	+63.3	+47.2
	2014	**134.6**	**42.9**	**13.6**	NS	**+5.7**	**+38.4**
The Wick	2010	723.8	33.1	10.5	NS	-2.1	+40.5
	2011	718.0	19.8	6.3	NS	-0.8	+33.9
	2012	568	29.9	11.3	* *	-20.9	-21.9
	2013	891.1	42.6	16.1	* *	+56.9	+28.1
	2014	**689.8**	**35.9**	**11.4**	* *	**-22.6**	**-5.3**
All Plots	2010	1647.9	184.7	58.4	NS	+1.7	+61.0
	2011	1386	102	36	*	-15.9	+15.4
	2012	1227.4	168	63.5	*	-11.4	-11.4
	2013	1829.4	68.6	25.9	* *	+49.0	+25.9
	2014	**1602.6**	**93.6**	**29.6**	* *	**-12.4**	**+3.9**

Note: Significance between years established using the t-test for comparing the means of two small samples (two-tailed test, df=n-1). N S Not significant, * Statistically significant ($P<0.05$), * * Statistically highly significant ($P<0.01$). See Appendix 3 for count details.

Figure 24 Whole-island counts of Razorbills 1962-2014



13.3 Breeding success

Sites were visited were every one to two days. Bull hole (studied by a long term conservation volunteer) received the most visits, whilst other plots received around 40 visits (2013: 39-45 visits per site). The first visit was conducted on the 4th May, and the last in late July.

Razorbills are particularly difficult to monitor, even visible sites often have a rock or crevice that a chick or adult can disappear into on occasions. The scattered nature of the nest sites also means that it is difficult to spend much time watching individuals in order to catch a glimpse of an egg or chick.

The Razorbill population has increased by around 100% since 1996 when study plots were originally set up. Walsh *et al.* (1995) suggests monitoring 5 plots of 10-50 nests (50-250 nests total), currently Skomer monitors around 300 nest sites (with some later being removed due to difficulty in seeing the occupants). 2014 is the second year one plot out of three has been excluded from monitoring efforts, however, overall numbers of nests monitored are still in excess of recommendations.

Productivity was given as the number of fledged or apparently fledged chicks (last seen at 15 or more days old) per active and regularly occupied site and per active site only (as defined by Walsh *et al.* 1995). Results are presented in Table 26, 27 and Figure 25. The mean productivity per active and regular site was 0.27 (0.28 per active only site), a decrease when compared to last year's results. However, total number of chicks fledging was almost identical, 98 this year compared to 100 last year. The difference in productivity only really serves to highlight the variation in what is recorded as an active or regular site. As was found with Common Guillemot data, in the past the definitions of 'active' versus 'regular' sites has not always been followed strictly.

The least productive site was High Cliff at 0.22 chicks per active or regular site (0.22 per active site only), and the most productive was Bull Hole at 0.34 chicks per active or regular site (0.35 per active site only).

The median fledge date in 2014 was 14th/15th July, ten days later than last year, with only 17% of chicks "fledging" within the five days centred on this date, a result of the drawn out latter part of the season.

Table 26 Razorbill breeding success 1993-2014

	Number of sites, active + regular, active only in brackets.	Number of chicks fledged	Mean productivity per active site	Mean productivity per active + regular site	SE
1993			-	0.56	
1994			-	0.55	
1995			0.79	0.72	
1996			0.71	0.64	
1997			0.73	0.75	
1998			0.71	0.66	
1999			0.74	0.56	
2000			0.54	0.48	
2001			0.64	0.58	
2002			0.37	0.36	
2003			0.61	0.48	
2004	406		0.56	0.50	
2005	328		0.64	0.57	
2006	418		0.33	0.30	
2007	374		0.62	0.56	
2008	486	94	0.32	0.22	
2009	395	145	0.47	0.39	
2010	466	171	0.51	0.40	
2012	281	66	0.21	0.17	
2013	294 (240) *	100	0.47	0.38	0.03
2014	252 (247) *	98	0.28	0.27	0.03
Mean				**0.49**	

Note: Data shown for active (a) and regular (r) sites
* From 2013, the methodology changed to only dropping one site out of three in rotation at the Wick each year.

Table 27 Razorbill breeding success 2014

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
High Cliff	143	143	31	0.22	0.22
Wick 1A					
Wick 3A	70	70	21	0.30	0.30
Wick 3B	39	35	9	0.23	0.26
Bull Hole	108	105	37	0.34	0.35
			Mean	0.27	0.28
			SD	0.06	0.06
			SE	0.03	0.03

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

Figure 25 Razorbill breeding success 1993-2014

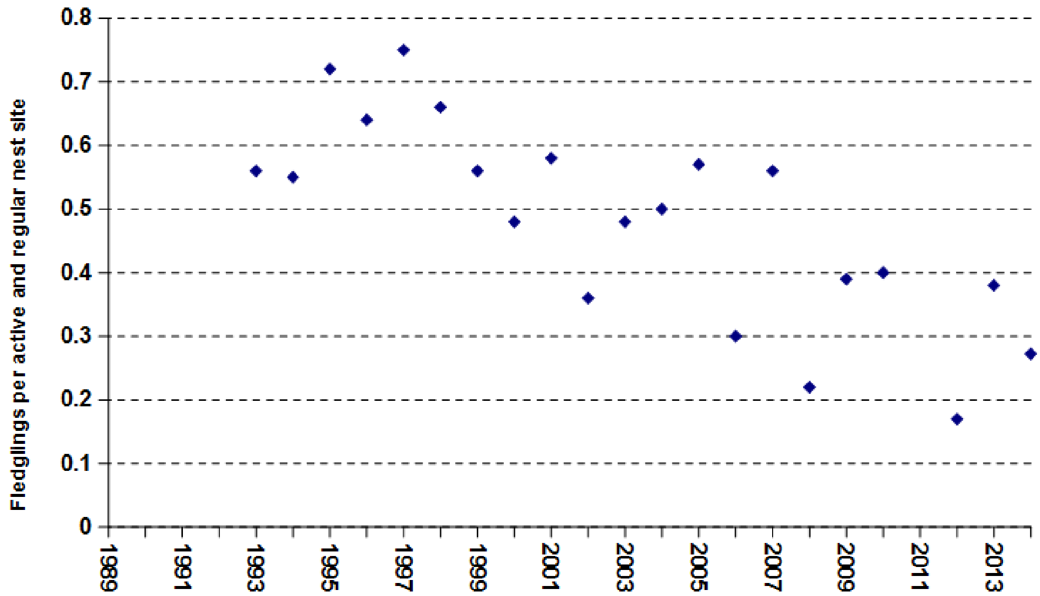
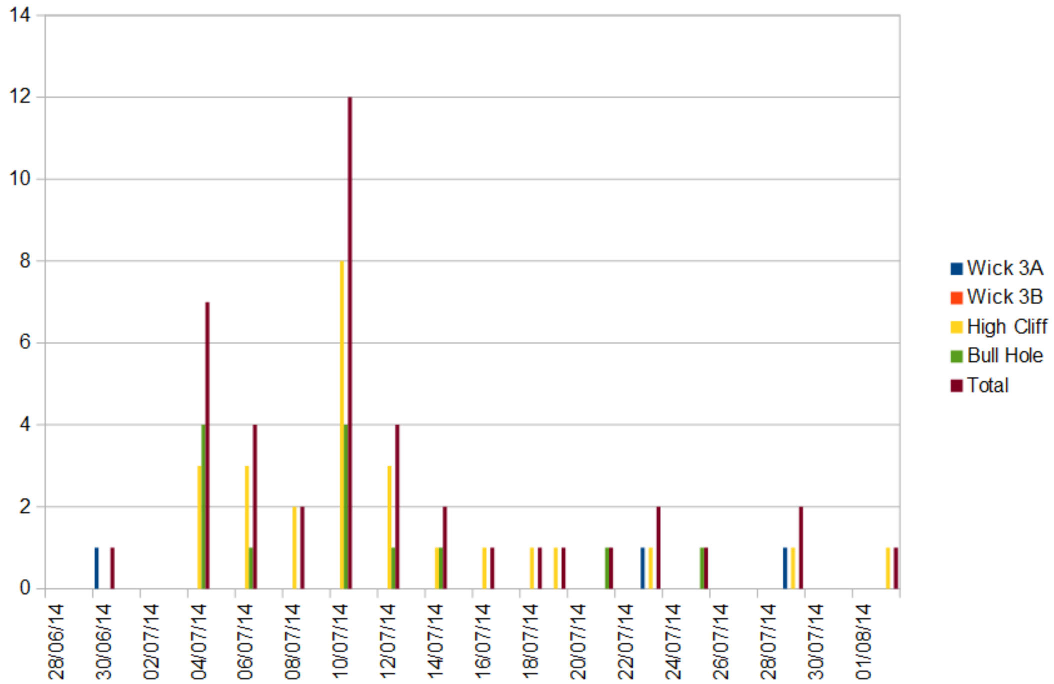


Figure 26 Common Guillemot fledging numbers each day



13.4 Timing of breeding

The first egg was noted at High Cliff on the 12th May. The first chick was seen on 16th June and the first 'jumplings' on 29th June at the Amos, the same date as 2013, but 16 days later than 2012. The highest number of fledglings left the cliffs on the 10th July, the same date as with Common Guillemots. The last chicks in the study plots fledged on the 2nd August at High Cliff.

