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Seabird monitoring on Skomer Island in 1999-2002

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Summary

This report details the results of seabird monitoring studies commissioned by the JNCC on Skomer Island National Nature Reserve in 1999-2002 and carried out by the Wildlife Trust of South and West Wales (formerly the Wildlife Trust West Wales) and Edward Grey Institute of Field Ornithology. For completeness and ease of reference, the results of additional relevant seabird monitoring studies undertaken on Skomer over the same period by the Wildlife Trust West Wales are included.

The whole-island count of northern fulmars decreased for the fourth successive year in 1999, following the population peak of 742 in 1991, but increased in 2000 and 2001, to 730 AON, the second highest number since 1960. The population decreased in 2002. Productivity was low in each year, particularly so in 2000, when just 0.33 chicks per AON fledged. Productivity recovered somewhat in 2001 and again in 2002.

Tape playback surveys of European storm petrel calls were conducted in 2000 and 2001 and an increase in responses was detected. No firm conclusions could be drawn about population size, however, due to lack of information on response rate to playback.

Productivity of Manx shearwaters fell from 1999 to 2000 and again in 2001, but increased to about the 1991-1998 average in 2002. Survival rate in 1999-2002 (the most recent years for which data are available) was generally fairly low, as has been the case on Skomer in many years.

Lesser black-backed gull numbers reached a low point in 1999 (the second lowest since comparable monitoring began in 1980), when 12,028 AON was estimated. Since then the population increased to 15, 185 nests in 2002. The years 1999-2002 was a period of low and declining productivity for lesser black-backed gull, with just 0.14 chicks fledged per nest in 2002, and annual survival was generally low, especially so in 1997 and 2000. Following the all-time low number of breeding herring gulls in 1998, the number increased in1999 and 2001. Productivity was moderate in 2000 and 2001 but very low in 2002; survival was high in 1997 but lower in subsequent years. The number of great black-backed gull continued its general increase, and productivity was high.

After the 20-year low in breeding numbers of black-legged kittiwakes in 1997, the population increased in 1998-2000, stabilised in 2001 and decreased in 2002, to reach a 25-year low, at 1,863 AON. Many nests were washed away by storms in 2002. Productivity was high in 1999 but very low in 2001. Survival increased, following apparent declines between 1993-1997.

The whole-island population of common guillemots in 1999 and 2000 continued to increase, but the rate of increase slowed down in 2001 and, particularly, in 2002; a similar pattern occurred in the study plots. Productivity was low in all four years.

The whole island razorbill count increased markedly between 1999 and 2001 and less so between 2001 and 2002 –a 73% increase over three years. Productivity was low, particularly so in 2002, when just 0.36 chicks fledged per site.

Spring counts of Atlantic puffins gave similar numbers to those of previous years, while breeding success was a little below average. Adult survival appeared to decline between 1997 and 2000.

1. Introduction

Seabirds are a significant component of the marine environment and Britain has internationally important populations of several species. A national Seabird Monitoring Programme (SMP), 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 a coverage of British waters 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 the Countryside Council for Wales (CCW). The island is part of the Skokholm and Skomer Special Protection Area (SPA), designated because of its seabird interest, and 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 also exists a long-term data set for seabirds on Skomer, which is invaluable in setting current results in context. 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, while the Oxford University Edward Grey Institute of Field Ornithology (EGI) has monitored populations and adult survival rates of burrow-nesting species and gulls on the island for over two decades. Other bodies have carried out additional studies of individual species.

This report documents the work undertaken in 1999-2002 by WTSWW and EGI on behalf of the JNCC and CCW. Specifically, the work was divided as follows between the two contractors. Whole-colony and study plot counts were undertaken by WTSWW, except the study plot count of Manx shearwaters, undertaken by EGI; breeding success was studied by WTSWW, except for Manx shearwater and lesser black-backed gull, which were undertaken by EGI; adult survival rates were studied by EGI, as was feeding rate of Atlantic puffins. The report also includes data on numbers of European storm petrels *Hydrobates pelagicus*, European shags *Phalacrocorax aristotelis*, great cormorants *P. carbo* and Atlantic puffins *Fratercula arctica* and on breeding success of razorbills *Alca torda* collected by WTSWW without external funding assistance. Information about some of this additional work is also published elsewhere by WTWW, e.g. in *The Island Naturalist - the Journal of the Friends of Skomer and Skokholm* and the annual *Puffin Pal* reports. Further details may be obtained from the WTSWW at the address given on the title page.

2. General methods

2.1 Whole island counts

The herring gull *Larus argentatus* and great black-backed gull *Larus marinus* censuses were carried out from mid to late May. The lesser black-backed gull *Larus fuscus* census followed the established method of counts from vantage points of sub-colonies (in the third week of May) corrected by a figure established from actual nest counts in sample areas (during the final week of May).

The whole island counts of the cliff-nesting species were largely carried out during the first week of June. In 1999 weather during that week was rather wet and some counts had to be carried out in drizzle. Sea conditions were ideal for only one day during the first few days of June, but there was a heavy swell on the north-west coast, and some sections would have benefited from a recount if this had been possible.

In 2000, most counts were undertaken during fine weather from 4-7 June, and remaining sections were counted during the last week of June, when good weather resumed. In 2001 counts were done between 4 and 18 June. In 2002 a continuous southwesterly swell during June and the temporary absence of the island boat hampered the whole island counts of cliff sections only accessible by boat. The whole island counts of the cliff nesting species were carried out 4-26 June, with some boat counts of northern fulmar *Fulmarus glacialis* and black-legged kittiwake *Rissa tridactyla* repeated on 7 July (where the swell hampered counts on the original visit) Most sections were counted by three or four observers at least once, and the mean figure used. Land counts tended to be carried out by small groups of people, with the mean count being used. If there was a marked difference in numbers counted, (greater than 5%-10%), then areas were recounted. Boat counts also followed this protocol, although in practise wind and sea conditions prevented full recounts.

Counting units and methods follows those recommended in 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

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; these are filed on the island.

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.

2.4 Adult survival estimates

The survival rate analyses presented have been made in the same way as in the other years since 1989, (but differ from those presented in earlier years) in that they have been made from a computer calculation of Maximum Likelihood Measurements and only one measure of survival for each year is presented. As with similar methods, two years of observations are needed to obtain the estimate for a given year, i.e. the 1999 estimate can only be obtained after observations in 2000 and 2001. Hence in this report estimates are given up to and including 2000. The most recent years are likely to change (probably only slightly) with the addition of further years of data.

2.5 Weather

Weather during the 1999 breeding season was extreme and variable with days of dry, sunny and calm weather interspersed with periods of wet and windy weather. Southwesterly gales with rain occurred on 8 and 9 May.

In 2000 fine, settled conditions prevailed during the second half of April and the first half of May, while the second half of May was unsettled with low pressure systems moving in from the west. June started very unsettled, with a south-westerly gale washing the bottom layer of black-legged kittiwakes and common guillemots off the Wick cliff on the 1st, and heavy rain causing an earth slip and associated loss of Atlantic puffin burrows on the Neck on the 2nd. A settled period of warm and sunny weather ensued from 4th, but wet and windy weather returned on 8th and generally lasted until 24th when warm and sunny conditions and light winds resumed. July was mixed – starting and ending wet but with a particularly settled period of warm and sunny conditions from 17th.

In 2001, April was generally unsettled. Winds were between the north and east, occasionally fresh, during the first half of May, but the month was generally dry and sunny. June was generally fine, although winds of force 5 or above were recorded on 12 days and heavy showers occurred on 15th. Wet and windy conditions prevailed during the first three weeks in July (with a northerly gale on 18th and torrential rain on 3rd, 17th and 20th) causing cliff auks to delay fledging by up to a week, and contributing to a very low black-legged kittiwake breeding success. More seasonal warm and sunny weather resumed in the final week of July.

Weather conditions in 2002 were generally unsettled and at times very windy and wet. The first half of April was fine but gale-storm force winds ended the month. May was fine for the first half, but a deluge of torrential rain and thunderstorms on 17th broke rainfall records and heralded a wet and windy period up to 25th. The final week of May was bright and breezy. ‘Changeable’ weather characterised June. The wind was lighter than Force 4 on just two days and below Force 5 on only 12 days, and a continuous south-westerly swell hampered boat counts. In July, an unsettled first week preceded a two-week period of sunshine and light winds. The first week of August was generally fine with light winds. Strong winds and showers occurred 9-11th, with mist and drizzle 13-14th. Light winds and showers occurred 9-11th, with mist and drizzle 13-14th . Light winds and warm sunshine prevailed up 25th .

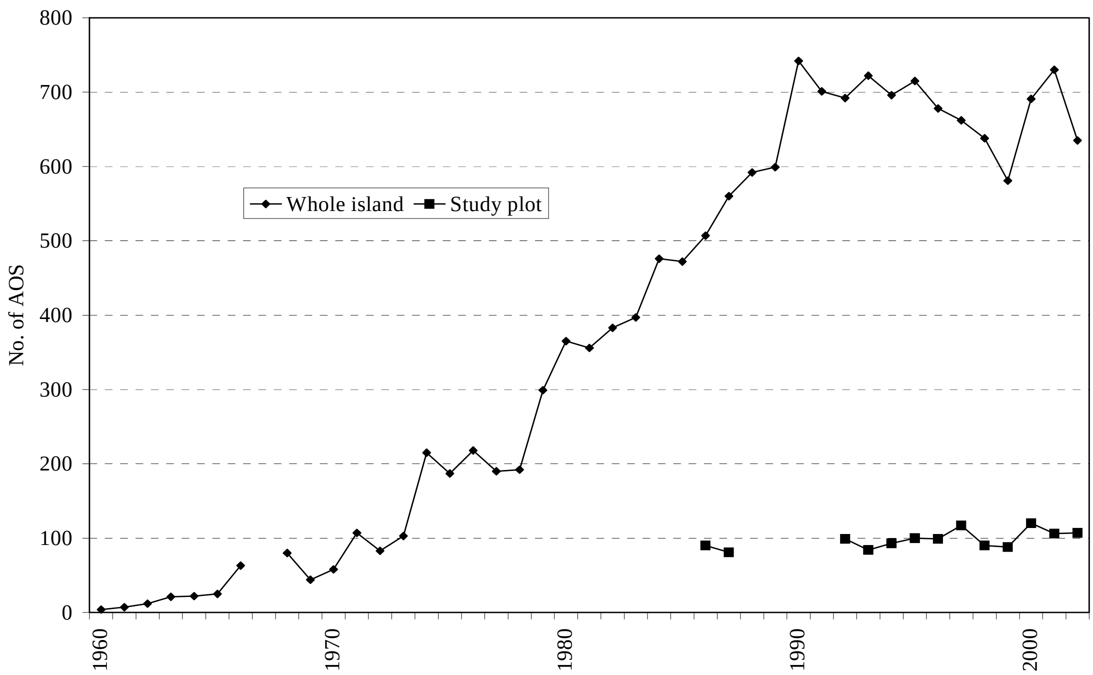
3. Northern fulmar

3.1 Breeding numbers - whole island counts

Following a period of general decline from 1991 to 1999, the population of northern fulmar increased in 2000 and 2001, to it second highest since monitoring began on Skomer. A decrease of nearly 100 Apparently Occupied Sites (AOS) was recorded in 2002, compared with 2001. It appears that, following the nearly continuous increase in numbers from 1960 (when just four AOS were present) to the peak count in 1990 (742 AOS), that the population of northern fulmar on Skomer is currently in a period of stability or decline (Figure 1).

The number of northern fulmar AOS in the breeding success study plots (see 3.2.1 for definition) can be compared to the whole island counts (Figure 1). There is no clear correlation between whole island numbers and numbers recorded in study plots.

Figure 1. Northern fulmar breeding numbers on Skomer Island 1960-2002.



3.2 Breeding success

3.2.1 Methods

Methods were as those of previous years, and follow Walsh *et al.* (1995). Three visits to observe site occupancy were made to the seven northern fulmar study plots between 21 May and 27 June. Further visits were made between 31 July and 14 August to determine the presence or absence of large chicks. A site was considered occupied if a bird was observed sitting on three consecutive dates, but in 2000, as visits to sites were in 5-10 days apart, a site was considered occupied if a bird was observed on two consecutive visits (as per Walsh *et al.* 1995). All large chicks were assumed to have fledged.

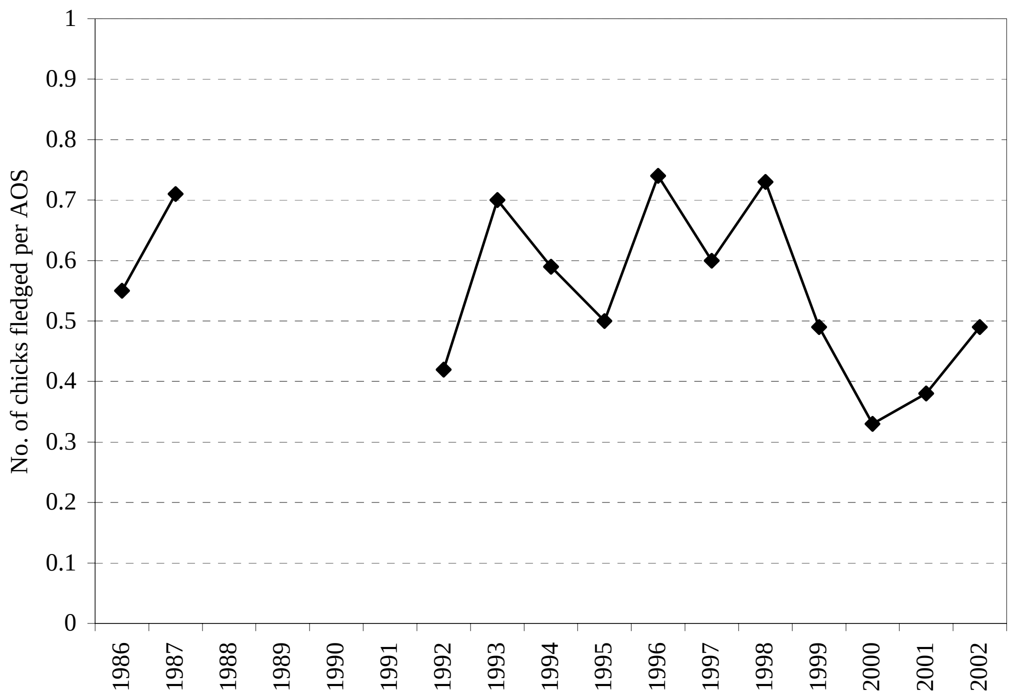
3.2.2 Results

Mean breeding success across seven monitoring plots in 2000 reached its lowest level since 1986 (when monitoring of success started on Skomer) and was again low in 2001 (Table 1, Figure 2). In 2000 success was particularly low at the small colony at Tom's House, where one chick fledged from nine AOS and at North Haven where just seven young fledged from 31 AOS. In contrast, success was relatively high at Matthew's Wick, at 0.54 chicks per AOS. Breeding success increased somewhat in 2002, but was still below average.

Table 1. Northern fulmar breeding success on Skomer Island 1995-2002. Figures are number of chicks per AOS and those in parentheses are the number of AOS in each study colony.