Table 28 Razorbill timing of breeding 2008–2014

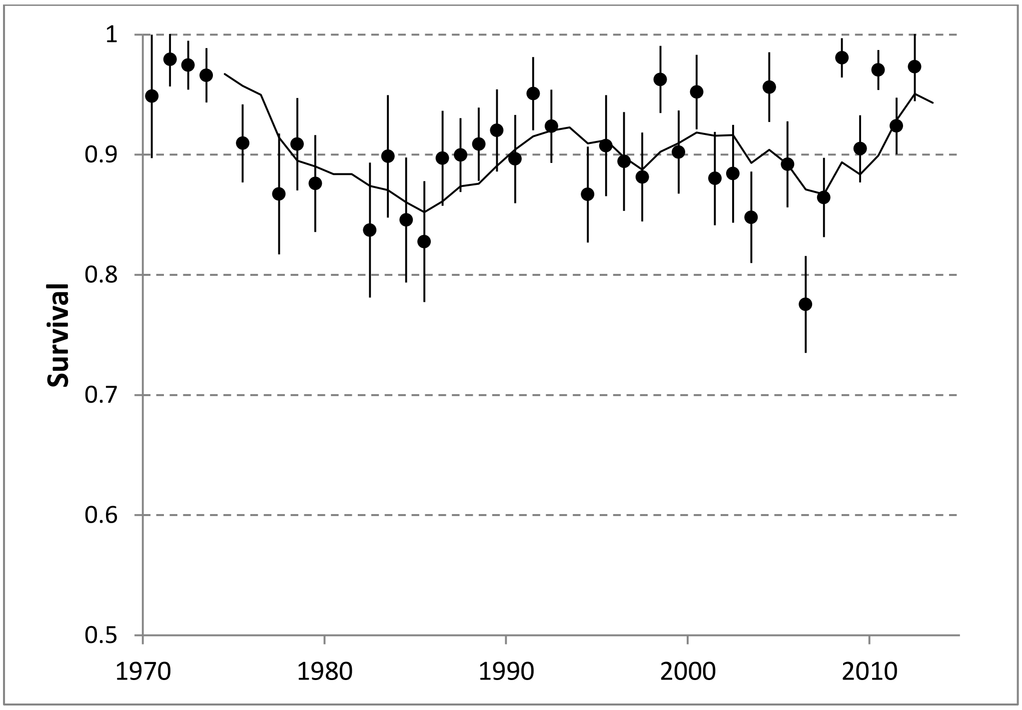
	2008	2009	2010	2011	2012	2013	2014
First egg	6th May	26th April	24th April	Unknown	23rd April	8th May	12th May
First chick	5th June	24th May	3rd June	Unknown	27th May	10th June	16th June
First 'jumpling'	28th June	13th June	21st June	Unknown	13th June	29th June	29th June

13.5 Breeding adult survival

Despite a poor year in 2006-7, survival rates appear to show a gradual increase since the 1980s, after the declines of the 1970s. Recent years show survival rates returning to the high levels at the outset of the long-term study. Survival across the long-term-study (1970-2014) averages 0.90.

The seabird wreck of 2014 included a large mortality of razorbills. Although we require a at least one further year's data to observe the effect of this event on long-term population parameters, preliminary estimates indicate a worrying drop in the survival of adult breeding Razorbills (Figure 7), after a period of steady increase over the last 30 years. Such analyses require more detailed scrutiny, better to understand the long-term population dynamics of this and other species into climatic variation and severe weather events.

Figure 27 Survival rates of adult breeding Razorbills 1970-2013



Notes:

1. Fitted line shows the five-year moving average, error bars ±1 standard error
2. Survival was non-estimable in 1974-5, 1976-7, 1980-82, 1993-4, and 2013-14. The final transition in the series is not estimable (Section 1.1) and requires at least one further year of data.
3. Appendix 1 gives the estimated survival rates for 1970-2014

14 Atlantic Puffin *Fratercula arctica*

14.1 Breeding numbers

Whole island counts of Puffins were made on two dates in April (17th and 18th, Table 31). Counts were also conducted in North Haven on seven dates between the 4th and 18th of April to assess Puffin attendance (Table 32). 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 18,237 was made on the 17th of April. A good opportunity to count maximum numbers of Puffins present around the island was missed on the 10th of April because of staffing and work constraints.

Counts were also made in July to try and look at peak attendance at a time when non breeding birds are present. Regular counts were done in North Haven and a whole island count was attempted on the 15th of July (10,488). The July counts from North Haven are presented in Table 32. The highest count was 4,389 on the 12th of July (Table 33) but the highest whole island count was 18,237 on the 17th of April (Table 31). This means that either we missed an opportunity to obtain a maximum peak attendance figure in July or that peak attendance was in fact in April.

Table 29 Maximum spring counts of individual Puffins: Skomer & Middleholm

Date	No. individual puffins inc. Middleholm	No. of individual Puffins excl. Middleholm
17/04/2014	18237	
18/04/2014	14875	
Max.	18237	
Mean	16556	

Table 30 Spring counts of individual Puffins: North Haven

Date	No. individual puffins in North Haven
04/04/2014	2417
09/04/2014	2900
10/04/2014	4135
11/04/2014	1865
16/04/2014	1534
17/04/2014	2684
18/04/2014	2382
Max.	4135

Table 31 July counts of individual Puffins: North Haven

Date	No. individual puffins in North Haven
08/07/2014	3432
09/07/2014	3055
12/07/2014	4389
15/07/2014	1815
20/07/2014	3738*
Max.	4389

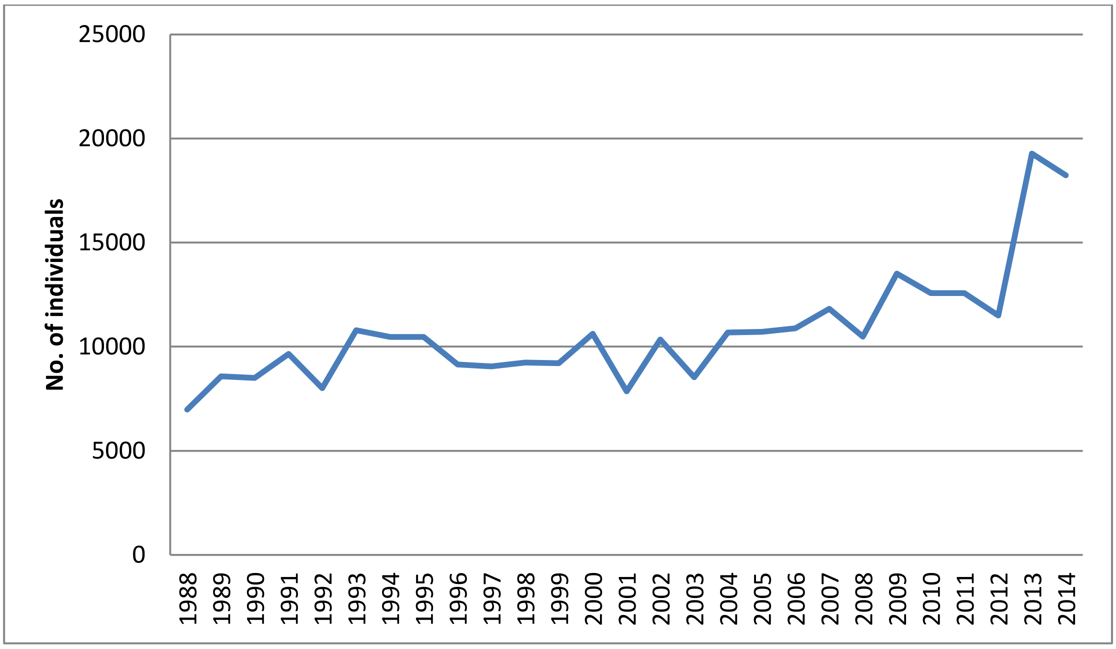
*All counts made between 17.00 and 19.00 except 20/07 which was made in the morning

Table 32 Maximum spring puffin counts on Skomer & Middleholm 1989-2014

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	+26.0
2010	12577	-6.89	+15.64
2011*	-	-	-
2012	11497	-8.59	+9.63
2013	19280	+67.70	+42.73
2014	18237	-5.41	+45.0

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

Figure 28 Maximum spring counts of Puffins: Skomer 1989-2014



14.2 Puffin burrow occupancy and breeding success

Puffin burrow occupancy and breeding success in the South East Isthmus study plot for 2014 is shown below.

Table 33 Burrow occupancy and breeding success of Atlantic Puffins

Burrow distance from the cliff edge (m)	Total no. burrows	No. occupied burrows	% Occupied	No. chicks based on 2+ feeds	Productivity based on 2+ feeds
<5	106	90	85%	46	0.51
5 - 10	57	48	84%	31	0.65
>10	74	44	59%	20	0.45
Total	237	182	77%	97	0.53

Burrow occupancy was established during six evening watches. The first adult Puffins carrying fish were seen coming ashore on 4th June, ten days later than last year. The first fish carrying puffins to the study plot were seen on 8th June. However, it was not until the second week of June that many birds started to feed chicks, suggesting the majority of birds did not lay until May (or very late in April). The majority of adults were still on land well into the last week of July, when in an average year they would all have left by this time.

Breeding success was based on 24 hour feeding watches. In the past, two watches have always been 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 were carried out every two weeks from the first date adults were seen bringing in fish, until there were little or no adults seen on land regularly.

Three 24 hour watches were conducted this year. These started two weeks later than in 2013, due to the very late breeding season: 04:30 – 22:00 on 25th June: two weeks after the first regular adults were seen coming in with fish.
04:30 – 22:00 on 8th July: the oldest chicks should only have been 30 days old so none should have fledged and therefore should have been recorded being fed on both watches, if they survived. Chicks hatched since the first watch were now being fed as well.
04:30 – 22:30 on 23 July: the very oldest chicks will have fledged but any chicks born since the first watch should only be an absolute maximum of 31 days old and therefore fed on the second and third watches.
By the 6th August, there were effectively no adult puffins seen on land with any regularity and so no further watches were conducted.

For an occupied burrow to be considered successful it had to have been fed during at least two watches. This gives a success rate of 53% (or 0.53 chicks fledged per burrow). Productivity is was therefore 25% lower than that of 2013.

The method has known limitations, which may warrant further study to align with other studies (e.g. Skokholm) but currently are not cause to question long-term trends. Some burrows known to be occupied were not picked up by feeding watches (e.g. four known chicks of fledging age were not fed during two of the 24 hour watches, a further seven were only seen being fed on one last watch) but more significantly, this method also does not account for Great Black-backed Gull predation, which usually occurs when older chicks emerge from burrows to exercise their wings in the evening. On Skokholm, Puffin productivity is monitored via short daily watches throughout the chick rearing period, and chicks are assumed to have survived if they reached at least 31 days old. In 2013 and 2014 this yields a much lower estimate of chicks fledged per occupied burrow than the current method on Skomer but more may be required. Skomer and Skokholm will liaise closely to discuss monitoring methods and (e.g. the possibility of applying a correction factor to Skomer puffin productivity estimates using Skokholm data on chick survival to day 15 vs 31) but some calibration work on Skomer would then be necessary as the densities of Great Black-backed gulls are different, currently much higher on Skokholm.

The new fieldworker (Ros Green) voiced concerns that burrow occupancy may have been under-estimated during watches compared to previous years, due to the challenges of taking on this fairly arduous fieldwork. If this were the case, the productivity would have been even lower than our estimate, so we can be confident that our estimate of Puffin productivity is not ‘too low’ as a result of the change in fieldworker. In the view of her supervisors (Matt Wood & Chris Perrins) Ros’s data collection was exemplary, including the highest encounter probability of Manx shearwaters detected since 1978 (the chance of finding a bird that is alive, a combination of field conditions and observer efficiency), so there should be every confidence in the reliability of her data collection.

14.3 Feeding rates

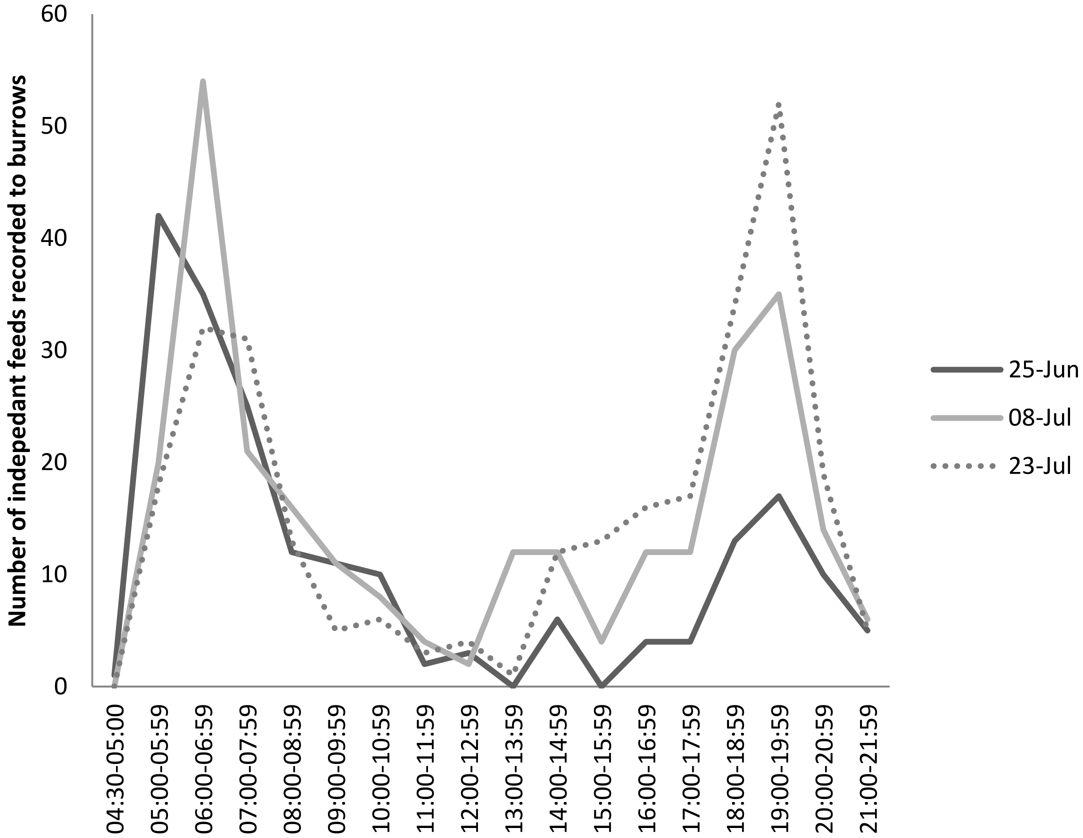
Details of feeding rates were recorded as follows:

Table 34 Feeding rates of Puffins 2014

	25 June	08 July	23 July
No. of burrows to which feeds were recorded	89	105	86
Total No. recorded feeds	200	273	281
Mean No. feeds per burrow (range)	2.2	2.6	3.3

Puffin feeding rates were far lower than those recorded in 2013. In 2013 the highest number of feeds recorded during one watch was 742 to 130 burrows. This is 2.6 times greater than the highest total for this year. This is indicative of the relatively poor breeding success in 2014, and may be due to the poor condition of returning adults or the availability of prey.

Figure 29 Number of feeds per hour for Puffins 2014



As usual, there was a pronounced feeding peak in the early morning and late evening. Normally the evening peak is noticeably lower than the morning peak, which is true for the watches on the 25th June and 8th July. However the larger peak on the 23rd July appeared to be in the evening. It is possible that some feeds were missed during the morning session due to the observer being unavailable; however, it is unlikely that a significant number were missed and so this difference in peak relationship remains unexplained.