	1995	1996	1997	1998	1999	2000	2001	2002
Tom's House	0.29 (7)	0.55 (9)	0.71 (7)	0.80 (5)	0.14 (7)	0.11 (9)	0.33 (6)	0.40 (5)
Basin (west)	0.43 (21)	0.71 (24)	0.82 (22)	0.68 (19)	0.61 (18)	0.27 (22)	0.27 (22)	0.62 (21)
Basin (east)	0.29 (14)	0.90 (10)	0.71 (14)	0.67 (11)	0.91 (11)	0.40 (15)	0.45 (11)	0.50 (8)
North Haven	0.40 (20)	0.62 (21)	0.52 (27)	0.70 (20)	0.39 (23)	0.23 (31)	0.33 (27)	0.40 (25)
South Haven	0.57 (14)	0.73 (11)	0.50 (14)	0.69 (13)	0.47 (15)	0.41 (17)	0.4 (15)	0.50 (14)
Castle Bay	0.73 (11)	0.82 (11)	0.27 (15)	0.75 (8)	0.46 (13)	0.38 (13)	0.27 (11)	0.50 (12)
Matthew's Wick	0.85 (13)	0.85 (13)	0.69 (16)	0.85 (13)	0.43 (14)	0.54 (13)	0.64 (14)	0.50 (14)
Mean	**0.50**	**0.74**	**0.60**	**0.73**	**0.49**	**0.33**	**0.38**	**0.49**
SE	0.08	0.13	0.07	0.03	0.09	0.05	0.05	0.03

Figure 2. Northern fulmar breeding success on Skomer Island 1986-87 and 1992-2002.



4. European storm-petrel

Potential storm petrel breeding sites were surveyed in 2000 and 2001, following on from a three-year survey between 1996-1998 (Poole *et al.* 1998; Poole and Smith 1997, 1998) and initial studies using the tape playback technique (Ashton 1993; James 1984a). Ten sites were visited in both years, between 16 June and 20 July in 2000 and between 5 and 20 July in 2001, the period when most birds are likely to be incubating (Scott 1970).

A recording of a churring male was played at likely site entrances, and any response noted. Searching for nest holes by smell proved unreliable, as a response was obtained from many sites that had no obviously perceptible odour. Population estimates are given using the correction factor used previously, based on a 100% response rate in males and 46% in females (James 1984b) and equal inter-sex incubation stints (Scott 1970). Thus, the number of sites where a response was obtained to playback was multiplied by 1.37 to give a total population estimate. (It is worthy of note that subsequent work, undertaken in 2003 and to be reported upon at a later date, suggested that the 1.37 conversion factor used in this and previous population estimates may result in an under-estimation of the population). All sites except the colony opposite the Mew Stone were visited just once. The previous three-year study involved two visits to each site and used the highest figure, but this would give an overestimate based on the assumptions of the correction factor. The Mew Stone site was visited on three dates, but only partially covered on each occasion. Nest holes where checks were duplicated and which produced a response on the second visit but not the first are ignored for the population estimate. Photographs were taken of marked AOS.

Table 2. European storm-petrel tape playback results on Skomer Island 1981-2001 (brackets denote most recent data where sites were not visited).

	2001 Responses	**2000 Responses**	**1998 Responses**	**1997 Responses**	**1996 Responses**	**1993 Responses**	**1981-82 Pairs rounded up to nearest 5**
North Haven	8	11	21	17	10	(10)	5
Mew Stone	38	11	9	12	17	10	40
Wick Basin	10	4	2	2	3	8	10
The Basin	0	1	0	2	2	(2)	10
Tom's Hse.	9	6	3	4	8	6	20 incl. Amos
The Amos	-	0	(2)	(2)	2	(2)	See above
Pigstone Bay	1	1	0	1	3	(3)	Not visited
The Spit	6	3	1	(1)	(1)	(1)	10
Littlewill Be.	7	7	0	(0)	(0)	(0)	Not visited
The Table	2	2	2	(2)	(2)	(2)	5
Paynes Ledg.	0	0	-	-	-	-	-
Tot. respon.	**81**	**46**	**40**	**43**	**48**	**44**	**-**
No. pairs (responses x 1.37)	**111**	**63**	**55**	**59**	**66**	**60**	**100**

Table 2 shows a remarkably narrow range of population estimates within the five years with records between 1993 and 2000, given the difficulties in storm petrel census. The 2000 and particularly the 2001 population estimates may indicate an increase in the population in recent years, although without simultaneous estimation of response rate at each survey it is difficult to draw firm conclusions. However, the increase in responses between 2000 and 2001 attained from the colony opposite the Mew Stone is striking. It should be noted that 1998 and earlier figures are likely to be overestimates, as more than one visit was carried out each year and the highest number of responses used, in contrast to the single visits in 2000; this would tend to strengthen apparent increases between 1993 and 2001. No survey work was undertaken on the species in 2002.

Of 37 little owl *Athene noctua* pellets collected in 2000, two contained remains of European storm petrels. Also in 2000, remains of one European storm-petrel were found regurgitated by a herring gull nesting by the colony at North Haven.

5. Manx shearwater Puffinus puffinus

5.1 Study plot census

Table 3 shows the number of responses to tape-recordings of male Manx shearwater calls from study plots on Skomer from 1998 (when monitoring began) to 2002. Note that the number of responses is not equal to the population size, since no correction factor has been applied which would allow for the response rate of males to tape play-back. However, the data give an indication of the relative numbers present in each year, and suggest that the overall population in the study plots has remained fairly stable since 1998, although there appears to be considerable year to year variation within many of the individual plots. Note that the number of burrows checked at each plot varies from year to year; this may have been an effect of different observers and/or of varying numbers of extant burrows.

Table 3. Number of responses to tape-recordings of male Manx shearwater calls from study plots on Skomer, 1998-2002.

Study Plot	**2002**	**2001**	**2000**	**1999**	**1998**
A	20 (98)	12 (94)	17 (87)	15 (70)	12 (51)
B	32 (98)	19 (240)	18 (193)	35 (102)	19 (75)
C	36 (193)	35 (202)	27 (259)	45 (255)	56 (299)
D	71 (320)	51 (244)	61 (296)	65 (235)	81 (200)
E	14 (61)	15 (67)	17 (66)	14 (65)	17 (63)
F	5 (17)	5(11)	2 (12)	3 (17)	3 (14)
G	9 (22)	3 (14)	4 (15)	6 (16)	2 (11)
H	16 (140)	15 (120)	10 (120)	17 (97)	23 (98)
I	75 (260)	117 (321)	74 (199)	88 (293)	72 (271)
J	54 (360)	67 (401)	107 (455)	75 (311)	77 (339)
L	142 (593)	131 (560)	186 (596)	132 (506)	147 (473)
M	79 (175)	62 (188)	67 (240)	80 (231)	85 (234)
N	52 (248)	49 (288)	39 (261)	67 (249)	51 (207)
O	30 (110)	34 (152)	38 (140)	29 (99)	27 (93)
P	78 (228)	67(204)	57 (234)	60 (205)	30 (151)
Q	29 (85)	17 (95)	17 (77)	26 (82)	34 (84)
R	56 (214)	39 (236)	65 (329)	44 (235)	48 (190)
S	63 (213)	51 (237)	45 (127)	67 (187)	37 (97)
Total	**861 (3,435)**	**789 (3,674)**	**851 (3,706)**	**868 (3,255)**	**821 (2,950)**

Note: First figure in each cell is the number of males that responded to play-back; the figure in parentheses is the number of burrows checked for responses. Study plot K was not relocated after 1998 and so is not presented here.

5.2 Breeding success

Measures of breeding success were obtained from study burrows on the Isthmus, shown in Table 4. Productivity was about average (1991-1998 mean=0.54, SD=0.23) during the years 1999-2002, although was somewhat low in 2001. Note that the 1999 estimate assumed that missing chicks survived, whereas in other years, following thorough searches, they were thought to have died; this may have elevated the 1999 productivity estimate relative to those of other years.

Table 4. Breeding success of Manx shearwaters on Skomer Island, 1999-2002

Parameter			**Year**	
	1999	**2000**	**2001**	**2002**
Burrows with eggs	84	83	98	108
Chicks hatched[1]	58	59	62	73
Chicks died	2	1	1	5
Chicks ‘missing’[2]	-	6	19	6
Chicks probably surviving to fledging[3]	56	51	42	62
Hatching success[4]	69.0%	71.1%	63.3%	67.5%
Fledging success[4]	96.5%	86.4%	67.7%	84.9%
Fledglings per laying pair	0.67	0.59	0.43	0.57

Notes:

1. Some of the losses may have been due to desertions;
2. Includes chicks that were known to have hatched, but which could not be found at a later stage; they were presumed to have died in 2000, 2001 and 2002 (following extensive searches) but thought to have survived in 1999. Also includes, in 2002, losses either at the egg or chick stage; since losses of chicks are rarer, they were assumed to be egg losses.
3. Chicks were ringed when large and were presumed to have survived to fledging, since mortality rate of large chicks is thought to be low.
4. In a number of the nests it was not possible to ascertain whether the nest failed in the egg stage or whether the egg hatched and the chick died. These were scored as the egg failing. Hence hatching success should be regarded as a minimum and fledging success as a maximum.

5.3 Adult survival

Survival estimates were based on re-sightings of colour-ringed birds from 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.

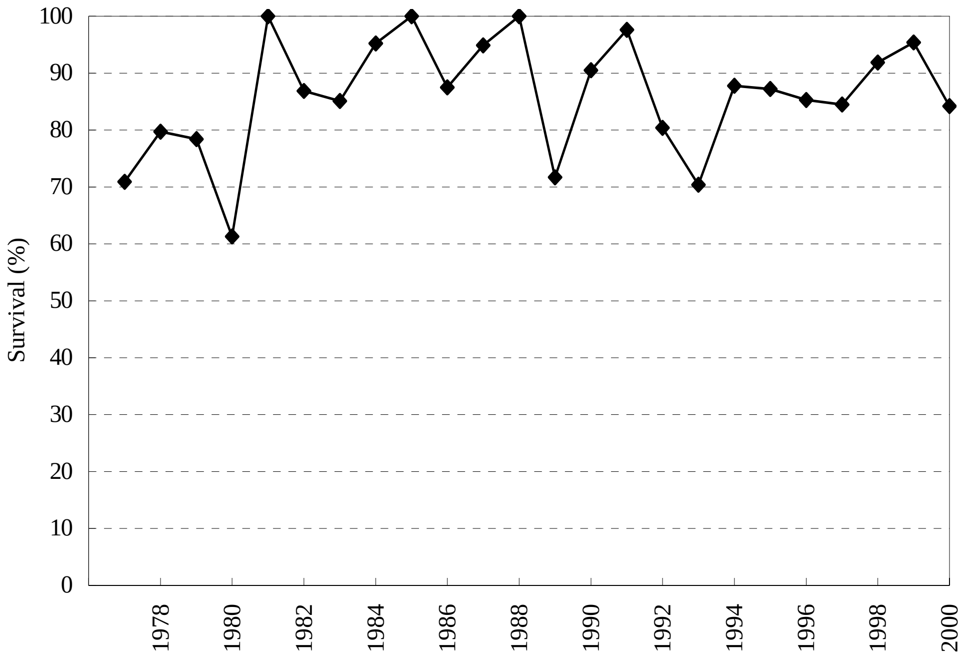
The estimated survival rate (Table 5; Figure 3) remains low, both in comparison with more detailed studies carried out earlier on Skokholm and with what one might expect for a bird with such a low reproductive rate, although it increased in 1998 and 1999. The average survival rate for the 10 years 1982-1991 was 93.1% whereas for 1992-97 was only 77.8%. This difference is significant using a t-test of arcsine transformed values (to normalise the data) ($t=2.98$, $df=14$, $P<0.01$). However, incorporating data for 1998-2000 into the comparison renders the difference non-significant, due to recent increases in survival rate ($t=1.86$, $df=17$, $P>0.05$). Two scenarios could explain the low estimates of survival over the last decade: either the population has declined or the estimated survival rates presented in Table 5 are lower than the real ones; if the latter case is true, this could be due to a number of reasons, such as birds not breeding in a particular year. It is worth noting that the 1998 Manx shearwater census on Skokholm indicated an increase (though not necessarily in the last few years) and a recent study on Rum indicates that there may have been a small decrease there in recent years.

One noteworthy example of Manx shearwater longevity was a female breeding in the burrows in 1999 that was hatched on Skokholm in 1967, making her 32 years old.

Table 5. Estimated annual survival rates of Manx shearwater on Skomer, 1977-2000

Year	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival	70.9	79.7	78.4	61.3	100	86.9	85.1
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	95.2	100	87.5	94.9	100	71.7	90.5
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	97.6	80.4	70.4	87.8	87.2	85.3	84.5
Year	**1998**	**1999**	**2000**				
Est. Survival	91.9	95.4	84.2				

Figure 3. Trend of annual survival estimates of adult Manx shearwaters on Skomer, 1977-2000



6 Great cormorant

6.1 Breeding numbers

The number of breeding great cormorant on Skomer has fluctuated at a rather low level over the past four decades. It increased - erratically - from 1970 to reach a peak of 26 nests in 1987, and since then has declined somewhat (Figure 4). In 2002, rough seas precluded an accurate count; the eight nests counted probably was an underestimate.

Figure 4. Great cormorant breeding numbers on Skomer Island 1960-2001

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6.2 Breeding success

In 2000, 23 chicks fledged from 18 nests, giving an average productivity of 1.28 chicks per nest. In 2001, about 18 probably fledged from 13 monitored nests (1.38 per nest). In 2002, about eight nests and five juveniles were noted on 7 July, but due to rough seas these figures are probably underestimates. (No record of productivity was made in 1999).

7 European shag

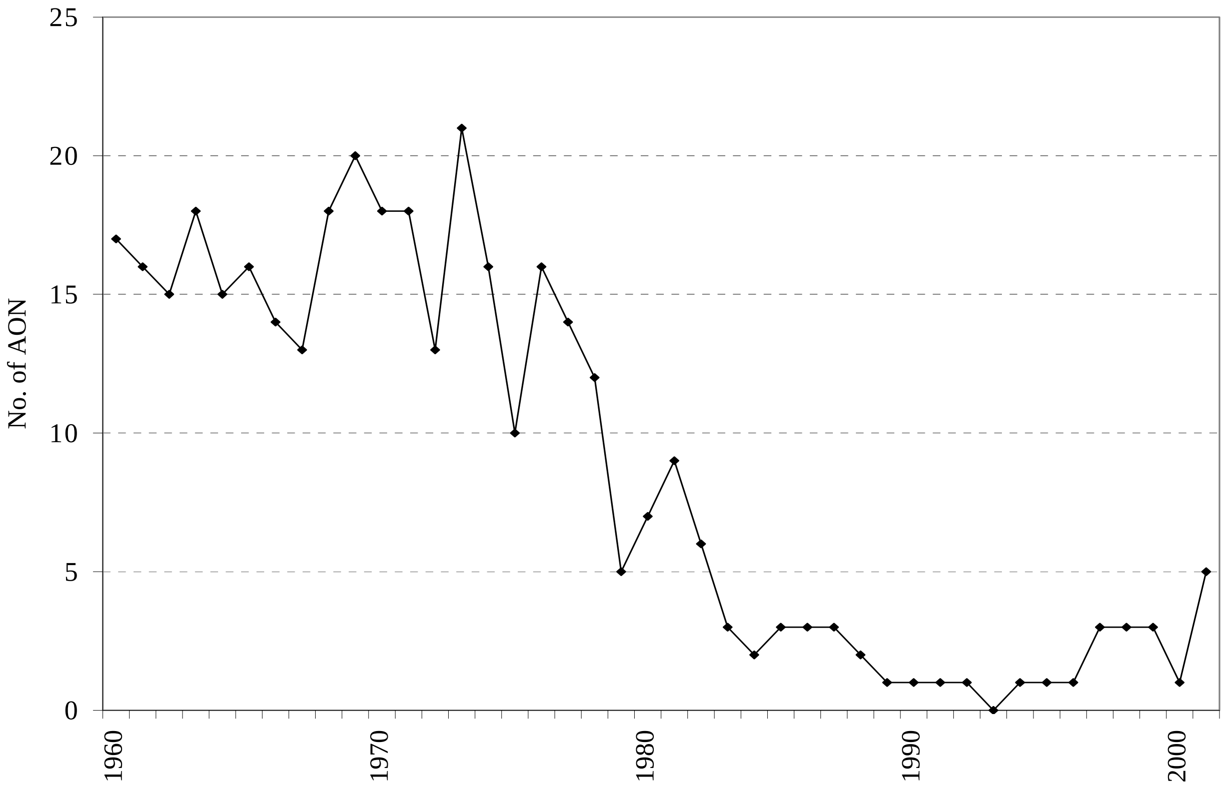
7.1 Breeding numbers

The number of European shags on Skomer has remained at very low levels since the early 1980s, following a decline starting around the 1970s, although numbers have always been modest (Fig. 5). In 2002, rough seas meant that no accurate count of European shags could be obtained.

7.2 Breeding success

No consistent monitoring of the breeding success of European shags on Skomer took place in 1999-2002. In 2000 2.14 chicks per Apparently Occupied Nest (AON) were raised on nearby Middleholm (South Pembrokeshire Ringing Group, SPRG). In 2001 five pairs raised nine young on Skomer, while on Middleholm an estimate of 1.9 chicks per AON was made by SPRG.

Figure 5. European shag breeding numbers on Skomer Island 1960-2001.



8 Lesser black-backed gull

8.1 Methods for estimating breeding numbers

Counts of AOS were made from various standardised viewpoints around the island. On most occasions a group of observers counted sub-colonies simultaneously (defined as the count 'event'); the mean counts from each event were then used to calculated the overall mean for each sub-colony. Nests, including empty nests, in selected sub-colonies were then systematically searched for, counted and marked with canes. The difference between the counts from viewpoints and the actual nest counts produced a mean adjustment factor, that was applied to the mean of the counts from viewpoints for the whole island. The adjustment factor varies both between years and between areas, depending upon factors such as habitat type and the height of the vegetation, both of which determine the proportion of nests that can be seen from a viewpoint. The method assumes that each pair built one nest. Applying a single correction factor to the whole range of sub-colonies, which vary in habitat type and breeding density, may lead to errors, although it is difficult to overcome this. Such errors could, perhaps, be reduced by excluding from the correction calculation those sub-colonies that are characterised by low, grazed turf or those that mainly comprise rock.

8.2 Breeding numbers – results

Table 6 shows the whole-island counts from vantage points, the adjustment factor and consequent whole-island estimates of lesser black-backed gull numbers on Skomer during 1999-2002. Appendices 2 and 3 give details of adjustment factors and counts from vantage points.

Looking at the whole-island population as shown by adjusted counts including empty nests (Figure 6) the population reached a low point in 1999 (the lowest since 1987 and the second lowest since comparable monitoring began in 1980), when 12, 028 AON were estimated. Since then the population has increased, to the 15, 185 nests estimated in 2002. The decline of the lesser black-backed gull population on Skomer during the mid 1990s was attributed largely to a reduction in fishery discard feeding opportunities (Sutcliffe 1997). Although the decline has been arrested and is starting to be reversed, the productivity estimated by EGI (see Section 8.2) has been consistently far too low to sustain the population (let alone provide for its increase) without immigration.

Table 6. Counts from vantage points and adjusted whole island estimates (including empty nests) of lesser black-backed gull on Skomer 1999-2002.

	1999	**2000**	**2001**	**2002**
Sum of counts from vantage points (Mean)	7, 334	6, 294	7,153	6,631
Mean adjustment factor (range)	1.64 (1.05-2.15)	2.14 (1.53-2.71)	1.82 (1.11-2.55)	2.29 (1.10-4.07)
Whole island estimate (Mean)	**12,028**	**13, 469**	**13, 018**	**15, 185**

Figure 6. Lesser black-backed gull breeding numbers on Skomer Island 1961-2002. Note that breeding numbers have been estimated using various techniques since 1961 (Sutcliffe 1993). The methodology outlined above has been used since 1987.

The ratio of empty nests to total nests has fluctuated quite markedly since this parameter was first measured in 1991 (Table 8) and differs markedly between sub-colonies (Table 7). This suggests that a note of caution should be applied to the interpretation of the whole island population estimates that combine the adjustment factor based on counts of nests including empty nests. A rather high ratio (30.7%) occurred in 2002, such that the population trend between 2001 and 2002 as revealed by counts including empty nests indicated a 17% increase, whereas the trend as revealed by counts excluding empty nests indicated a 4% decrease. A large proportion of empty nests has been postulated (e.g. Sutcliffe, 1997) to be an indication of breeding abandonment at an early stage, possibly as a result of food stress. Indeed, the high ratio of empty nests in 2002 coincided with a particularly unproductive breeding season (see section 8.2). There are further, methodological, reasons for being cautious about the interpretation of counts that include empty nests: the counting of ‘empty nests’ is somewhat subjective, and has largely been carried out by different volunteers each year. Also, a pair may build more than one nest, which might potentially be counted more than once.

Table 7. The ratio (%) of lesser black-backed gull empty nests to total nests during last week of May on sub-colonies of Skomer Island 1999-2002.

Sub-colony name	Year			
	1999	**2000**	**2001**	**2002**
2 Marble Rocks	22	28	16	34
5 Bull Hole	8	27	5	29
8 Sheer Face W	25	26	18	30
9 Sheer Face E	25	21	14	36
M N Wick Ridge - S	26	20	19	37
N N Wick Ridge - N	20	21	19	23
Y Field 11	16	23	19	26
Mean	**20.3**	**23.7**	**15.7**	**30.7**

Note: Details of counts are given in Appendix 4.

Table 8. The mean ratio of lesser black-backed gull empty nests to total nests during last week of May on Skomer Island 1991-2002

	1991	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
% empty nests	19.0	26.4	39.0	27.9	39.9	48.6	23.2	13.8	20.3	23.7	15.7	30.7

8.3 Breeding success

Breeding success was estimated using a mark-recapture calculation (see Table 9), in which a sample of chicks (ideally 500) is metal-ringed and the proportion of ringed to un-ringed chicks is counted once most chicks have fledged.

The period 1999-2002 was a period of low and declining breeding success of lesser black-backed gulls, such that by 2002 it was estimated that only 0.14 chicks were fledged per AON (Table 9). Even if we assume that the recent increase in the whole island population over this period is exaggerated by including empty nests in the calculations (which would have the effect of decreasing the apparent overall productivity), productivity would still be very low, at 0.20 chicks per AON in 2002.

Although food shortages have been thought to be the cause of this very low nesting success for many years, the very poor weather in May 2002 was thought to have contributed to the low success in that year. Some regurgitates were noted as being fish, indicating that at least some birds were able to feed on their preferred prey. Two sub-colonies in 2002 replaced their lost broods and had small young in late July; if any of these fledged, the total number of fledglings would be a little higher than that estimated above.

Table 9. Estimated productivity of lesser black-backed gulls on Skomer, 1999-2002

	1999	**2000**	**2001**	**2002**
No. fledglings ringed	500	500	287	369
Estimated total no. fledglings[1] (mean)	5,016	4,330	3,583	2,109
Total AON	12,028	13,469	13,019	15,185
Productivity	0.42	0.32	0.28	0.14

Note: See Appendix 5 for details. [1]Estimated Number = $\frac{\text{Total fledglings seen} \times \text{Number Ringed}}{\text{No. ringed fledglings seen}}$

8.4 Adult survival

The survival rate of lesser black-backed gulls between 1978-2000 is shown in Table 10 and the trend is displayed graphically in Figure 7.

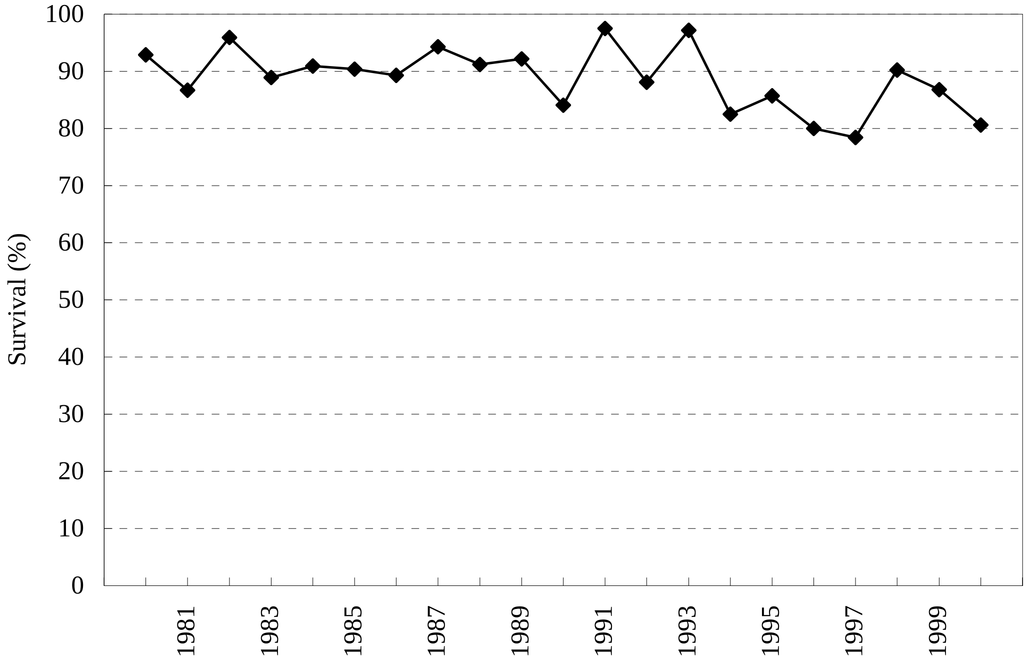
Table 10. Estimated annual survival rates of lesser black-backed gulls on Skomer, 1978-2000

Year		**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival		98.1	91.7	92.9	86.7	95.9	88.9
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	90.9	90.4	89.3	94.3	91.2	92.2	84.1
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	97.5	88.1	97.2	82.5	85.7	78.0	78.4
Year	**1998**	**1999**	**2000**				
Est. Survival	90.2	86.8	80.6				

Note: As in the last few years, re-sighting was difficult because the grass was very long throughout the season, making the colour rings inconspicuous. In 1997 a very small number of birds that had lost a colour ring were assigned identities from the pool of birds that could have given rise to the observed combination of colour rings. If birds with ‘missing’ colour rings were seen in 1998 and subsequently, they were treated as being the same individuals as in 1997.

As noted above, there was a marked decline in the breeding population of lesser black-backed gulls on Skomer during the mid- to late 1990s, followed by a moderate increase in numbers (Figure 6). While the decline in number may be due (in part at least) to the very low breeding success observed, it does not explain the recent increases, since breeding success remained low and even decreased during that time. Until recently, there has been no very convincing evidence that adult survival has also declined significantly. However, the annual survival estimates from 1987- 1997 show a significant downwards trend ($P = 0.006$, adjusted $r^2 = 54\%$), although including 1998-2000 survival estimates makes this not (quite) significant. However, survival rate appeared to decline more markedly between 1993 and 1997 (Figure 7), the period when population decline was most marked. Thus, there is tentative evidence that the observed population decline was related to a decline in survival rate, though the relationship is far from clear. We cannot, of course, distinguish between mortality and emigration but it is very unusual for adult birds to move far from an established breeding site (Cramp and Simmons 1983). However, in the face of continued failure to breed, it remains possible that a proportion of the population has emigrated.

Figure 7. Trend of annual survival estimates of adult lesser black-backed gulls on Skomer, 1980-2000



9 Herring gull

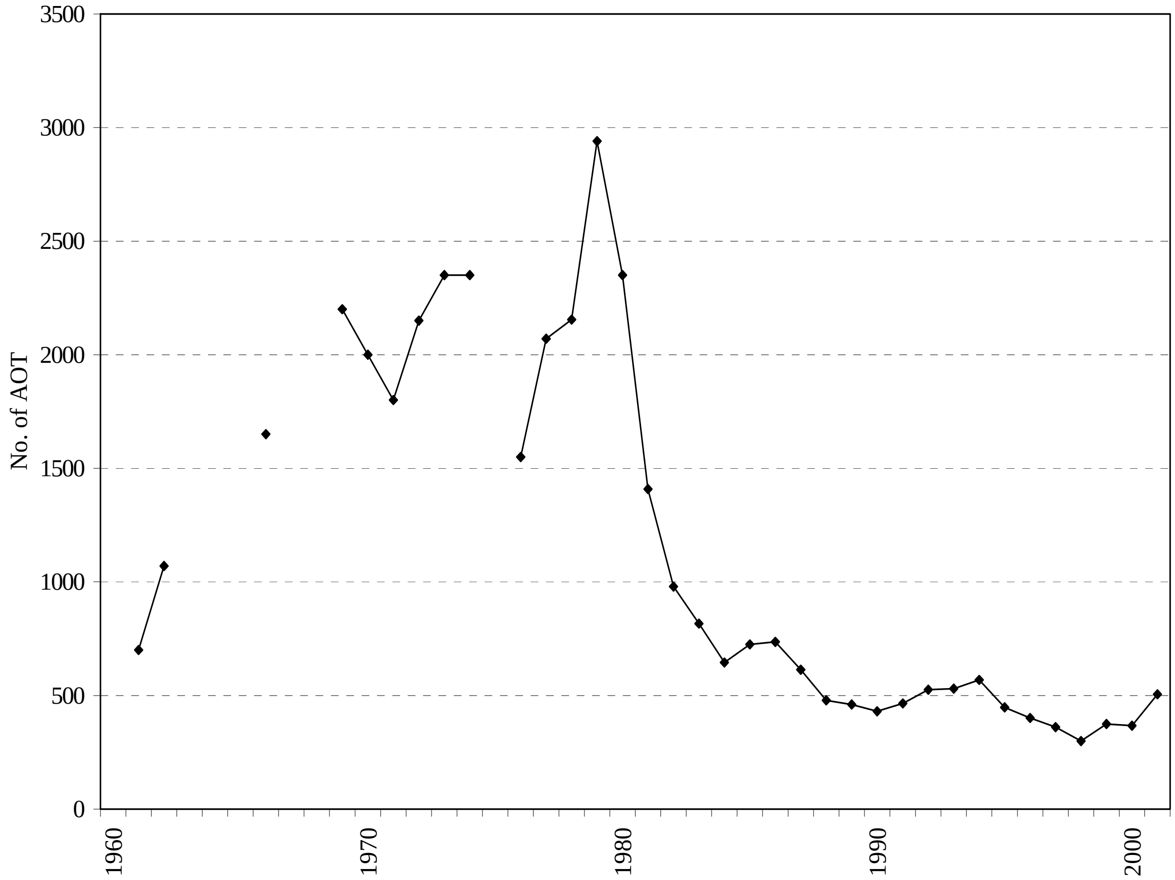
9.1 Breeding numbers

Following the all-time low of 299 breeding pairs of herring gulls in 1998, the number increased by 75 pairs in 1999, decreased slightly in 2000 and increased more substantially in 2001, to 505 AOT (Figure 8). However, the population remains at a similarly low level as it has over the past decade, following the dramatic decline in the early 1980s. This decline was attributed mainly to an outbreak of botulism caused by the introduction of black plastic dustbin liners; the gulls at that time foraged mostly on refuse dumps (Sutcliffe 1997). Subsequent changes in tip management, reducing feeding opportunities, and a decline in the local fishing industry may have contributed to the lack of recovery, but it is not clear why the population has remained at the current low levels. Breeding success has varied from year to year (Figure 9) but is significantly higher than that of the lesser black-backed gull.

The number breeding on the adjacent island of Middleholm increased between 1998 and 2001: 87 AOT in 1998, 104 in 1999, 113 in 2000 and 147 in 2001.

The ratio of coastal nesters to inland nesters was 80:20 in 1999, 80:20 in 2000 and 85:15 in 2001 (no census was possible in 2002, due to storms). The ratio has varied little each year since 1992.

Figure 8. Herring gull breeding numbers on Skomer Island 1961-2001. Note: It was not possible to conduct an all-island herring gull count in 2002 due to stormy conditions during the census period.