With an increased population of puffins in the study plot, future 24 hour feeding watches require two observers, or a reduced study plot area, if indeed 24 hour watches are justified when the great majority of feeds take place in the hours after dawn and before dusk.

14.4 Timing of breeding

The first Puffin of the year was seen on the sea in North Haven on the 18th of March (9 days later than in 2013). On the 3rd of April the first Puffin was seen on land and on the 19th of May the first egg was found (16 days later than in 2013). However, when calculating the date of the first egg by looking at the date the first birds were seen with fish (4th June) we come up with a very different date: in 2014 this lies between the 23rd-27th April which is more similar to the date of first egg (15th April) calculated in 2013 (date of first birds seen with fish 25th May 2013). As can be seen 2014 was another extremely late season for Puffins on Skomer Island.

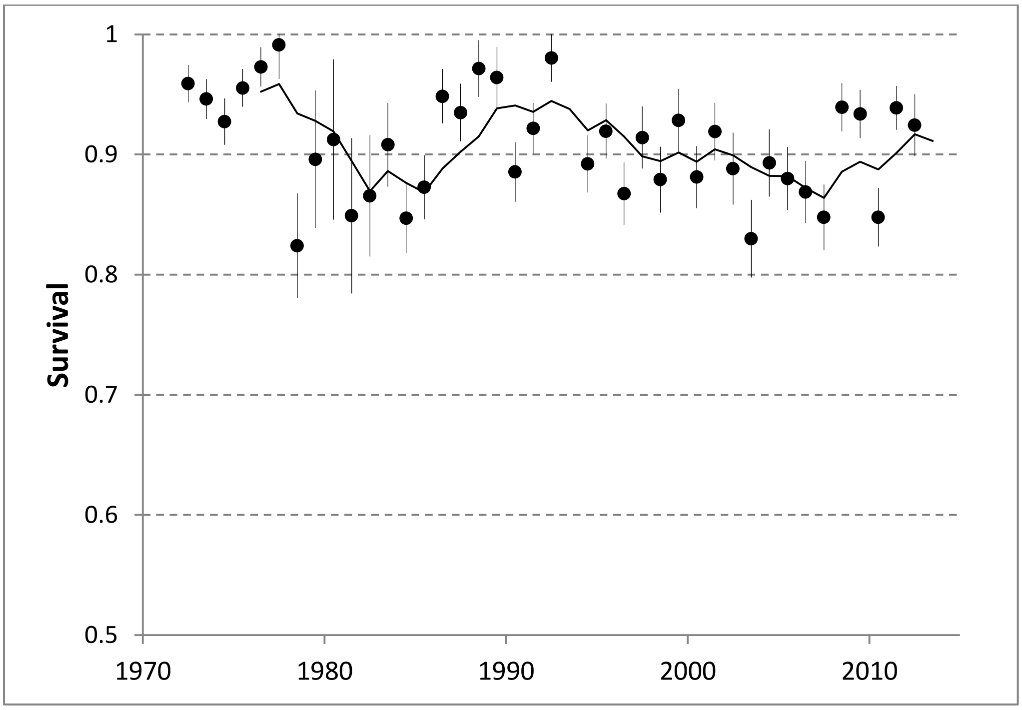
In future we might need to consider changing the methodology we use to determine timing of breeding as recording only the first egg laid does not reflect the true start of egg laying. In order be more accurate we will need to take the mean of a sample of eggs laid.

14.5 Breeding adult survival

Appendix 1 gives the estimated survival rates of Puffins. Only 59.6% of 2013's breeding adults retuned to Skomer in 2014, the poorest on record and a drop of almost 25% on 2012-13 (84.2%). Long-term capture-recapture analyses (Section 1.1) show that the reliable estimate of average survival remains at 0.91, with signs of a recovery in survival rates after the steady decline beginning in the late 1980s. Unfortunately, these analyses do not yield an accurate estimate breeding adult survival for the final year's survival (at least one year's further re-sighting data is required). We anticipate data from 2015 to cast some light here.

The long-term impacts of severe climatic events such as the 2013-14 seabird wreck remain poorly understood: continued and more detailed further study is required.

Figure 30 Survival rates of adult breeding Puffins 1972-2014



Notes:
1. Fitted line shows the five-year moving average, error bars ±1 standard error
2. Survival was non-estimable in 1993-4, and 2013-14. The final transition in the series in such analyses is inestimable (Section 1.1)
3. Appendix 1 gives the estimated survival rates for 1970-2013

15 References

Ashton, H (1993) *The Breeding Population of the British Storm Petrel* Hydrobatespelagicus *on Skomer Island, Dyfed*. Report to the Dyfed Wildlife Trust.

Birkhead, TR (2003) *Skomer guillemot studies 1999-2001*. Department of Animal and Plant Sciences, The University of Sheffield. CCW Contract Science Report 532.

Birkhead, TR and Hatchwell,BJ (2000) *Skomer Island Razorbill Study 2000*. Department of Animal & Plant Sciences, University of Sheffield.

Birkhead, TR and Hatchwell,BJ (2001) *Skomer Island Razorbill Study 2001*. Department of Animal & Plant Sciences, University of Sheffield.

Birkhead, TR, Hatchwell,BJ and Bowgen, K. (2010) *Skomer Island Guillemot Study 2010.* Department of Animal & Plant Sciences, University of Sheffield.

Boulinier, T and Danchin, E (1996) Population trends in Kittiwake *Rissatridactyla* colonies in relation to tick infestation. *Ibis* 138:326-334.

Cramp, S and Simmons, KEL (eds) (1983) *Handbook of the birds of Europe, the Middle East and North Africa: the birds of the Western Palearctic. Volume III. Waders to gulls*. Oxford University Press, Oxford.

Field, RH, Birkhead, TR &Hatchwell, BJ (1999) *Skomer Island razorbill study 1999*. Department of Animal and Plant Sciences, The University of Sheffield.

James, PC (1984a) *The vocal and homing behaviour of the Manx shearwater* Puffinuspuffinus *with additional studies on other Procellariformes*. Appendix B. PhD thesis, Oxford University.

James, PC (1984b) Sexual dimorphism in the voice of the British Storm Petrel *Hydrobatespelagicus*. *Ibis*, 126, 89-92.

Poole, J and Sutcliffe, SJ (1992) *Seabird studies on Skomer Island in 1992*. JNCC Report No. 139.

Poole, J & Sutcliffe, SJ (1993) *Monitoring of seabirds on Skomer Island in 1993*. Report to JNCC by DWT.

Poole, J, Smith, S, Perrins, CM, Birkhead, TR and Thompson, KR (2001) *Seabird monitoring on Skomer Island in 1997 and 1998*. JNCC Report, No.318.

Sutcliffe, SJ (1993) *Population trends of the* Larus*gulls breeding on Skomer Island NNR 1960-92*. Report by Dyfed Wildlife Trust for CCW.

Sutcliffe, SJ (1997) Populations of breeding *Larus* gulls on Welsh islands. In Rhind, PM, Blackstock, TH and Parr, SJ (eds.) Welsh islands: ecology, conservation and land use. CCW.

Taylor, CJ., Boyle, D. and Perrins, CM, Kipling, R. (2012) *Seabird monitoring on Skomer Island in 2012.JNCC Report*

Walsh, PM, Halley, DJ, Harris, MP, del Nevo, A, Sim, IMW, Tasker, ML (1995) *Seabird monitoring handbook for Britain and Ireland.* Peterborough, JNCC, RSPB, ITE, Seabird Group.

Wilson, SA (1992) *Population trends of guillemots* Uria aalge *and razorbills Alca torda on Skomer Island, Wales 1963-1991*. Report to CCW by Sheffield University.