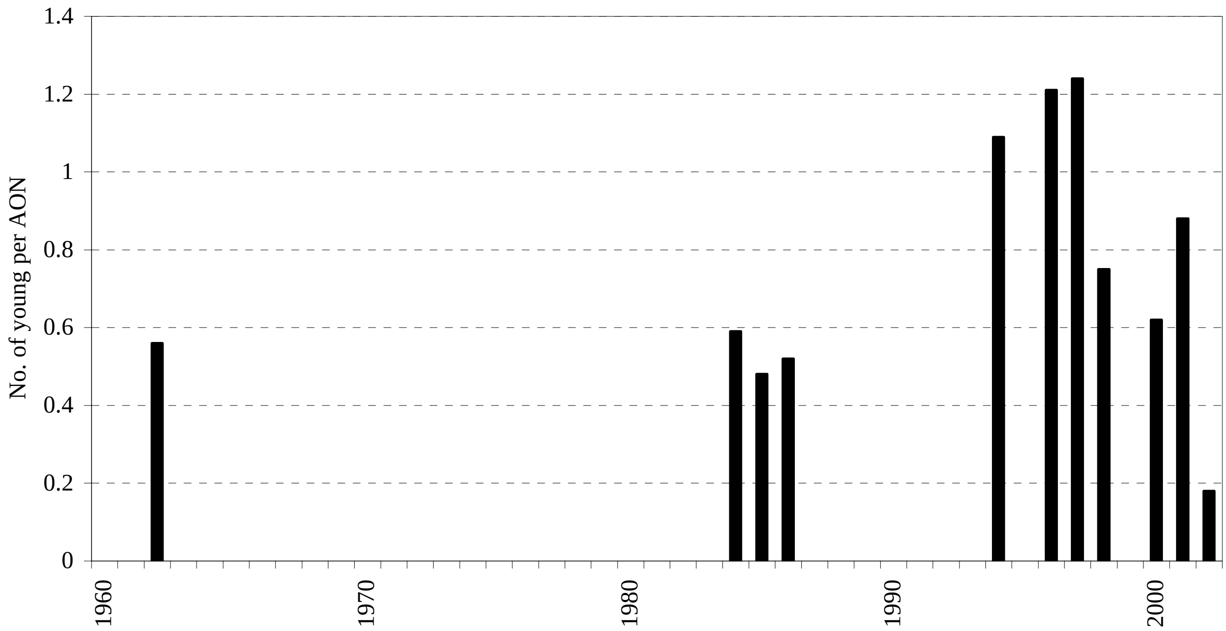


9.2. Breeding success

Monitoring of the breeding success of herring gulls was included within the JNCC contract from 1999. Following the recommendations in Poole *et al.* 2001, monitoring of breeding success of herring gulls in both inland and coastal sub-colonies was initiated, although difficulties in observing chicks in rank vegetation (and other methodological problems)in the inland sites prevented much useful data from being gathered from there for all years 1999-2002. Similar problems prevented data collection at the coastal sub-colony in 1999. Methodology and site selection are being reviewed.

Breeding success in 2000 and 2001 was moderate (0.62 and 0.88 chicks per AON, respectively), compared with the mean of the eight years of available data from 1962 to 1998 (0.81 chicks per AON), but was particularly low in 2002, when just five chicks fledged from 28 monitored nests (0.18 chicks per AON). This was by far the lowest breeding success so far recorded for herring gulls on Skomer (Figure 9). Additionally, seven AONs were monitored at Bull Hole in 2002; three young fledged from these, giving a breeding success of 0.43 per pair from this small sample. Despite the fairly high breeding success of herring gulls on Skomer in most years since the mid1990s, the breeding population has only made very modest signs of recovery from the dramatic decline that it underwent in the early 1980s.

Figure 9. Breeding success of coast-nesting herring gulls on Skomer Island, 1962-2002.



Note: Number of AON monitored at Tom’s House and number of young assumed to have fledged were, respectively: 29 and 18 in 2000; 42 and 37 in 2001; 28 and 5 in 2002. No data were collected in 1999.

9.3 Adult survival

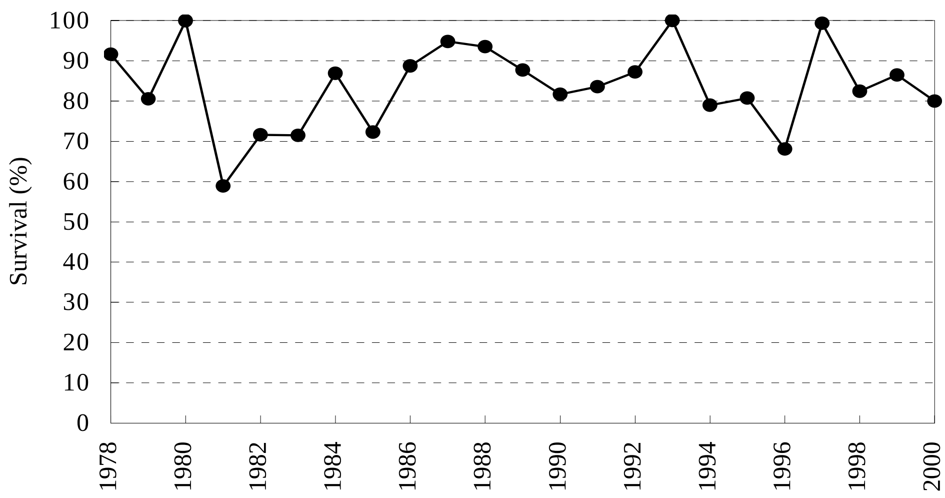
Survival rates are shown in Table 11 and in Figure 10. These data are based mainly on birds nesting along the north coast of Skomer, but because population size there decreased so markedly, we established a second study plot in the area from the Amos to Skomer Head. The samples are still smaller than would be desirable.

Table 11. Estimated annual adult survival rates of herring gulls on Skomer, 1978-2000

Year		**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival		91.6	80.5	99.9	58.9	71.6	71.5
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	86.9	72.3	88.7	94.8	93.5	87.7	81.7
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	83.6	87.2	(100)	79.0	80.7	68.1	99.3
Year	**1998**	**1999**	**2000**				
Est. Survival	82.4	86.5	80.0				

Adult annual survival of herring gulls breeding on Skomer has shown varying trends over the last two decades. After a particularly marked decrease in 1981 survival showed an increasing trend until 1987. Thereafter survival rate showed a general decline (except in 1993, when survival was high), until 1996, when it reached a 15-year low. Thereafter, survival increased markedly in 1997, but fell to lower values in 1998-2000.

Figure 10. Trend of annual survival estimates of adult herring gulls on Skomer, 1979-2000

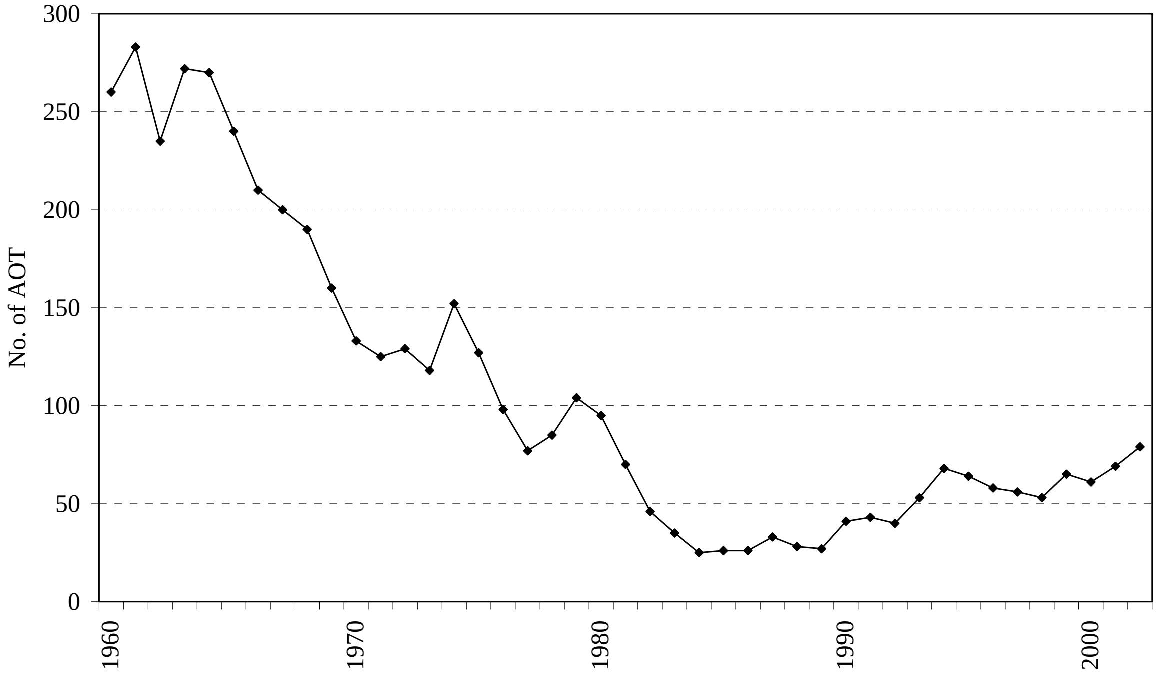


10 Great black-backed gull

10.1 Breeding numbers

In 1999-2002, the breeding population of great black-backed gull on Skomer has continued its general increase, which began in the early 1990s, following the severe long-term decline from the mid-1960s to the mid-1980s (Figure 11).

Figure 11. Great black-backed gull breeding numbers on Skomer Island 1960-2002.



The decline 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 contributed to the decline (Sutcliffe 1997).

Breeding numbers of nearby Middleholm have remained relatively stable during 1999-2002 (with a marked decrease in 2000): 34 AOS in 1999, 14 in 2000, 29 in 2001 and 32 in 2002.

10.2 Breeding success

Monitoring of the breeding success of great black-backed gull was included in the JNCC contract from 1999.

Following moderately productive breeding seasons in 1996-1999, productivity increased in 2000 (to 1.52 chicks per AOT, the highest in the 7 years that data have been collected), falling slightly in 2001 and 2002 (Figure 12).

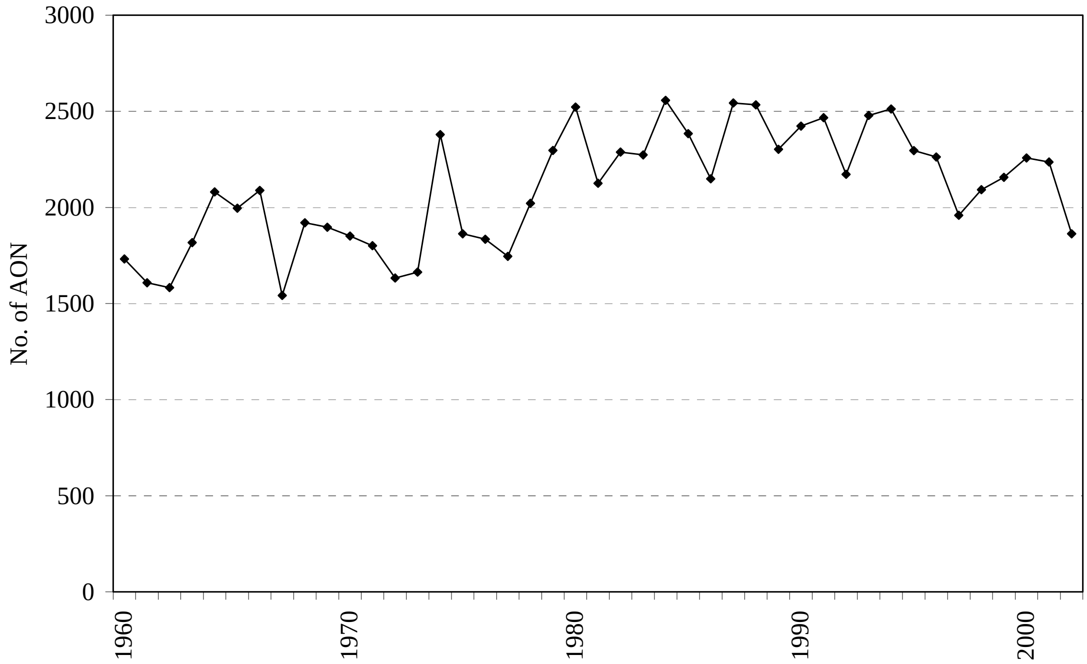
Figure 12. Great black-backed gull breeding success on Skomer Island 1996-2002.

11. Black-legged kittiwake

11.1 Breeding numbers

After the 20-year low in breeding numbers in 1997, the population increased in 1998-2000, stabilised in 2001 and decreased in 2002, to reach a 25-year low, at 1,863 AON (Figure 13). It should be noted that the counts in 1997 and 1998 were thought to have been depressed by, in 1997, a large proportion of nests having been washed away by storms, which were later re-built, but too late to be registered as AONs during the count and, in 1998, by late building of nests and laying (Poole *et al.* 2001). Also, storms in May 2002 washed away many nests from ledges nearest to the sea, contributing to the low count, although it is not known how many of these were subsequently rebuilt. Over all, the population trend appears to be one of recent decrease, following a stable period in the 1980s and into the early 1990s, itself preceded by a fluctuating but generally low population in the 1960s and 1970s.

Figure 13. Black-legged kittiwake breeding numbers on Skomer Island 1960-2002.



11.2 Breeding success

11.2.1 Methods

The breeding success of between 796 and 903 black-legged kittiwake AON was monitored at the three sub-colonies studied since 1989, using the same methods as in previous years. Photographs of the cliffs were used and each nest marked on a transparent overlay. Six or seven visits were made to each sub-colony to monitor progress from nest construction to fledging. Chicks were judged to have fledged on the basis of their size on the previous visit or the wing length of any remaining sibling(s) in the nest; for details see Appendix 6.

11.2.2 Results

Breeding success in 1999, of 0.95 chicks per AON, was the highest -just- of the 1990s (Table 12 and Figure 14), indeed the second highest success recorded on Skomer since 1986, when the SMP started. Breeding success fell in 2000 and dramatically so in 2001, when just 0.21 chicks per AON was raised; this was by far the lowest productivity recorded on Skomer since recording began in 1986 and under half that of the next lowest figure (0.45 in 1986 and 1996). In 2002, breeding success recovered somewhat, but was still below average (Table 12), although storms in May washed off many nests at one sub-colony, contributing to the overall lack of success.

The ultimate factors causing the very low breeding success in 2001 appeared to vary - predation of chicks by great black-backed gulls in some areas, nests being washed off cliffs by heavy rain in others – but food availability and poor July weather may have been common causes, with the kittiwake population on nearby Ramsey Island suffering a similar general breeding failure. There was noted a scarcity of mackerel in local waters during July – perhaps a reflection of a scarcity of their sandeel prey. Desertion of chicks by parents in search of food was not apparent, however, as adults' attendance of chicks was generally high.

Table 12. Black-legged kittiwake breeding success (per AON) on Skomer Island in 1989-2002.

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
Mean (SE)	0.68 (0.056)	-

Figure 14. Black-legged kittiwake breeding success on Skomer Island 1989-2002.

The relationship between breeding success and number of chicks hatched per nest was examined (Table 13). In 1999, 2000 and 2002, nests in which two chicks hatched fledged, on average, about twice the number than did those in which one chick hatched. This was what may be expected if food was abundant during chick rearing. However, in 2001, when overall productivity was particularly low, nests of two chicks were only slightly more productive than those of one chick; furthermore, the few nests that hatched three chicks in 2001 failed to fledge any young. This suggests that food availability in 2001 may have limited the number of chicks for which a parent could provide.

Table 13. Black-legged kittiwake fledging success in relation to the number of chicks hatched per nest on Skomer Island 1999-2002.

Year	No. of chicks in nest	No. of nests	Total no. of chicks	No. chicks fledged	Success rate per nest
	1	308	308	248	0.81
1999	2	342	684	547	1.60
	3	8	24	16	2.00
	1	293	293	227	0.77
2000	2	344	688	494	1.44
	3	6	18	11	1.83
	1	345	345	114	0.33
2001	2	140	280	56	0.4
	3	2	6	0	0
	1	285	288	193	0.67
2002	2	187	374	236	1.26
	3	3	9	5	1.67

11.3 Adult survival

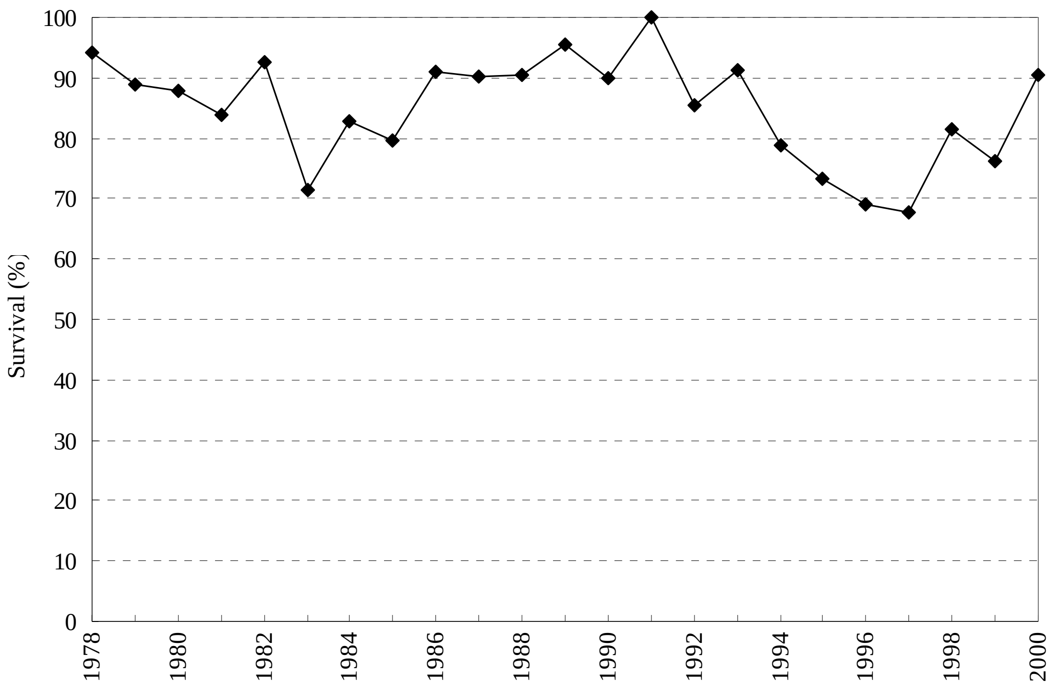
Survival rates of black-legged kittiwakes are presented in Table 14. These are based on colour-ringed birds at two sites: Tom's House and South Cliff.

Table 14. Estimated adult annual survival rates of black-legged kittiwakes on Skomer, 1978-2000

Year		**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival		94.2	89 .0	87.7	83.9	92.5	71.4
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	82.9	79.7	91.0	90.3	90.4	95.6	90.0
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	(100)	85.5	91.3	78.9	73.4	69.1	67.6
Year	**1998**	**1999**	**2000**				
Est. Survival	81.5	76.3	90.5				

After the apparent decline during 1994-1997, adult survival increased in 1998, fell in 1999 and increased substantially in 2000 (Figure 15). By 1997 survival was the lowest recorded since records began in 1978. However, the low survival rates recorded in 1994 and 1995 may have been the result of the decline of the Tom's House colony (Poole *et al.* 2001) and no breeding occurs there now. The explanation for this is not clear, but elsewhere it has been shown that small-scale colony decline can be associated with heavy tick infestations of the breeding ledges (Boulinier and Danchin 1996).

Figure 15. Trend of annual survival estimates of adult black-legged kittiwakes on Skomer Island, 1978-2000



It is possible that on Skomer in 1994 and 1995 colour-marked birds survived but moved to other parts of the island, where they were undetected. However, this would not explain the low survival rate observed in 1996 or 1997, since the birds had moved by then, perhaps point to a real decline in adult survival at the study colony during those years at least. The period of increased survival during 1998-2000 coincided with above-average productivity (Table 12) and was matched by increases in the size of the breeding population (Figure 13).

12 Common guillemot

12.1 Breeding numbers - whole island counts

The whole-island population of common guillemots in 1999 and 2000 increased at a similar rate to that seen in many years of the past decade or more, but the rate of increase slowed down in 2001 and, particularly, in 2002 (Table 15, Figure 16).

Table 15. Common guillemot whole island counts on Skomer Island, 1995-2002.

	Land count	% change	Sea count	% change	Total count	% change	5-year % change
1995	7,965	+17.5	2,030	+22.8	9,995	+18.6	+32.9
1996	7,083	-11.1	2,091	-16.2	9,174	-8.2	+14.2
1997	7,228	+2.1	2,478	+18.5	9,706	+5.8	+11.2
1998	7,838	+8.2	3,061	+23.5	10,899	+12.1	+29.3
1999	8,304	+5.9	3,831	+25.2	12,135	+11.3	+21.4
2000	9,777	+17.7	4,075	+6.4	13,852	+14.1	+51.0
2001	10,064	+2.9	4,217	+3.5	14,281	+3.1	+47.1
2002	12,253	+21.8	2,181	-48.3	14,434	+1.1	+32.4

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 are thought to occur within colonies. This can only be so, however, while the number of birds within plots are still expanding: once they become ‘saturated’ then an expanding colony will not be reflected by study plot counts. For details of counts refer to Appendix 7.

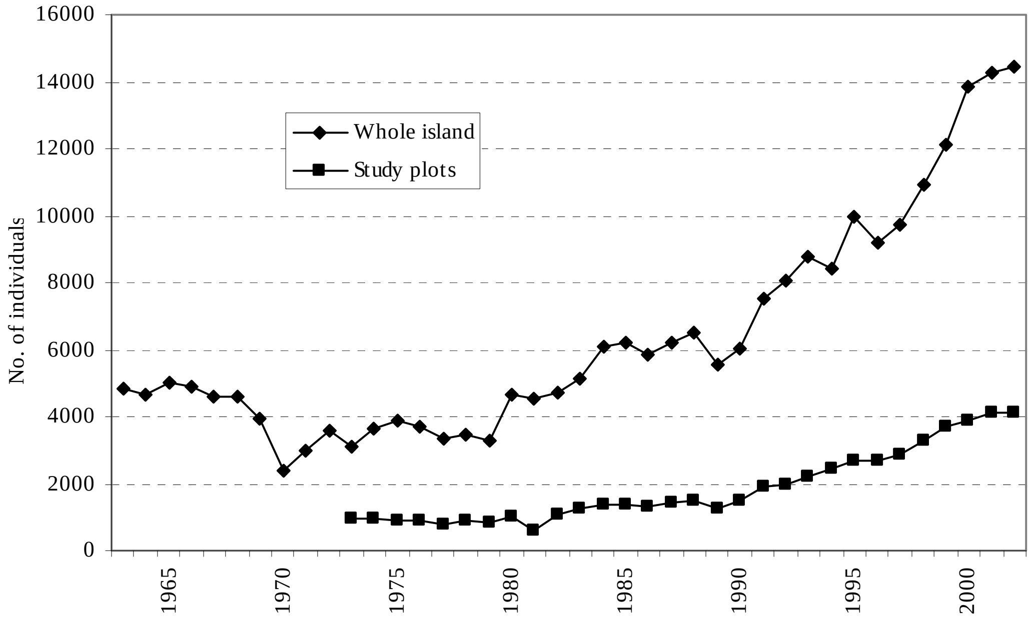
The number of common guillemots within the study plots as a whole continued to increase during 1999-2002, although, as was seen in the whole-island counts, the rate of increase has tailed off, such that only the 1998-1999 comparison showed a statistically significant increase; by 2002 the increase compared with the previous year was just 0.7% (Table 16). It therefore appears that the study plots are representative of the whole-island population of common guillemots. There was some variation between the study plots (Table 16), with the sub-colony at South Cliff seeing a moderately large and statistically significant increase between 2001 and 2002, whereas numbers at other sites showed a slowing in the rate of increase or a decrease in number.

Table 16. Common guillemot study plot totals on Skomer Island 1995-2002.

Study plot	Year	Mean	S.D.	S.E.	Significance	% change	5-year % change
Bull Hole	1995	1,565	52	17	* *	+8.0	+54.6
	1996	1,556	63	20	N S	-0.6	+46.6
	1997	1,638	69	26	*	+5.3	+30.8
	1998	1,962	68	22	* *	+19.8	+35.4
	1999	2,297	161	51	* *	+17.1	+46.7
	2000	2,308	181	68	N S	+0.5	+48.3
	2001	2,475	118	42	N S	+7.2	+51.1
	2002	2,402	126	48	N S	-2.9	+22.4
High Cliff	1995	865	25	8	* *	+12.0	+27.9
	1996	879	40	13	N S	+1.5	+21.7
	1997	934	53	20	*	+6.3	+28.
	1998	1,020	64	20	* *	+9.2	+32.1
	1999	1,051	105	33	N S	+3.0	+21.4
	2000	1,170	104	39	*	+11.4	+33.2
	2001	1,204	103	37	N S	+2.9	+29.0
	2002	1,242	95	36	N S	+3.1	+21.8
South Stream	1995	234	6.4	2.0	* *	+14.0	+5.0
	1996	229	19.7	6.2	N S	-2.0	+22.7
	1997	266	21.7	8.2	* *	+16.1	+9.7
	1998	314	32.9	10.4	* *	+9.2	+32.1
	1999	381	53	16.9	* *	+21.3	+62.8
	2000	389	25.0	10.2	N S	+2.1	+69.5
	2001	422	38.9	13.7	N S	+8.7	+58.6
	2002	484	42.7	16.2	*	+14.6	+44.8
All plots	1995	2,665	47	15	* *	+9.8	+39.4
	1996	2,664	106	33	N S	0	+14.9
	1997	2,838	129	49	* *	+6.5	+27.9
	1998	3,296	137	43	* *	+16.1	+35.9
	1999	3,728	227	72	* *	+13.1	+39.9
	2000	3,867	293	111	N S	+3.7	+45.2
	2001	4,102	140	50	N S	+6.0	+44.5
	2002	4,128	251	95	N S	+0.7	+25.3

Note: Significance between years in Table 16 established using the t-test for comparing the means of two small samples (two-tailed test, df=18). N.S. Not significant, * Statistically significant (P<0.05), **Statistically highly significant (P<0.01).

Figure 16. Common guillemot breeding numbers on Skomer Island 1963-2002.



12.3 Breeding success

12.3.1 Methods

The number of active and regularly occupied sites was established at study plots and their histories followed. Each year between 1999-2002 sites were visited on between 16 and 54 dates within a single season, from between 22 April and 25 July, when the few remaining chicks were considered large enough to fledge; this equated to an average visit frequency of once every three to four days. This frequency of visit was also used in 1998, but in previous years the frequency of visits to plots was lower, typically weekly, due to time constraints.

In 1999 sites were considered ‘regular’ if occupied by single birds on three consecutive occasions. This method is a ‘hybrid’ of that of Walsh *et al.* (1995) (who recommended that sites are defined as ‘regular’ if occupied by a pair of birds on two out of any three consecutive visits) and that previously used on Skomer (when sites qualified if only a single bird was present on two out of three consecutive visits – see Poole *et al.* 2001). The definition of ‘regular’ in 1999 was used because of the increase in visit frequency and an initial difficulty in recognising pairs in the field. In 2000-2002, the recommended method of Walsh *et al.* (1995) was adopted. Therefore, when comparing productivity over the years one should take account of the differing definitions of ‘regular’ that have been used and exercise a degree of caution.

12.3.2 Results

Mean productivity across the five study plots was consistently low during the years 1999-2002, lower than in all of the preceding years to 1989, when recording began (Table 17, Figure 17). However, a change in the definition of ‘regular site’ that was over this period (see Methods, above) makes direct comparison problematic. For example, we would expect, all things being equal, that the 1999 estimate of productivity would tend to be slightly higher than the 1998 estimate, since it would tend to include an underestimate of the number of active sites relative to 1998 (due to a more stringent definition of ‘active’). The calculated *decrease* in the estimates between these years may actually have been greater because of this potential relative over-estimation of productivity.

It is perhaps interesting to note that 1999 and 2000 were very early breeding seasons for common guillemot, with evidence of eggs being laid 30-31 April (Birkhead 1999) and 27 April, respectively.

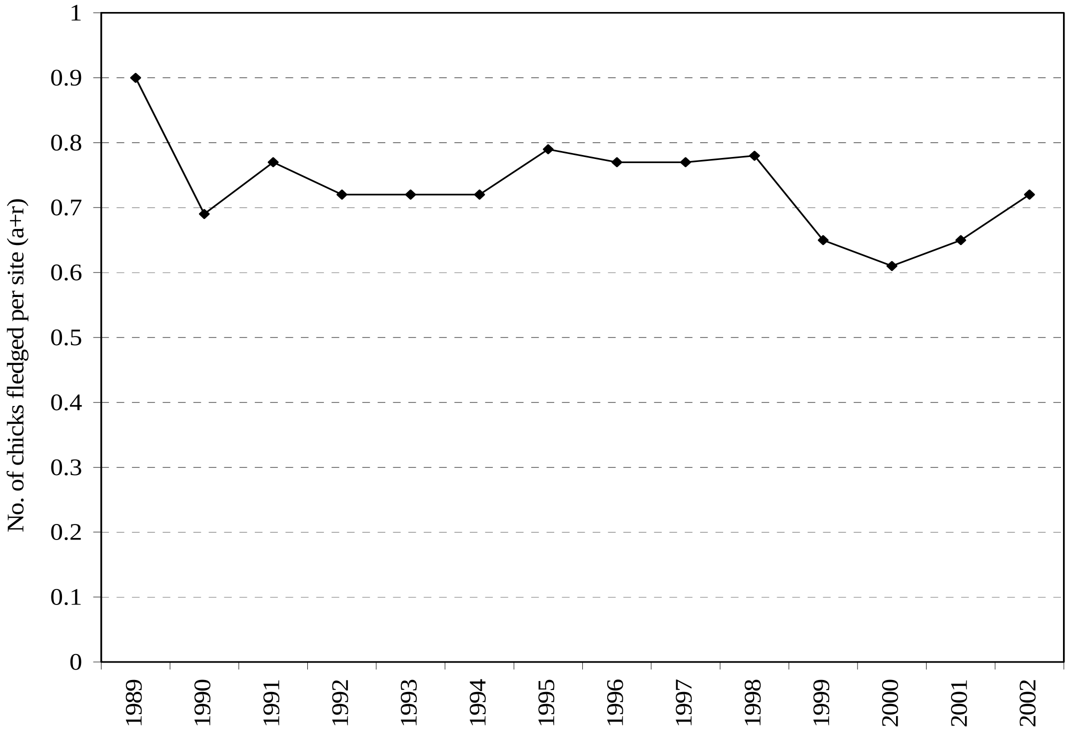
Fledging was delayed in 2001 in many cases, probably due to poor weather conditions. Because of this, actual breeding success may have been lower than the reported figures, as birds disappearing after 15 days were assumed to have fledged, but a prolonged stay on the cliff may have increased the risk of predation.

Table 17. Common guillemot breeding success (per active and regular sites) on Skomer Island 1989-2002.

Year	No. sites	Large chicks	Mean productivity across study plots	Standard Error
1989	120	96	0.90	0.05
1990	112	80	0.69	0.05
1991	117	89	0.77	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	0.79	0.04
1996	210	161	0.77	0.02
1997	226	174	0.77	0.33
1998	201	154	0.78	0.04
1999	242	147	0.65	0.05
2000	225	137	0.61	0.08
2001	259	160	0.65	0.08
2002	244	170	0.72	0.05
		Mean (1989-2002)	0.73	0.02

Notes:* Was given as range 167-171. See Appendix 8 for details of 1999-2002 productivity estimates, which also includes figures for active sites only.