16 Appendices

Appendix 1 Breeding adult survival rates from capture-recapture analyses

* 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		Estimated survival*					
From	To	MX	LB	HG	KI	RZ	PU
1970	1971					0.9486	
1971	1972					0.9793	
1972	1973					0.9744	0.9589
1973	1974					0.9660	0.9461
1974	1975						0.9273
1975	1976					0.9094	0.9554
1976	1977					-	0.9728
1977	1978	0.8125				0.8672	0.9911
1978	1979	0.7805	0.9830	0.8936	0.9441	0.9086	0.8241
1979	1980	0.7931	0.9211	0.8087	0.891	0.8760	0.8961
1980	1981	0.6118	0.9214	-	0.8861	-	0.9125
1981	1982	-	0.8741	0.6075	0.8423	-	0.8490
1982	1983	0.8865	0.9596	0.7051	0.9182	0.8372	0.8656
1983	1984	0.8506	0.8943	0.7237	0.7264	0.8985	0.9080
1984	1985	0.9533	0.9170	0.8959	0.8297	0.8456	0.8469
1985	1986	-	0.8923	0.7270	0.8046	0.8276	0.8727
1986	1987	0.8764	0.8834	0.8721	0.9139	0.8970	0.9485
1987	1988	0.9420	0.9437	0.9507	0.8977	0.8997	0.9349
1988	1989	-	0.9144	0.9383	0.8968	0.9087	0.9715
1989	1990	0.7216	0.9217	0.8798	0.9595	0.9201	0.9640
1990	1991	0.9235	0.8422	0.8204	0.899	0.8964	0.8855
1991	1992	-	0.9775	0.8381	-	0.9508	0.9217
1992	1993	0.8226	0.8812	0.8751	0.8663	0.9236	0.9804
1993	1994	0.7247	0.9727	-	0.9054	-	-
1994	1995	0.9067	0.8255	0.7997	0.7686	0.8668	0.8922

1995	1996	0.8913	0.8586	0.7715	0.7783	0.9075	0.9195
1996	1997	0.8828	0.8091	0.7213	0.7102	0.8944	0.8675
1997	1998	0.8677	0.8025	-	0.7352	0.8813	0.9141
1998	1999	0.9504	0.9059	0.8296	0.8708	0.9626	0.8790
1999	2000	0.9787	0.8680	0.8466	0.7789	0.9021	0.9284
2000	2001	0.9075	0.8220	0.8678	0.9096	0.9520	0.8812
2001	2002	0.9176	0.7944	0.7870	0.9212	0.8801	0.9190
2002	2003	0.8396	0.7548	0.8713	0.7969	0.8841	0.8882
2003	2004	0.9244	0.7755	0.8043	0.8899	0.8479	0.8299
2004	2005	0.9102	0.8984	0.8557	0.7782	0.9562	0.8929
2005	2006	0.8298	0.8701	0.7814	0.8416	0.8920	0.8800
2006	2007	0.9312	0.9019	0.8063	0.6794	0.7754	0.8689
2007	2008	0.8653	0.8810	0.8913	0.7747	0.8644	0.8478
2008	2009	0.8385	0.9201	0.8800	0.7493	0.9806	0.9393
2009	2010	0.7868	0.8290	0.6949	0.9507	0.9049	0.9337
2010	2011	0.8361	0.8304	0.7632	0.9174	0.9705	0.8478
2011	2012	0.8474	0.8348	0.7419	0.8077	0.9239	0.9387
2012	2013	0.8707	0.8766	0.7500	0.9331	0.9731	0.9243
2013	2014	-	-	-	-	-	-

Appendix 2 Mean seabird counts by section

Whole island count section	Counted from Sea or Land?	Fulmar - AOS mean	Kittiwake - AON mean	Guillemot - IND mean	Razorbill - IND mean
1	Sea	35.0	0.0	684.5	522.0
2	Sea	0.0	9.0	314.5	205.0
3	Sea	16.5	108.5	204.5	70.5
4	Sea	28.0	1.0	283.0	77.0
5	Sea	14.5	38.0	547.0	97.0
6	Sea	12.5	11.5	213.5	85.0
7	Sea	0.0	0.0	19.0	53.5
8	Land and sea	19.0	0.0	207.5	74.5
9	Land	18.0	0.0	73.5	30.0
10	Sea	1.0	0.0	7.0	4.5
11	Sea	26.0	0.0	192.5	270.5
12	Land	29.0	0.0	14.0	25.0
13	Land	0.5	0.5	0.0	19.0
14	Land	1.0	112.5	972.0	135.0
15	Sea	26.0	75.5	11.5	54.5
16	Land	33.5	135.5	2290.0	392.0
17	Sea	0.0	0.0	0.0	29.0
18	Sea	0.0	0.0	0.0	0.0
19	Sea	0.0	0.0	314.0	174.5
20	Sea	1.0	0.0	0.0	19.5
21	Land	0.0	0.0	0.0	0.0
22	Land	46.5	602.5	4298.0	690.0
23	Land	0.0	3.0	3.5	12.0
24	Sea	0.0	0.0	59.5	65.0
25	Sea	0.0	0.0	13.0	19.0
26	Land	41.5	0.5	337.5	204.5
27	Land	0.0	120.0	2401.0	53.5
28	Land	3.5	0.0	10.5	62.0
29	Sea	0.0	0.0	0.0	0.0
30	Land	0.0	0.0	273.5	36.5
31	Land	3.0	0.0	307.0	38.5
32	Land	0.5	0.0	53.0	42.0
33	Land	1.5	33.5	525.5	50.5
34	Land	0.5	0.0	670.5	150.5
35	Sea	15.0	24.5	1227.0	482.5
36	Sea	6.5	111.5	3653.0	398.0
37	Land	0.0	0.0	0.0	0.0
38	Sea	2.5	100.0	563.5	210.5
39	Sea	49.5	0.0	953.5	593.0
40	Sea	6.5	0.0	673.5	236.5
41	Sea	31.0	0.0	99.5	147.0
42	Sea	55.0	0.0	496.0	183.0
43	Sea	24.5	0.0	104.5	94.0
44	Sea	6.5	0.0	275.5	279.0
45	Sea	0.0	0.0	146.0	155.0
TOTAL		**555.5**	**1487.5**	**23492.5**	**6540.5**

Appendix 3 Dates of visits to Black legged kittiwake sub-colonies in 2014

Checks were made more regularly than the recommended 2 week interval when there were chicks in the nest so that as few as possible were missed. One check towards the middle of June was missed due to a high workload associated with other monitoring projects. It is unlikely that this had much impact on the data as nests had already been built and checked twice by this stage, and chicks had not yet hatched.

1st visit	Late May	Identify nests sites, take new photographs
2nd visit	6th/8th June	Record incubating birds / new sites
3rd visit	1st/6th/7th July	Record incubating birds / small chicks
4th visit	17th/19th July	Record large chicks
5th visit	27th/28th July	Record large chicks
6th visit	2nd/4th August	Record large chicks

Appendix 4 Guillemot and Razorbill Population Study Plots

Common Guillemot study plot counts in 2014 (No. Individuals)

Date	Weather	High Cliff	Bull Hole	S.Stream	ALL
01/06/14	SSW2	2239	3248	982	6469
03/06/14	W1	2424	3584	1026	7034
05/06/14	W1	2219	3641	916	6776
07/06/14	S2-3	2237	3661	1046	6944
09/06/14	SE2-3	2310	3735	1020	7065
11/06/14	SW2	2385	3649	1016	7050
14/06/14	N3 v.hot	2269	3654	888	6811
16/06/14	N2	2364	3721	1057	7142
19/06/14	N3	2280	3580	910	6770
21/06/14	N2	2177	3606	863	6646
	Mean	**2290.40**	**3607.90**	**972.40**	**6870.70**
	SD	79.31	136.45	71.39	213.46
	SE	25.08	43.15	22.58	67.50
	TTEST p value	0.0203	0.4520	0.0960	0.3115

Razorbill study plot counts in 2014 (No. Individuals)

Date	Weather	High Cliff	Wick	Bull Hole	S.Stream	ALL
01/06/14	SSW2	449	705	312	178	1644
03/06/14	W1	498	638	421	151	1708
05/06/14	W1	300	729	365	108	1502
07/06/14	S2-3	387	674	368	158	1587
09/06/14	SE2-3	388	630	370	108	1496
11/06/14	SW2	402	698	368	159	1627
14/06/14	N3 v.hot	373	671	394	63	1501
16/06/14	N2	372	737	328	189	1626
19/06/14	N3	449	706	468	155	1778
21/06/14	N2	305	710	465	77	1557
	Mean	**392.30**	**689.80**	**385.90**	**134.60**	**1602.60**
	SD	62.06	35.89	52.11	42.86	93.61
	SE	19.63	11.35	16.48	13.55	29.60
	TTEST p value	0.1707	0.0000	0.0057	0.6391	0.0000

Appendix 5 Maximum spring Puffin counts on Skomer & Middleholm

Count date	No. individual Puffins
17/04/2014	18,237
18/04/2014	14,875

Appendix 6 Ringing Totals for 2014

	Adult	Pullus	Total
Manx Shearwater	183	416	599
Storm Petrel	47		47
Puffin	72	116	188
Guillemot	51	240	291
Razorbill	28	51	79
Kittiwake	5		5
Lesser Black-backed Gull	16	376	392
Herring Gull	5		5

All birds ringed as part of Research Projects.

Appendix 7 Gull Diet Survey: Comparison of Methods

This report was issued to JNCC in November 2012. The JNCC have had the raw data and are doing some further analysis (2012).

Ali Quinney and Richard Kipling

Introduction

For several years the WTSWW Field Assistant on Skomer Island has carried out a diet survey of the 25 Great Black-backed gull nests included in the breeding productivity survey. The diet survey has evolved over time, and as a result there are some vagaries in the methodology which may affect the accuracy of findings. Here, the results of the WT diet survey carried out in 2012 are compared with the results of a more rigorous method, in order to test the validity of the WT findings.

The WT Method

The WT survey of GBBGU diet involves a visit to each nest shortly after the chicks have fledged. The purpose is to provide a straightforward estimate of the diet of GBBGU chicks, and to record the frequency, number and relative abundance of rabbit and Manx Shearwater remains. A simple visual survey is made of the area surrounding each nest, and each prey item is recorded.

There are two issues with the WT methodology:

1) Some of the prey categories are to some extent subjective, and some prey items could be fitted into a number of them, depending on the experience of the recorder. For example, if a bone is found it may be classed simply as 'bone', identified as bird or mammal, or identified to species level. A number of bones found close together may be grouped together as a single entry, or treated separately, and again this is a matter of judgement for the surveyor.

2) The size of the area around the nest in which prey is included is left to the discretion of the recorder, and this introduces a further element of uncertainty and variation into the dataset.

The Comparison (Transect) Method

The purpose of the comparison method was:

1) To assess if the proportions of recorded prey types differed from those found using the WT survey method.

2) To assess changes in the amount or type of prey items found at increasing distances from each nest, in order to provide recommendations on how far from a nest prey items should be recorded.

A cross-shaped transect centred on each nest was used to observe prey items. Along the transect a one metre square quadrat was used, and prey items observed within each quadrat recorded. Prey categories defined in a previous intensive diet survey were used as the basis for the classification of prey. Items were divided into categories specific enough to minimise subjectivity in the classification of each prey type (Appendix 2).

Prey were recorded at the centre of the transect (the nest site itself, distance zero). From the centre, quadrats then led out from the centre to a total distance of ten metres. The direction of each arm of the cross-shaped transect was, either, north south east and west, or along and perpendicular to the rocky outcrop (for nests found on linear ridges). Nests were allocated to three categories: ridge (nest on linear feature), rocky outcrop (nest on non-linear feature), plateau (nest on flat area with no significant drops or edges close). Only at ridge nests were transect arms dictated by the direction of the geographical feature on which the nest was situated. The nest categories allowed data gathered using different orientation rules to be analysed separately, and enabled a comparison of ecological differences between nest sites to be undertaken (results in separate report).

Data Analysis Methods

Analysis of Prey Changes with Distance from nest

The amounts of different prey types recorded at each distance (0-10 m) from nests were calculated. Because each distance except zero metres (the centre) included observations from four quadrats (one on each transect arm), these data were divided by four to allow comparison with the amount of prey recorded in the central quadrat. All prey items were included, and results were summed across all nests. Linear regression was used to ascertain whether the number of prey items decreased significantly with increasing distance from the nest, and the cumulative percentage of total prey recorded was calculated for each increase in distance. The analysis was repeated for nests in the three different categories defined, so see if the location of a nest affected the spread of prey around it.

Changes in the type of prey recorded at increasing distances from the nest were analysed by comparing the proportions of different prey types recorded at different distances. A Chi Squared Test was used, and data were merged into broad prey categories to ensure that the test was valid (no categories with expected values < 5).

Methodological Comparison of Findings

Data were collected using the Transect Method at 18 of the 25 nest sites at which the WT diet study was conducted. The WT survey was carried out at the same time as the Transect survey where possible. At the remaining sites the WT survey was carried out first, with care taken not to disturb prey items. In order to compare the two methods, prey categories used in the Transect survey were merged to match those in the WT survey. Prey amounts were summed over all 18 nests for both methods. The proportion of prey in each merged category was compared across methodologies using a Chi Squared test, in order to ascertain if the two methods returned significantly different prey proportions.

Results

Prey Changes with Distance from Nest

The amount of prey found was found to decrease with distance from nests with a leptokurtic distribution (Fig. 1a). Linear regressions were carried out on Log10 transformed data for all nests (Fig. 1b) and showed a significant relationship between distance and amount of prey for all nests, and for Ridge and Stony Outcrop type nests treated separately (Table 1). There was only one Plateau type nest, so no analyses were carried out on this category. More than 80 % of prey was found between zero and five metres from nests.

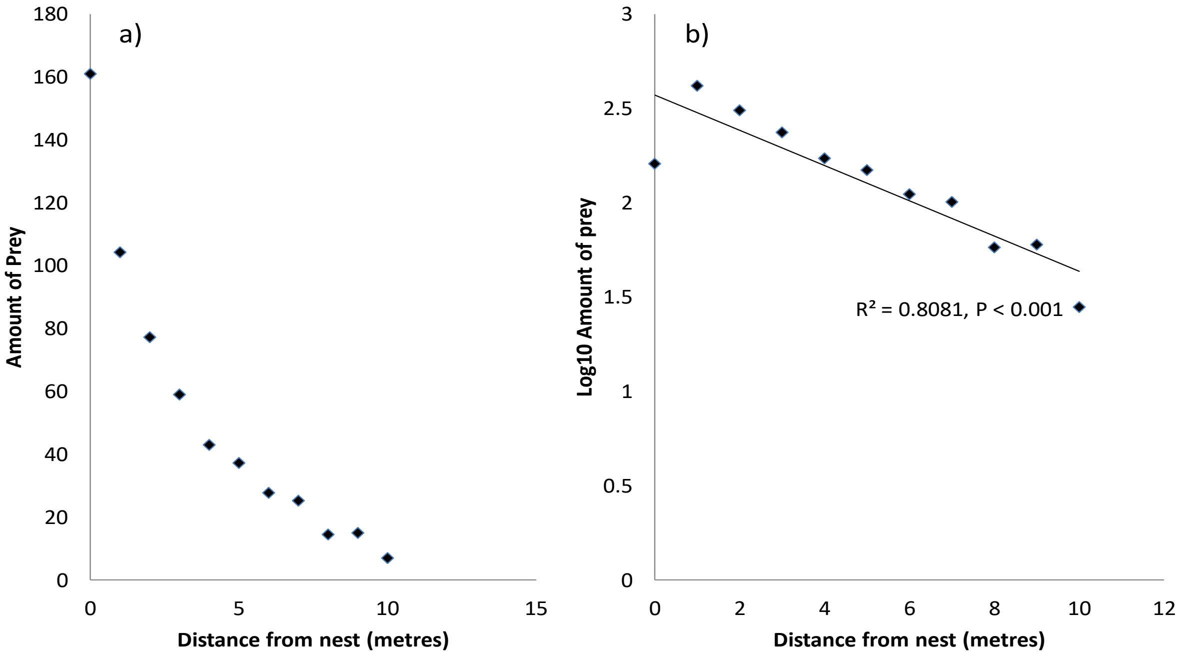


Fig. 1 Amounts of prey found at different distances from nest sites: a) total amounts, b) Log10 transformed amounts, with the results of linear regression analysis.