Figure 17. Common guillemot breeding success on Skomer Island 1989-2002



12.4 Adult and juvenile survival

This and other common guillemot studies undertaken by University of Sheffield in 1999-2001 under contract by CCW are reported upon in Birkhead (2003).

13 Razorbill

13.1 Breeding numbers - whole island counts

Due to difficulties in censusing the 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 has at times been fairly erratic (Figure 18). In the most recent years, however, there has been a marked increase in breeding numbers, with 2000 and 2001 seeing particularly large annual increases. The increase between 2001 and 2002 was more modest, but 2002 exceeded the 5,000 individuals level, resulting in an increase of 73% in just three years (Table 18).

Table 18. Razorbill whole island count details on Skomer Island, 1995-2002

	Land count	% change	Sea count	% change	Total count	% change	5-yr % change
1995	1,513	-3.8	1,880	+24.3	3,393	+10.0	+13.5
1996	1,268	-16.2	1,666	-11.4	2,934	-13.5	-6.4
1997	1,455	+14.8	1,476	-11.4	2,931	-0.1	-20.3
1998	1,535	+5.4	1,802	+22.1	3,337	+13.9	+8.2
1999	1,282	-16.5	1,656	-8.1	2,938	-12.0	-13.4
2000	1,729	+34.9	2,169	+31.0	3,894	+32.6	+32.8
2001	2,455	+42.0	2,317	+6.8	4,772	+22.5	+62.8
2002	3,248	+32.3	1,847	-20.3	5,095	+6.8	+52.7

13.2 Breeding numbers - study plot counts

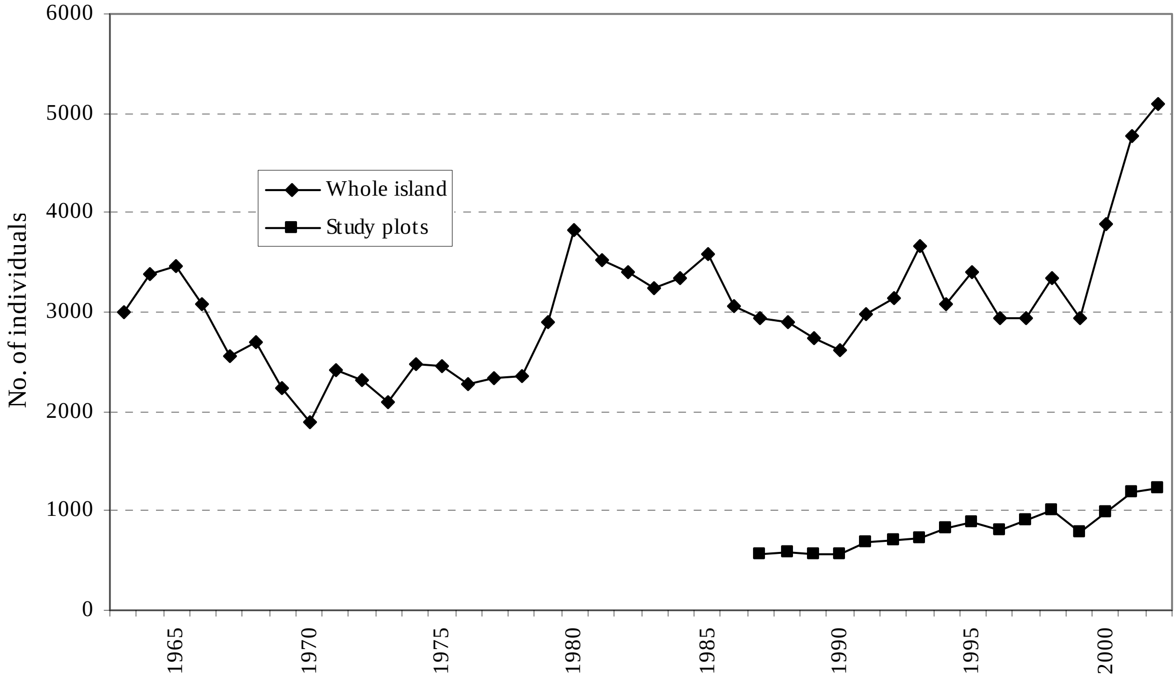
The razorbill study plot counts have been considered to be less representative of the whole island population as those of common guillemots (Wilson 1992). Figure 18 and Table 19 show that the study plot numbers have generally increased since 1990, but that there was a marked and statistically significant decrease in numbers at the plots in 1999, compared with 1998, as was seen in the whole-island count. More marked increases at the plots occurred between 1999-2000 and 2000-2001 and a smaller increase between 2001-2002, again as was seen in the whole-island counts.

Table 19. Razorbill study plot totals on Skomer Island 1995-2002.

Study plot	Year	Mean	S.D.	S.E.	Significance	% change	5-year % change
Bull Hole	1995	223.2	12.0	3.8	*	+7.8	+31.4
	1996	183.5	18.8	9.9	* *	-17.8	+11.9
	1997	208.1	17.9	6.8	* *	+13.4	+23.5
	1998	257.5	14.1	4.5	*	+23.7	+24.4
	1999	177.2	21.4	6.8	* *	-31.2	-20.6
	2000	225.4	35.6	13.4	*	+27.2	+22.8
	2001	276.1	30.3	10.7	*	+21.6	+31.7
	2002	266.6	30.0	11.3	N S	-3.6	+3.5
High Cliff	1995	248.1	10.5	3.3	* *	+20.6	+68.4
	1996	222.5	13.4	4.2	* *	-11.3	+28.3
	1997	248.7	21.3	8.1	* *	+11.8	+48.4
	1998	247.1	10.8	3.4	N S	-0.6	+20.0
	1999	180.7	41.8	13.2	* *	-26.9	-27.2
	2000	197.4	32.3	12.2	NS	+9.2	-11.3
	2001	272.0	31.7	11.2	*	+21.6	+31.7
	2002	277.3	52.3	19.8	N S	+1.9	+12.2
South Stream	1995	68.8	4.2	1.3	N S	-0.9	+57.8
	1996	70.8	6.2	1.9	N S	-2.9	+29.9
	1997	80.9	7.9	3.0	* *	+14.3	+49.8
	1998	76.0	6.5	2.0	N S	-6.1	+9.5
	1999	80.0	20.3	6.4	N S	+5.3	+16.3
	2000	100.4	18.1	6.8	*	+25.5	+41.8
	2001	100.8	31.7	11.2	N S	+0.4	+24.6
	2002	114.7	31.0	11.7	N S	+13.8	+50.9
The Wick	1995	346.0	11.6	3.7	N S	-1.4	+4.7
	1996	330.6	19.5	6.2	N S	-4.5	+5.5
	1997	368.0	11.9	4.5	* *	+11.3	+11.1
	1998	417.5	21.5	6.8	* *	+13.5	+18.9
	1999	352.2	74.3	23.5	*	-15.6	+1.8
	2000	463.3	38.2	14.5	*	+31.5	+40.1
	2001	535.5	44.7	15.8	* *	+15.6	+45.5
	2002	565.9	62.2	23.5	N S	+5.7	+35.5
All plots	1995	886.1	21.3	6.7	* *	+6.3	+28.1
	1996	807.4	36.7	11.6	*	-9.0	+14.5
	1997	905.7	44.2	16.7	* *	+12.2	+25.6
	1998	998.1	32.3	10.2	* *	+10.2	+19.8
	1999	790.1	106.5	33.7	* *	-20.8	-10.8
	2000	986.6	58.6	22.1	*	+24.9	+22.2
	2001	1184.5	58.5	20.6	* *	+20.1	+30.8
	2002	1224.5	133.3	50.4	N S	+3.4	+22.7

Note: Significance between years established using the t-test for comparing the means of two small samples (two-tailed test, df=18). N S Not significant, * Statistically significant ($P<0.05$), * * Statistically highly significant ($P<0.01$). See Appendix 9 for count details.

Figure 18. Razorbill breeding numbers on Skomer Island 1963-2002.



Note: Pre-1982 totals have been recalculated as number of individuals present as in Wilson (1992).

13.3 Breeding success

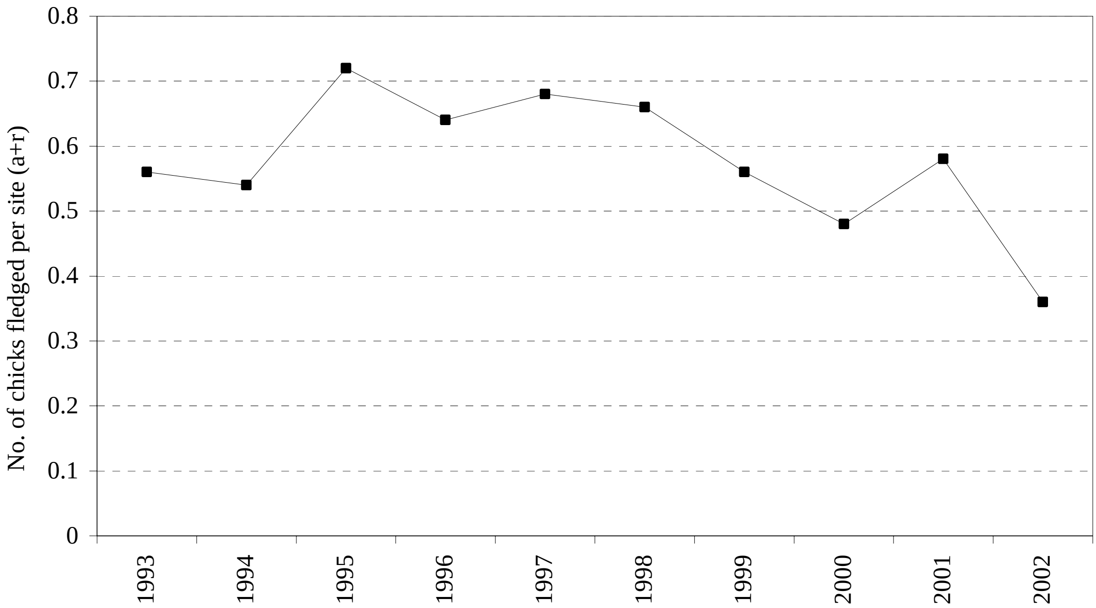
Productivity was given as the number of fledged or apparently fledged chicks per active and regularly occupied site and per active only site. Regular sites were those where birds were in attendance on three consecutive visits or two visits if recorded incubating on one. Active sites were defined by birds apparently incubating on three consecutive visits. Results are presented in Table 20 and Figure 19. As with common guillemots, there was an increase in the frequency of visits to razorbill study plots to more accurately determine early failures.

Productivity was low in each of the years 1999-2002, but particularly so in 2002, when just 0.36 chicks were fledged per active and regular site, the lowest productivity seen on Skomer since recording began in 1993 and 25% lower than the previous low in 2000. There appears to have developed an overall trend of declining productivity since 1995 (apart from a small increase between 1996 and 1997 and a larger one between 2000 and 2001) although this has not apparently affected breeding numbers (Figure 18). Researchers from Sheffield University recorded a productivity of 0.34 and 0.38 on their study site on the Neck in 2000 and 2001, respectively; the incidence of nest failure there a result of predation, predominantly by ravens *Corvus corax* and, to a lesser extent, herring gulls (Birkhead and Hatchwell 2000; Birkhead and Hatchwell 2001).

Table 20. Razorbill breeding success on Skomer Island 1993-2002

	Productivity per active site	Productivity per active + regular site
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
Mean	0.65	0.59

Figure 19. Razorbill breeding success on Skomer Island 1993-2002



13.4 Adult survival

This was assessed by the EGI, (reported here) and in additional studies by the University of Sheffield (Birkhead and Hatchwell 2000; Birkhead and Hatchwell 2001; Field *et al.* 1999). Table 21 gives the percentage survival rates for this species based on the marked colony in the Basin, and Figure 20 shows the trend since 1970.

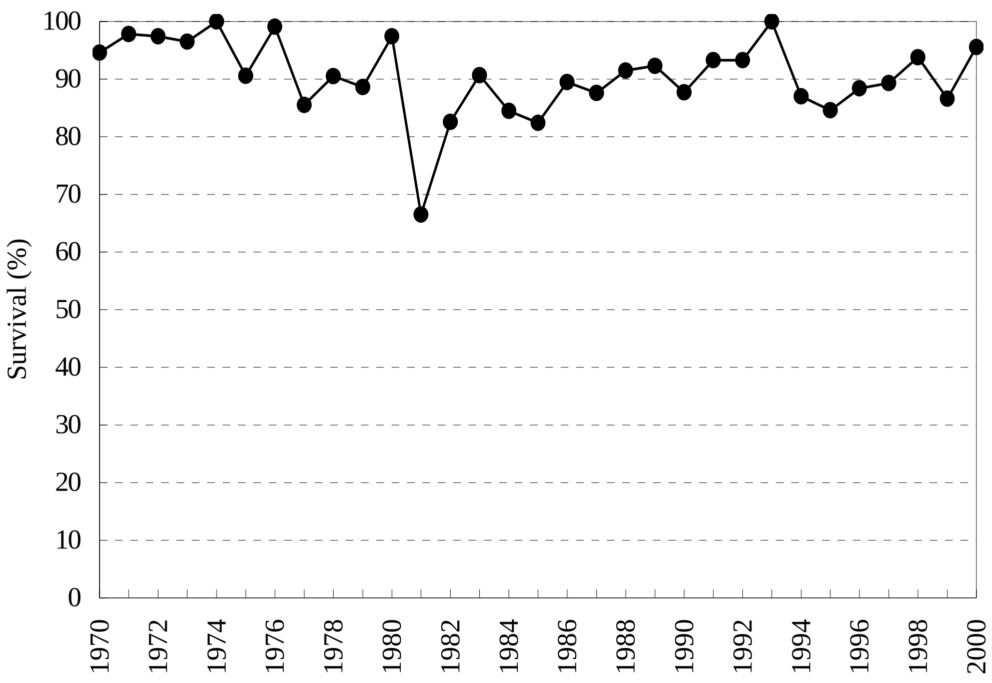
The data indicate that survival has decreased over the period since it was first measured in 1970. During the seven years 1970-1976, the survival rate only once dropped markedly below 95% and averaged 96.6%, whereas in the period 1977-2000 (excluding 1981), the survival rate was higher than 95% on only two occasions and averaged only 88.7%. The data include one year, 1981/1982 with a particularly low survival, though we know of no reason for this. In recent years, survival rate has increased somewhat (apart from in 1999, when it was again low), with 2000 recording a rate of 95.6%, the highest since 1993.

Razorbills are very difficult to census accurately and the changes in the numbers recorded (Figure 19) do not match the variations in survival rates. In particular, there is no sign in the census figures of the marked drop in numbers that might be expected to have been associated with the low survival rate of 1981.

Table 21. Estimated annual survival rates of razorbills on Skomer Island, 1970-2000

Year	**1970**	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**
Est. Survival	94.6	97.8	97.4	96.5	(100)	90.6	99.1
Year	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival	85.9	90.5	88.6	97.4	66.5	82.6	90.7
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	84.5	82.4	89.5	87.6	91.5	92.3	87.7
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	93.3	93.3	(100)	87.0	84.6	88.4	89.3
Year	**1998**	**1999**	**2000**				
Est. Survival	93.8	86.6	95.6				

Figure 20. Trend of annual survival estimates of adult razorbills on Skomer Island, 1970-2000



14. Atlantic puffin

14.1 Breeding numbers

Whole island counts of birds on land and sea were made during late April/early May on evenings when numbers in North Haven were high. Count details are shown in Appendix 10.