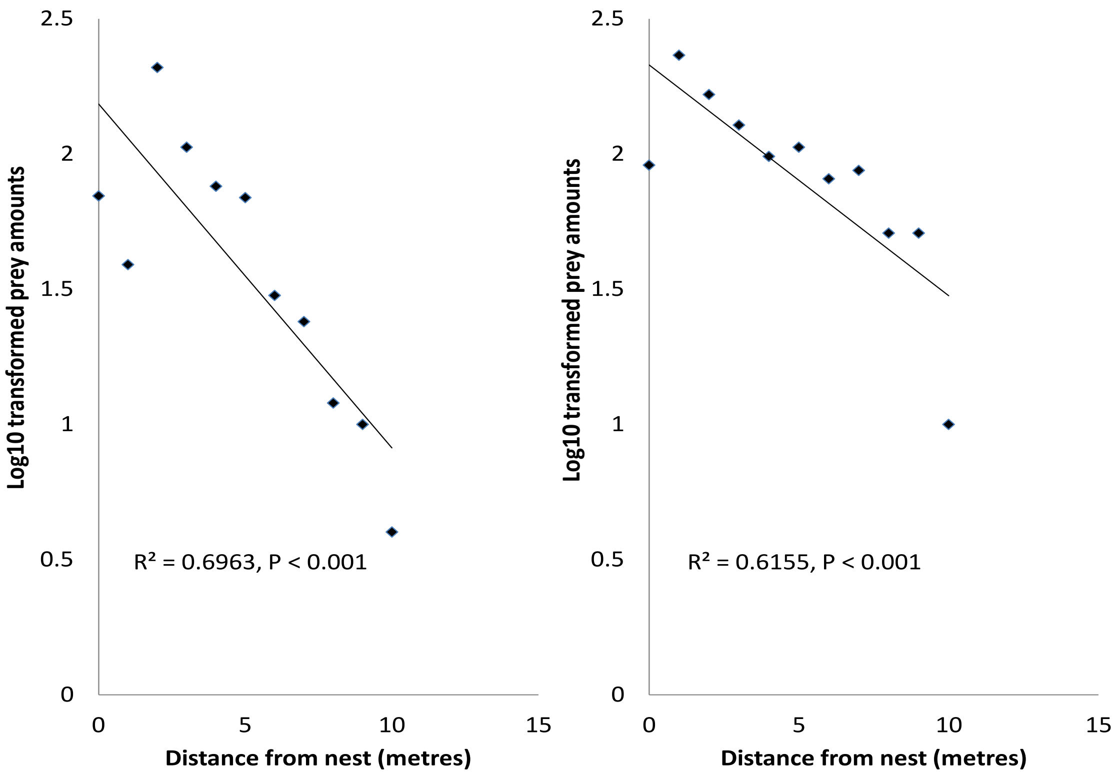


Fig.2 Log10 transformations of amounts of prey found at different distances from nest sites, with results of linear regression analysis a) Ridge nests, b) Stony Outcrop nests.

The proportions of different types of prey found close to the nest (zero to five metres) were significantly different to the proportions found further from the nest (six to ten metres) (Fig. 2). The proportion of Manx Shearwaters was lower closer to the nest site and the proportion of rabbits higher. There was no significant difference between the proportions of different types of prey found between zero and five metres from the nest, and the proportions found over all distances (Fig. 3).

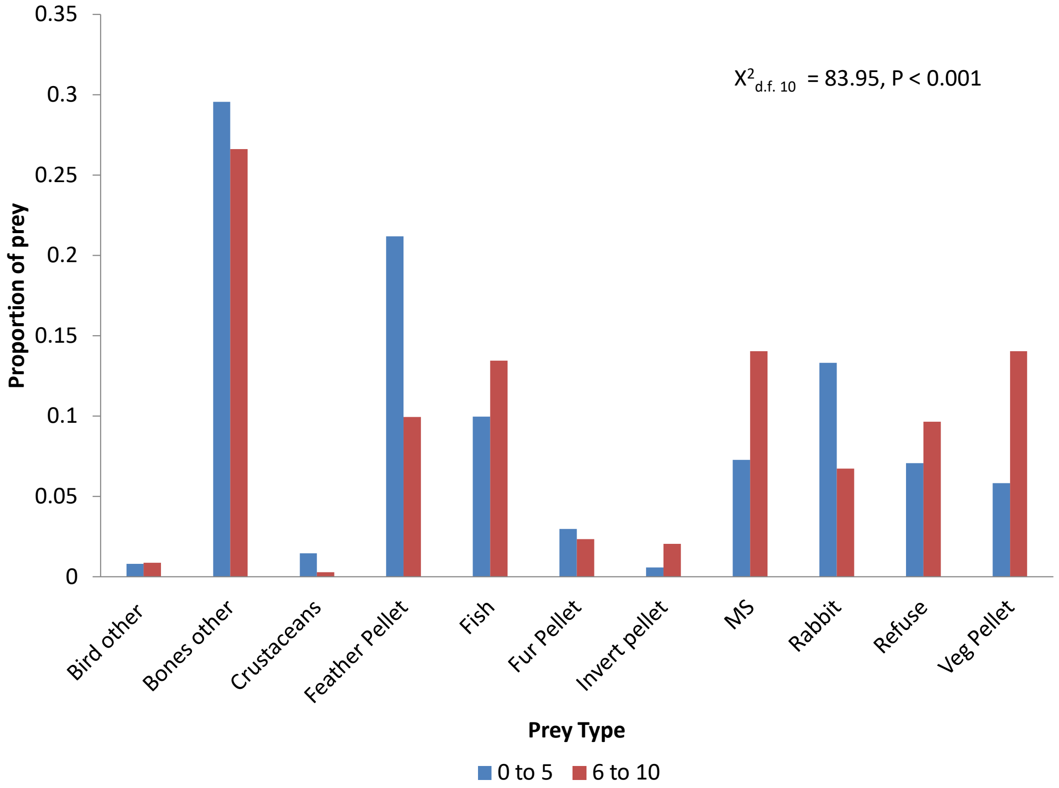


Fig. 2 Proportions of prey found close to nests (0-5 metres) and far from nests (6-10 metres). Results of Chi Squared analysis are shown.

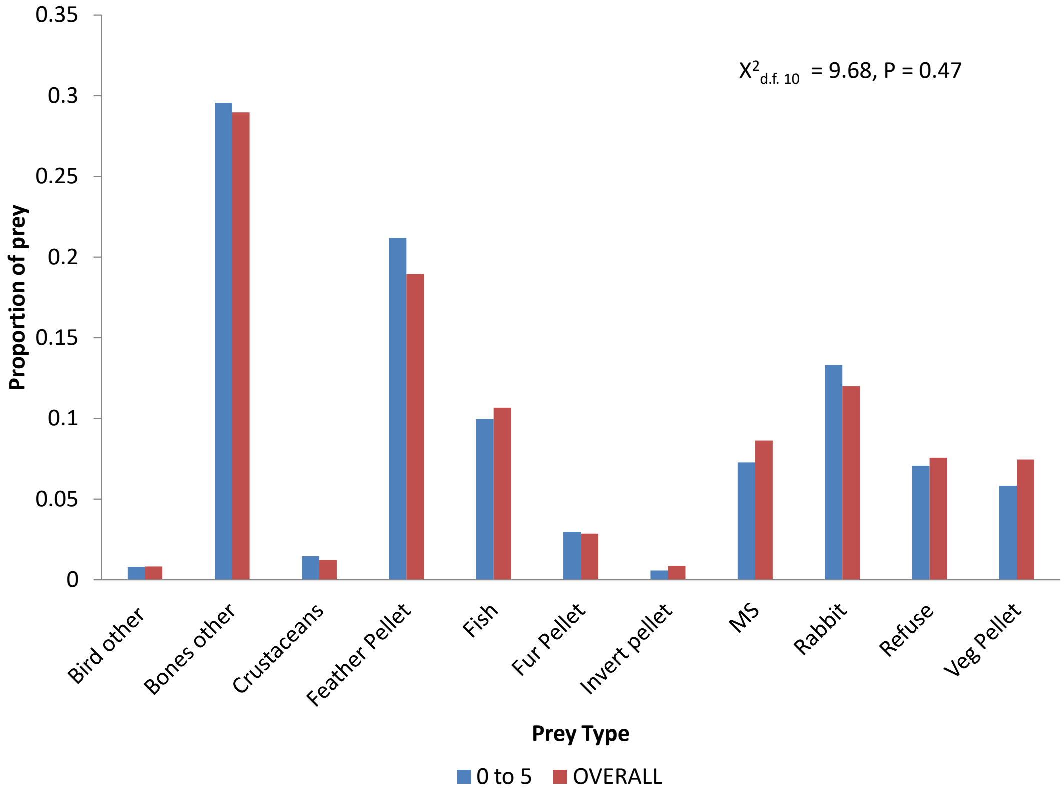


Fig 3 Proportions of prey found close to nests (0-5 metres) compared to overall proportions of prey found (0-10 metres). Results of Chi Squared analysis are shown.

Methodological Comparison of Findings

The proportions of prey in different categories for each survey methodology are shown in Fig. 4, along with the results of Chi Squared analysis. There were significant differences in the proportions of different prey items recorded using each method. The largest differences were in the categories: rabbit, bones (other), fur pellet and fish pellet. Manx shearwater, refuse, bird (other), feather pellet and crustacean categories differed least between methodologies.