Numbers have remained rather similar during the entire period from 1989 to present, considering the difficulties in estimating numbers of individuals (Table 22). The 2001 count was low and this is thought to have been due at least in part to there being no large evening gatherings of puffins in that year.

Table 22. Maximum spring counts of Atlantic puffin on Skomer Island and Middleholm 1989-2002.

Year	No. individual puffins
1989	8,573
1990	8,500
1991	9,645
1992	8,000
1993	10,791
1994	10,465
1995	10,473
1996	9,141
1997	9,049
1998	9,235
1999	9,213
2000	10,614
2001	7,854
2002	10,338

14.2 Breeding success

Burrow occupancy and breeding success are shown in Table 23, which also divides the burrows into their position in relation to the cliff edge. Burrow occupancy was established during two periods comprising several evenings during early and late May. Most activity was observed between 1930hrs and dusk. During two periods in late June-early July and in mid July all-day watches were made to establish those burrows where chick feeding was taking place. The presence of a chick was confirmed when food was seen being taken into a burrow on at least two occasions over the two days.

Breeding success of Atlantic puffins was slightly below the 1986-1998 mean of 0.78 (SD 0.08) during each of the years 1999-2002. Breeding seems to have occurred very early in 1999, such that when the search for chicks was undertaken, most of the burrows were empty. In view of other observations, there seems to have been no reason to assume that it was an unproductive breeding season, just that the birds had fledged early, perhaps as much as 10 days earlier than usual. Given the early season and the possibility that some chicks might have fledged by inspection dates, the 1999 figure should be considered a minimum.

There was a consistent pattern across the years 1999-2002 of those burrows closest to the cliff edge being more productive than those farther way from it. Burrows more than 10m from the edge appeared to be markedly less productive, apart from in 2002, when those in the 5-10m range had only slightly higher productivity to those more than 10m from the edge.

Table 23. Breeding success (chicks per apparently occupied burrow) of Atlantic puffins on Skomer Island 1999-2002.

Distance from cliff edge (m)	**Year**			
	1999	2000	2001	2002
<5	0.75 (59)	0.77(48)	0.72 (43)	0.72 (53)
5-10	0.72 (18)	0.73(15)	0.73(26)	0.65 (17)
>10	0.45 (11)	0.67(6)	0.62(21)	0.63 (8)
Total	0.70 (88)	0.75(69)	0.71(90)	0.69 (78)

Note: Figures in parentheses are the number of AOB from which the breeding success estimate was made.

14.3 Feeding rates

Feeding rates varied quite considerably form year to year, during 1999-2002 but were apparently relatively high in 2001 and low in 2002, 2000 and, particularly so, in 1999, compared with recent previous years (Table 24). There appeared to be no relationship between feeding rates and breeding success during 1999-2002; in particular, the low feeding rate recorded in 1999 was not accompanied by especially low breeding success (Table 23).

The time of day at which the peak feeding rate occurred generally ranged between 05.00 and 07.00, although during the second sample in 2000 the peak rate occurred between 13.00 and 14.00.

Table 24. Feeding rates of Atlantic puffins on Skomer Island, 1999-2002

	Year			
	1999	**2000**	**2001**	**2002**
Dates of 1st sample	3-5 July	30 June-1 July	29-30 June	30 June-1 July
Dates of 2nd sample	7-9 July	7-8 July	9-10 July	8-9 July
Mean rate 1st sample[1]	1.8 (161, 88)	2.9 (179, 62)	6.4 (406, 63)	2.6 (147, 56)
Mean rate 2nd sample	2.1 (186, 88)	2.4 (99, 42)	4.8 (203, 42)	3.0 (153, 51)
Peak rate 1st sample[2]	-	27 (06.00-07.00)	68 (05.00-06.00)	27 (05.00-06.00)
Peak rate 2nd sample[2]	-	17 (13.00-14.00)	41 (06.00-07.00)	28 (06.00-07.00)

Notes.

1. Feeding rates shown are number of feeds per active burrow over the period 0500-2200. Figures in parentheses are the number of feeds recorded in the observation period and the number of active burrows under observation, respectively.
2. Peak feeding rate is given as number of feeds per hour and, in parenthesis, the hourly interval at which the peak rate occurred.
3. For comparison, feeding rates (feeds per burrow per day) for recent previous years were as follows: 1998: 4.75; 1997: 4.1; 1996: 3.9; 1995: 4.4.

14.4 Adult survival

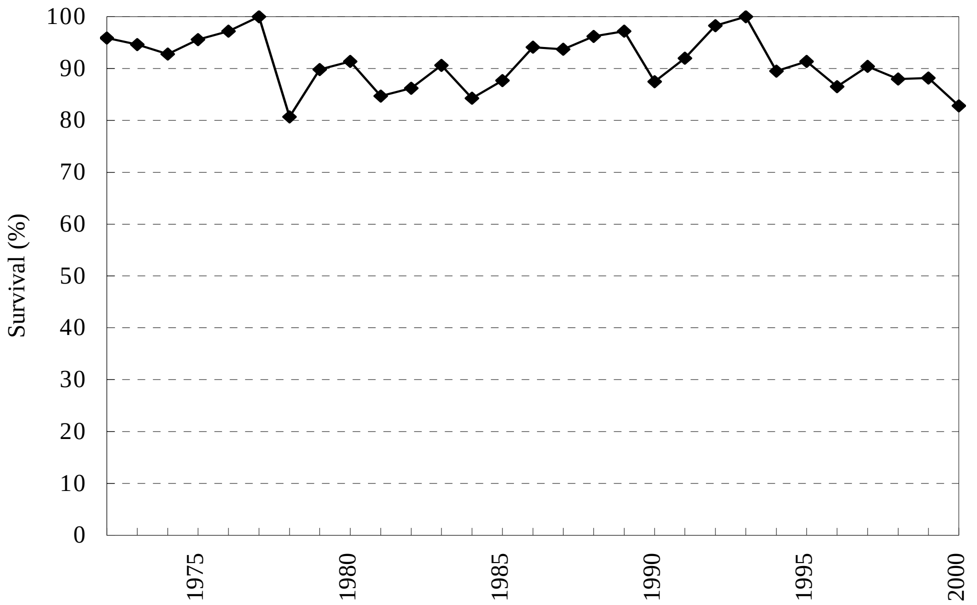
Survival rate of Atlantic puffins on the Isthmus colony appears to have declined slightly over the period 1997-2000 - the latest period for which figures are available (Table 25, Figure 22). The survival figure for 2000, at 82.8% is particularly low, although of course this is a minimum estimate and may increase slightly if further ringed birds are re-sighted in subsequent years.

One noteworthy example of longevity was in 1999, when a male, colour-ringed as a breeding adult in the study area in 1972, successfully raised a chick. Since Atlantic puffins do not normally breed until they are four or five years old, and are somewhat more likely to fail on their first attempt, the bird was likely to have been not less than 31 or 32 years old.

Table 25. Estimated annual survival rates of Atlantic puffins on Skomer, 1972-2000

Year			**1972**	**1973**	**1974**	**1975**	**1976**
Est. Survival			95.9	94.6	92.8	95.6	97.2
Year	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**
Est. Survival	100	80.7	89.8	91.4	84.7	86.2	90.6
Year	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Est. Survival	84.3	87.7	94.1	93.7	96.2	97.2	87.5
Year	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**
Est. Survival	92.0	98.3	(100)	89.5	91.4	86.5	90.4
Year	**1998**	**1999**	**2000**				
Est. Survival	88.0	88.2	82.8				

Figure 21. Trend of annual survival estimates of adult Atlantic puffins on Skomer, 1972-2000



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Appendix 2. Lesser black-backed gull nest total estimates on Skomer 1999-2002, using counts from vantage points and cane counts.

2a 1999

	Cane count (a)	Extra nests 2nd count (b)	Total (c)	Adj. Total [(b/a)b]+c	Count from vantage point	Ratio
2 Marble Rocks	342	95	437	463	277	1.67
5 Bull Hole	97	1	98	99	94	1.05
8 Sheer Face West	336	61	397	408	242	1.69
9 Sheer Face East	280	49	329	338	157	2.15
M N Wick Ridge - S	224	105	329	376	273	1.38
N N Wick Ridge - N	417	102	519	544	350	1.55
Y Field 11	418	72	490	502	250	2.01
					Mean	1.64
					SD	0.37

Note: There were no re-counts of the cane counts in 1999.

2b 2000

	Cane count (a)	Extra nests 2nd count (b)	Total (c)	Adj. Total [(b/a)b]+c	Eye count	Ratio
2 Marble Rocks	321+72	29+24	350+96	353+104= 457+180 =637	240	2.65
5 Bull Hole	106	13	119	121+44=165	93	1.77
8 Sheer Face West	127+173	9+8	136+181	137+181= 318+114= 432	186	2.32
9 Sheer Face East	175	34	209	216+59= 275	122	2.25
M N Wick Ridge - S	242+25	37+3	279+28	285+28= 313+78 =391	255	1.53
N N Wick Ridge - N	148+101	31+26	179+127	185+134= 319+86=477	277	1.72
Y Field 11	109+110	26+39	135+149	141+163= 304+92=396	146	2.71
					Mean	2.14
					SD	0.47

2c 2001

	Cane count (a)	Extra nests 2nd count (b)	Total (c)	Adj. Total [(b/a)b]+c	Eye count	Ratio
2 Marble Rocks	462	116	578	607	252	2.41
5 Bull Hole	117	23	140	145	81	1.79
8 Sheer Face West	383	56	439	447	175	2.55
9 Sheer Face East	180	22	202	205	121	1.69
M N Wick Ridge - S	395	50	445	451	322	1.40
N N Wick Ridge - N	363	44	407	412	370	1.11
Y Field 11	485	79	564	577	324	1.78
					MEAN	1.82
					SD	0.51

2d 2002

	Cane count (a)	Extra nests 2nd count (b)	Total (c)	Adj. Total [(b/a)b]+c	Eye count	Ratio
2 Marble Rocks	458	110	568	594	146	4.07
5 Bull Hole	149	16	165	167	88	1.90
8 Sheer Face West	316	77	393	412	163	2.53
9 Sheer Face East	284	56	340	351	146	2.40
M N Wick Ridge - S	430	92	522	542	301	1.80
N N Wick Ridge - N	318	59	377	388	354	1.10
Y Field 11	431	83	514	530	237	2.24
					MEAN	2.29
					SD	0.92

Appendix 3. Vantage point counts of lesser black-backed gull AOT in sub-colonies on Skomer Island in 1999-2002.

3a 1999

Sub colony	**No. count 'events' (total no. counts)**	**Min AOT**	**Max AOT**	**Mean AOT**	**S.D.**
1 South Old Wall Ridge	3 (6)	144	197	175	24.83
2 Marble Rocks	4(10)	231	313	277	28.93
3 Abyssinia	2(5)	108	127	120	5.66
4 Anvil Rock	3(7)	345	373	356	12.45
5 Bull Hole	6(15)	85	108	94	2.49
6 Pyramid Rock	4(9)	308	391	352	20.89
7 North Plain	3(6)	280	321	306	13.61
8 Sheer Face W	4(9)	212	260	242	13.52
9 Sheer Face E	4(10)	139	185	157	7.45
10 The Hill	4(10)	14	32	25	4.87
11 Double Cliff	3(7)	43	61	53	5.86
12 North slopes	1(2)	90	100	95	7.07
13 N Valley Rise	1(2)	324	376	350	36.77
14 Green Plain	2(4)	452	549	508	58.69
15 S Neck - Thorn Rock	1(2)	11	11	11	0
16 W/S Field	2(5)	43	56	48	3.89
17 Saunders Fist	1(5)	0	0	0	
18 Harold Stone	1(2)	0	0	0	
19 Wick Cliff	1(3)	2	2	2	
20 Tom's House-Sk Head	1(4)	5	6	6	0.58
21 South Park - bottom	2(5)	41	55	48	3.18
22 Garland Stone	1(3)	3	5	4	1.15
23 NW Neck	2(5)	70	80	77	2.83
24 New 96 - E of W Pond	1(3)	10	11	11	0.58
25 New colony 99 - NE of Wick	1(1)	5	5	5	0
A Lantern	1(1)	0	0	0	
B Neck E	1(4)	372	410	390	16.08
C Neck W	1(4)	159	181	171	9.2
D South Castle	1(4)	158	179	166	9.18
E Neck SW coast	2(4)	80	93	86	0.7
F South Haven	2(3)	155	161	159	1.41
G S Stream Cliff	2(4)	109	135	121	9.55
H Welsh Way	2(4)	102	117	110	0.35
I High Cliff	2(4)	193	218	200	8.84
J S Wick Ridge	1(3)	22	25	23	1.53
K Wick	1(4)	1	1	1	0
L Welsh Way Ridge	2(6)	119	148	129	5.66
M N Wick Ridge - S	4(12)	243	316	273	20.45
N N Wick Ridge - N	2(5)	324	369	350	0.71
O Moorey Meadow	3(7)	85	119	112	5.86
P South Stream	3(9)	178	222	193	14.64
Q Bramble	2(5)	70	83	77	4.24
R Lower Shearing Hays	2(6)	353	400	385	13.08
S New Park	2(6)	7	7	7	0
T Shearing Hays	3(10)	57	78	66	4.51
U Captain Kites	3(7)	219	267	240	14.02
V Wick Basin	1(3)	34	38	36	2.08
W The Basin	1(4)	1	1	1	0
X South Park - W	3(9)	119	151	135	11.68
Y Field 11	4(10)	221	267	250	7.94
Z Basin-South Pond	1(4)	235	247	242	1.41
Coastal extras		89	89	89	
	TOTAL (sum)	**6,670**	**7,946**	**7,334**	**418.42**

3b 2000

Sub colony	Number of counts	Min AOT	Max AOT	Mean AOT	S.D.
1 South Old Wall Ridge	7	160	181	167	10.69
2 Marble Rocks	6	235	244	240	4.27
3 Abyssinia	9	131	150	141	7.66
4 Anvil Rock	4	114	220	215	4.51
5 Bull Hole	5	89	99	93	4.56
6 Pyramid Rock	5	189	226	213	15.35
7 North Plain	5	253	291	277	16.07
8 Sheer Face W	6	173	193	186	7.38
9 Sheer Face E	7	118	126	122	3.20
10 The Hill	7	27	35	30	3.13
11 Double Cliff	3	30	36	33	3.06
12 North slopes	1	100	100	100	0
13 N Valley Rise	1	288	288	288	0
14 Green Plain	1	419	419	419	0
15 S Neck - Thorn Rock	1	12	12	12	0
16 W/S Field	5	55	62	58	2.88
17 Saunders Fist	3	0	0	0	0
18 Harold Stone	1	3	3	3	0
19 Wick Cliff	6	3	4	4	0.41
20 Tom's House-Sk Head	1	12	12	12	0
21 see X – colony now joined	-	-	-	-	-
22 Garland Stone	2	8	8	8	0
23 NW Neck	2	66	76	71	7.07
24 see 3 – colony now joined	-	-	-	-	-
25 New colony 99 - NE of Wick	1	7	7	7	0
A Lantern	1	7	7	7	0
B Neck E	1	286	286	286	0
C Neck W	1	191	191	191	0
D South Castle	2	43	49	46	4.24
E Neck SW coast	4	97	104	100	2.99
F South Haven	1	244	244	244	0
G S Stream Cliff	3	119	136	125	9.29
H Welsh Way	2	138	148	143	7.07
I High Cliff	6	222	253	236	10.82
J S Wick Ridge	5	44	69	50	10.57
K Wick	1	2	2	2	0
L Welsh Way Ridge	3	113	120	116	3.61
M N Wick Ridge - S	7	208	298	255	42.40
N N Wick Ridge - N	1	277	277	277	0
O Moory Meadow	1	120	120	120	0
P South Stream	1	227	227	227	0
Q Bramble	2	58	60	59	1.41
R Lower Shearing Hays	2	220	285	253	45.96
S New Park	3	14	14	14	0
T Shearing Hays	5	49	57	53	3.51
U Captain Kites	4	259	284	274	10.66
V Wick Basin	4	44	51	47	3.30
W The Basin	7	6	9	8	1.13
X / 21	1	178	178	178	0
Y Field 11	8	120	171	146	15.65
Z Basin-South Pond	6	104	151	138	17.51
	TOTAL (sum)	**5,882**	**6,583**	**6,294**	

3c 2001

Sub colony	
1 South Old Wall Ridge	178
2 Marble Rocks	252
3 Abyssinia	244
4 Anvil Rock	307
5 Bull Hole	81
6 Pyramid Rock	290
7 North Plain	364
8 Sheer Face W	175
9 Sheer Face E	121
10 The Hill	15
11 Double Cliff	44
12 North slopes	106
13 N Valley Rise	456
14 Green Plain	446
15 S Neck - Thorn Rock	23
16 W/S Field	59
17 Saunders Fist	0
18 Harold Stone	0
19 Wick Cliff	6
20 Tom's House-Sk Head	12
21 see X – colony now joined	
22 Garland Stone	22
23 NW Neck	95
24 see 3 – colony now joined	
25 New colony 99 - NE of Wick	
A Lantern	0
B Neck E	165
C Neck W	201
D South Castle	33
E Neck SW coast	73
F South Haven	128
G S Stream Cliff	73
H Welsh Way	111
I High Cliff	237
J S Wick Ridge	77
K Wick	2
L Welsh Way Ridge	144
M N Wick Ridge - S	322
N N Wick Ridge - N	370
O Moory Meadow	154
P South Stream	193
Q Bramble	95
R Lower Shearing Hays	367
S New Park	8
T Shearing Hays	71
U Captain Kites	247
V Wick Basin	68
W The Basin	22
X / 21	137
Y Field 11	324
Z Basin-South Pond	235
TOTAL	**7,153**

3d 2002

Sub colony	
1 South Old Wall Ridge	144
2 Marble Rocks	146
3 Abyssinia	172
4 Anvil Rock	247
5 Bull Hole	88
6 Pyramid Rock	248
7 North Plain	297
8 Sheer Face W	163
9 Sheer Face E	146
10 The Hill	27
11 Double Cliff	54
12 North slopes	106
13 N Valley Rise	367
14 Green Plain	320
15 S Neck - Thorn Rock	23
16 W/S Field	38
17 Saunders Fist	0
18 Harold Stone	20
19 Wick Cliff	2
20 Tom's House-Sk Head	11
21 see X – colony now joined	
22 Garland Stone	26
23 NW Neck	83
24 see 3 – colony now joined	
25 New colony 99 - NE of Wick	15
A Lantern	0
B Neck E	110
C Neck W	176
D South Castle	58
E Neck SW coast	59
F South Haven	255
G S Stream Cliff	141
H Welsh Way	139
I High Cliff	200
J S Wick Ridge	75
K Wick	3
L Welsh Way Ridge	133
M N Wick Ridge - S	301
N N Wick Ridge - N	354
O Moory Meadow	141
P South Stream	237
Q Bramble	80
R Lower Shearing Hays	393
S New Park	6
T Shearing Hays	78
U Captain Kites	245
V Wick Basin	56
W The Basin	31
X / 21	177
Y Field 11	237
Z Basin-South Pond	193
S. Neck coastal	10
TOTAL	**6,631**

Appendix 4. The ratio of lesser black-backed gull empty nests to total nests during last week of May on Skomer Island, 1999-2002.

4a 1999

Sub-colony name	Total nests	Empty nests	% Ratio
2 Marble Rocks	437	97	22.2
5 Bull Hole	98	8	8.2
8 Sheer Face W	397	100	25.3
9 Sheer Face E	329	82	24.9
M N Wick Ridge - S	329	86	26.1
N N Wick Ridge - N	519	102	19.7
Y Field 11	490	78	15.9
		Mean	20.3

4b 2000

	Total nests	Empty nests	% Ratio
2 Marble Rocks	637	180	28
5 Bull Hole	165	44	27
8 Sheer Face W	432	114	26
9 Sheer Face E	275	59	21
M N Wick Ridge – S	391	78	20
N N Wick Ridge – N	477	86	21
Y Field 11	396	92	23
		Mean	24

4c 2001

	Total nests	Empty nests	% Ratio
2 Marble Rocks	578	91	16
5 Bull Hole	140	7	5
8 Sheer Face W	439	80	18
9 Sheer Face E	202	29	14
M N Wick Ridge - S	445	84	19
N N Wick Ridge - N	407	76	19
Y Field 11	564	108	19
		Mean	16

4d 2002

	Total nests	Empty Nests	%Ratio
2 Marble Rocks	568	195	34
5 Bull Hole	165	48	29
8 Sheer Face W	393	118	30
9 Sheer Face E	340	121	36
M N Wick Ridge - S	522	192	37
N N Wick Ridge - N	377	88	23
Y Field 11	514	132	26
		Mean	31

Appendix 5. Estimated numbers of fledgling lesser black-backed gulls on Skomer, 1999-2002

5a 1999

Date	No. ringed fledglings seen	Number unringed fledglings seen	Total fledglings seen	Estimated[1] Number of fledglings
3/8/99	25	229	254	5,080
6/8/99	37	270	307	4,149
8/8/99	29	233	262	4,517
9/8/99	25	291	316	6,320

5b 2000

Date	No. ringed fledglings seen	Number unringed fledglings seen	Total fledglings seen	Estimated[1] Number of fledglings
1/8/00	26	241	267	5,135
2/8/00	36	222	258	3,583
3/8/00	40	278	318	3,975
4/8/00	20	165	185	4,625

5c 2001

Date	No. ringed fledglings seen	Number unringed fledglings seen	Total fledglings seen	Estimated[1] Number of fledglings
1/8/00	26	328	354	3,908
2/8/00	35	360	395	3,239
3/8/00	25	320	345	3,961
4/8/00	35	358	393	3,223

5d 2002

Date	No. ringed fledglings seen	Number unringed fledglings seen	Total fledglings seen	Estimated[1] Number of fledglings
5/8/02	22	97	119	1,996
7/8/02	25	125	150	2,214
11/8/02	30	136	166	2,042
12/8/02	23	113	136	2,182

Note: [1] Estimated Number = $\frac{\text{Total fledglings seen} \times \text{Number Ringed}}{\text{No. ringed fledglings seen}}$

Appendix 6. Black-legged kittiwake breeding success (chicks fledged per AON) on Skomer Island, 1999-2002.

6a 1999

	Nests started	AON	Incubating pairs	Nests w/chicks	Total chicks	Large chicks	Chicks fledged	Breeding success
South Stream	194	187	172	144	224	209	195	1.04
High Cliff	122	115	112	84	129	114	96	0.84
The Wick	537	530	519	430	663	579	520	0.98
							Mean	0.95
							SD	0.11
							SE	0.06

6b 2000

	Nests started	AON	Incubating pairs	Nests w/chicks	Total chicks	Large chicks	Chicks fledged	Breeding success
South Stream	228	220	213	161	250	213	193	0.88
High Cliff	132	128	113	66	101	84	79	0.62
The Wick	571	543	532	416	648	485	449	0.83
							Mean	0.78
							SD	0.14
							SE	0.08

6c 2001

	Nests started	AONs	Incubat. pairs	Nests w/chicks	Total chicks	Large chicks	Chicks fledged	Breeding success
South Stream	213	202	187	104	144	91	72	0.36
High Cliff	109	101	72	45	66	29	11	0.11
The Wick	538	522	481	338	421	160	87	0.17
							Mean	0.21
							SD	0.13
							SE	0.08

6d 2002

	Nests started	AONs	Incubat. pairs	Nests w/chicks	Total chicks	Large chicks	Chicks fledged	Breeding success
South Stream	215	210	202	136	198	148	138	0.66
High Cliff	110	108	99	68	98	81	75	0.69
The Wick	498	479	409	271	375	261	228	0.48
							Mean	0.61
							SD	0.11
							SE	0.07

Appendix 7. Common guillemot study plot totals by sub-colony, 1999-2002 (no. individuals)

7a 1999

Date/wind direction + speed	**South Stream**	**High Cliff**	**Bull Hole**	**All Plots**
1 June Var.2	313	816	2,201	3,330
6 June W1	357	1,049	2,384	3,790
7 June E3	398	1,006	2,225	3,629
8 June NE2-3	374	1,107	2,226	3,707
10 June NE1	425	1,136	2,547	4,108
12 June NE2	401	1,058	2,413	3,872
14 June SW2-3	408	1,014	1,997	3,419
16 June SW1-2	483	1,098	2,304	3,885
18 June E1	319	1,011	2,470	3,800
22 June NW2	329	1,212	2,199	3,740
MEAN	**380.7**	**1,050.7**	**2,296.6**	**3,728.0**
SD	53.3	104.7	160.7	226.8
SE	16.8	33.1	50.8	71.7

7b 2000

Date/wind direction + speed	**South Stream**	**High Cliff**	**Bull Hole**	**All Plots**
5 June W1	369	1,020	1,994	3,383
7 June W3	354	1,145	2,257	3,756
10 June SW2-6	423	1,267	2,537	4,227
11 June SW1	393	1,239	2,352	3,984
13 June SW1	414	1,308	2,445	4,167
16 June SE2	372	1,118	2,186	3,676
18 June SE3	395	1,094	2,388	3,877
MEAN	**388.6**	**1,170.1**	**2,308.4**	**3,867.1**
SD	53.29	104.75	160.74	226.83
SE	16.85	33.13	50.83	71.73

7c 2001

Date/wind direction + speed	**South Stream**	**High Cliff**	**Bull Hole**	**All Plots**
1 June W3-4	384	1215	2649	4248
3 June NE3-4	419	1184	2359	3962
5 June E4	456	1303	2346	4105
7 June W3	360	988	2491	3839
9 June W3	405	1137	2628	4170
11 June NW2	478	1288	2459	4225
12 June E2	447	1265	2367	4079
18 June SE2-3	430	1254	2501	4185
MEAN	**422.4**	**1204.3**	**2475.0**	**4101.6**
SD	38.9	103.3	117.5	140.0
SE	13.7	36.5	41.5	49.5

7d 2002

Date/wind direction + speed	**South Stream**	**High Cliff**	**Bull Hole**	**All Plots**
1 June ESE 3-4	438	1231	2319	3988
4 June WSW 3-4	455	1198	2391	4044
6 June N4	510	1200	2278	3988
9 June SW4	440	1126	2307	3873
12 June SW 4	531	1329	2529	4389
15 June SW 4	540	1409	2617	4566
19 June SSW 3-4	477	1201	2373	4051
MEAN	**484.4**	**1242**	**2402**	**4128.4**
SD	42.7	95.2	125.6	250.7
SE	16.2	36.0	47.5	94.8

Appendix 8. Common guillemot breeding success (per active site and per active and regular site) on Skomer Island 1999-2002.

8a 1999

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
Wick I	57	44	34	0.60	0.77
Wick II	69	47	37	0.54	0.79
Wick Corner	70	56	41	0.59	0.73
Trans. Ledge	18	16	14	0.78	0.87
Bull Hole	28	27	21	0.75	0.78
			MEAN	0.65	0.79
			SD	0.11	0.05
			SE	0.05	0.02

8b 2000

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
Wick I	47	45	18	0.38	0.42
Wick II	68	61	39	0.57	0.66
Wick Corner	63	59	43	0.68	0.78
Trans. Ledge	18	17	12	0.57	0.71
Bull Hole	29	30	25	0.86	0.87
			MEAN	0.61	0.69
			SD	0.18	0.17
			SE	0.08	0.07

8c 2001

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
Wick I	51	48	20	0.39	0.42
Wick II	73	61	41	0.56	0.67
Wick Corner	84	76	59	0.70	0.78
Trans. Ledge	19	17	16	0.84	0.94
Bull Hole	32	30	24	0.75	0.80
			MEAN	0.65	0.72
			SD	0.18	0.19
			SE	0.08	0.09

8d 2002

	No. active + regular sites	No. active sites	Large chicks	Productivity (a+r)	Productivity (a only)
Wick I	48	47	32	0.67	0.68
Wick II	67	63	42	0.63	0.68
Wick Corner	79	78	55	0.70	0.69
Trans. Ledge	20	19	14	0.70	0.74
Bull Hole	30	29	27	0.90	0.93
			MEAN	0.72	0.74
			SD	0.10	0.11
			SE	0.05	0.05

Appendix 9. Razorbill study plot totals by sub-colony, 1999-2002 (no. individuals)

9a 1999

Date/wind direction+speed	**South Stream**	**High Cliff**	**Bull Hole**	**The Wick**	**All Plots**
1 June Var2	65	142	166	213	586
6 June W1	67	223	190	428	908
7 June E3	71	179	179	376	805
8 June NE2-3	50	156	152	458	816
10 June NE1	99	149	209	282	739
12 June NE2	70	163	153	311	697
14 June SW2-3	83	231	164	404	882
16 June SW1-2	90	146	175	302	713
18 June E1	83	158	214	374	829
22 June NW2	122	260	170	374	926
MEAN	**80.0**	**180.7**	**177.2**	**352.2**	**790.1**
SD	20.3	41.8	21.4	74.3	106.5
SE	6.4	13.2	6.8	23.5	33.7

9b 2000

Date/wind direction+speed	**South Stream**	**High Cliff**	**Bull Hole**	**The Wick**	**All Plots**
5 June W1	124	231	208	448	1011
7 June W3	92	196	160	436	884
10 June SW2-6	93	231	232	408	964
11 June SW1	79	172	273	529	1053
13 June SW1	104	220	247	471	1042
16 June SE2	125	187	219	470	1001
18 June SE3	86	145	239	481	951
MEAN	**100.4**	**197.4**	**225.4**	**463.3**	**986.5**
SD	18.1	32.3	35.5	38.2	58.6
SE	6.8	12.1	13.4	14.4	22.1

9c 2001

Date/wind direction+speed	**South Stream**	**High Cliff**	**Bull Hole**	**The Wick**	**All Plots**
1 June W3-4	71	234	323	496	1124
3 June NE3-4	79	281	277	477	1114
5 June E 4	161	285	261	570	1277
7 June W3	80	226	303	524	1133
9 June W3	72	254	307	561	1194
11 June NW2	127	299	258	493	1177
12 June E2	110	312	240	559	1221
18 June SE 2-3	107	285	240	604	1236
MEAN	**100.9**	**272.0**	**274.1**	**535.5**	**1184.5**
SD	31.8	30.8	30.3	44.7	58.5
SE	11.2	10.9	10.7	15.8	20.7

9d 2002

Date/wind	**South Stream**	**High Cliff**	**Bull Hole**	**The Wick**	**All Plots**
1 June ESE 3-4	142	228	252	605	1227
4 June WSW 3-4	69	264	262	560	1155
6 June N 4	120	265	280	462	1127
9 June SW 4	79	218	221	513	1031
12 June SW 4	154	363	294	618	1429
15 June SW 4	123	330	309	564	1326
19 June SSW3-4	116	273	248	639	1276
MEAN	**114.7**	**277.0**	**266.6**	**565.9**	**1224.5**
SD	31.0	52.3	30.0	62.2	133.3
SE	11.7	19.8	11.3	23.5	50.4

Appendix 10. Spring Atlantic puffin counts on Skomer Island, 1999-2002.

	Count date	**No. individual puffins**
1999	30 April	7,578
	4 May	6,874
	12 May	9,213
	12 July	9,483
2000	22 April	7,761
	27 April	8,432
	9 May	9,278
	19 May	10,614
	26 July	14,638
2001	17 April	6,725
	2 May	6,981
	16 May	7,854
2002	23 April	10,338
	9 May	7,105
	16 May	10,154