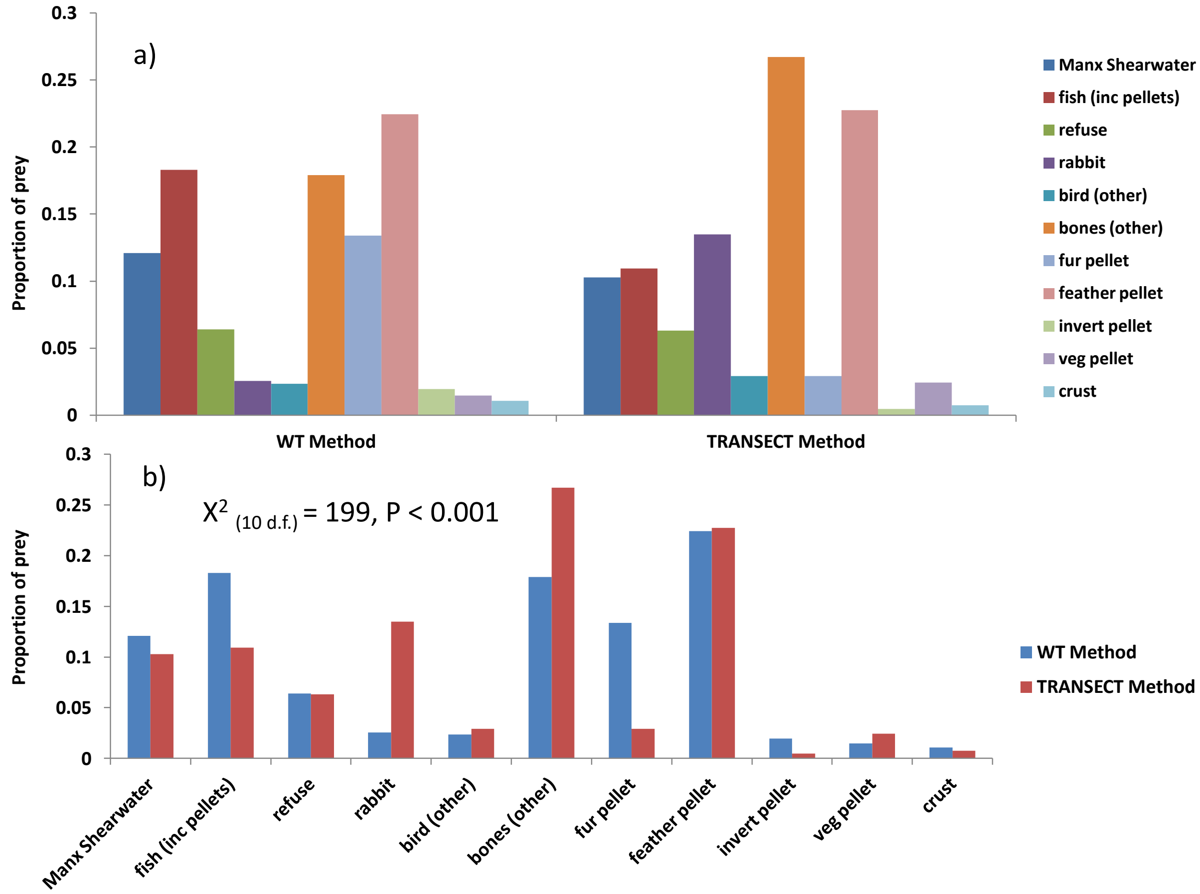


Fig. 4 The proportions of prey types found using the WT and Transect survey methods, a) arranged by method, and b) arranged by prey type. Panel b) includes the results of a Chi Squared test on the differences in prey proportions between methods.

Discussion

The results of this study, and big differences in the proportions of prey found in 2012 relative to 2011 (sea Skomer Sea Bird Reports 2011 & 2012) show that the outcomes of the WT GBBGU diet survey are highly sensitive to changes in the definition of prey categories, and their interpretation on the ground. This sensitivity means that the findings of previous studies must be treated with caution. Problems with prey categorisation appear to be the main reason that the WT and Transect methodologies yielded different results, and overcoming such difficulties would increase confidence in the data from WT method surveys.

Analysis of the distribution of prey around nests suggests that more than 80 % of prey remains are deposited within five metres of a nest site. Prey proportions up to five metres from nests are significantly different to prey proportions between six and ten metres (Fig. 4). This suggests that a survey area greater than five metres is necessary to capture prey proportions and amounts more accurately. However, as so little prey is found beyond five metres, excluding larger distances would not have significantly changed the prey proportions recorded using the transect method within a five metre area (Fig. 3). It appears that surveying up to five metres from a nest is sufficient to gain an accurate estimate of prey types.

As Manx Shearwater and Rabbit remains are quick to survey, and their relative numbers are of ecological significance, future surveys could include a wider sweep (up to ten metres) for these prey remains only. Of course, extra rabbit and shearwater remains found in this wider area should not be included in comparisons with prey types sampled only within five metres of nests.

Although many of the differences between the WT and Transect survey could be accounted for by differences in categorisation, some are likely to have arisen due to prey being overlooked using the WT method. The use of quadrats is likely to increase survey accuracy, providing detailed analysis of specific areas; small pellets etc. are liable to be missed in a general sweep of an area. However, quadrats are time consuming so a decision needs to be taken as to whether the increased accuracy achieved is worth the added survey effort. One solution would be to give a set time for observations at each nest (fifteen minutes may be reasonable), which would to some extent standardise survey effort and ensure that estimates of prey amounts between years were comparable.

Summary and Recommendations

1) Prey categories should be clearly and unambiguously defined for future WT surveys. Eleven broad categories are suggested below (Appendix 1).
2) It should be ensured that surveyors do not try to identify remains in more detail than the categories suggest. If this occurs, similar remains are likely to be counted differently depending on the knowledge of the surveyor (for example, an experienced worker might identify a bone as rabbit remains, while a less experienced worker would simply record them as ‘bones – other’)
3) An area of five metres, centred on the nest, should be sufficient to gain a good estimate of prey remains for all nest types
4) If a quadrat-based method is not used (due to the survey effort required) a set time should be defined for the WT search method, within the zero to five metre perimeter. This should ensure that a similar survey effort is made each year, so that prey estimates are comparable.
5) Manx shearwater and rabbit remains may be estimated up to ten metres from a nest, in order to capture differences in the proportions of these species observed at increasing distances. Only observations of rabbits and shearwaters found within the five metre area should be included in comparisons with other prey types.

Appendix 7.1: Suggested Prey Categories

Manx Shearwater	**Includes shearwater bones, wings, skulls, carcasses**
Fish (inc pellets)	**Fish bones, or entire pellets**
Refuse	**Pieces of plastic, cloth, glass etc**
Rabbit	**Bones with rabbit fur, carcasses, pellets with feet etc (if bones w/o fur etc count as Bones (other)**
Bird (other)	**All bird remains (gull, guillemot, razorbill etc). Can make note e.g. of puffin numbers separate from main analysis; for analysis include all species except Manx shearwaters in this category.**
Bones (other)	**All bones not obviously Manx shearwater or fish (do not attempt detailed ID as many bones taken from landfill sites)**
Fur pellet	**Pellets containing fur. Unless obvious rabbit foot or bone count in this category, not as rabbit**
Feather pellet	**All pellets containing feathers. Include pellets with egg shell**
Invert Pellet	**All pellets containing invertebrates**
Veg Pellet	**All pellets which are vegetation only (without feathers/fur/inverts**
Crustacean	**All pellets, crustacean remains, shells**

Appendix 7.2: Prey Categories used in Transect survey

Prey type	Prey Item
Manx shearwater	Complete carcasse
	Partial carcasse
	Wings
	Pellet of feathers without inverts
	Pellet of feathers with inverts
	Head
	Assorted bones
Rabbit	Complete carcasse
	Partial carcasse
	Fur pellet without inverts
	Fur pellet with inverts
	Bones
Refuse	Plastic
	Paper
	Bones (not from island)
	Other
Fish	Pellet
	Bones
Intertidal	Crab remains
	Mussel/limpet
Pellet: Vegetation	solely veg
	with invert remains
	egg shell in pellet
Other birds(record species as reqd)	Other bird bone
	Puffin foot
	Puffin wing
	LBB Remains
	Guillemot/Razorbill carcass
	Puffin skull
Bones	Bird sp.
	Mammal sp.