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Isle of May seabird studies 1991

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Nominated officer: M L Tasker

ISLE OF MAY SEABIRD STUDIES IN 1991

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C O N T E N T S

SUMMARY

1. Breeding success of shag, guillemot and razorbill was high, that of fulmar, terns and puffin moderate. The kittiwake had a very poor season.

2. Several species appeared to be short of food early in the season but conditions then improved.

3. Adult survival of shag, kittiwake, guillemot and razorbill were high, that of the puffin continued to be low.

4. An investigation of the effects of timing and number of checks on the calculated value for annual survival rate of colour ringed kittiwakes indicated that intensive checks in the pre-laying period followed by less frequent checks during the rest of the season gave the best estimate of survival rate. Restricting checks to the incubation period markedly underestimated survival rate.

5. Sandeels predominated by number in the diet of all species, but half (by weight) of the regurgitations collected from kittiwake were Gadidae.

1 BACKGROUND

The Nature Conservancy Council (now JNCC) has a responsibility to advise on the condition of the natural marine environment. Seabirds are one of the more important components of this environment, and Britain has internationally important populations of several species. NCC has designed a programme that will allow the numbers of selected species of seabirds to be monitored at several colonies. In addition, selected colonies have been targetted for more detailed monitoring of reproductive performance and annual survival rates. These selected colonies are geographically spread in order to give as full a coverage as possible of British waters. The Isle of May NNR is a very suitable site in East Britain.

The Institute of Terrestrial Ecology (ITE) has had a long term interest in seabirds on the Isle of May. Since 1986, ITE has received NCC/JNCC support for a more formalised seabird monitoring programme. Long-term studies on numbers, breeding success, adult survival, chick growth and chick food are underway on up to 8 species. Due to the long period of immaturity and high annual survival rates of seabirds, it is essential that continuity of these long-term studies is maintained. As part of its Seabird Monitoring Programme, NCC/JNCC placed a contract with ITE to supply information annually on the following topics:

(a) the breeding success of fulmar Fulmarus glacialis, shag Phalacrocorax aristotelis, kittiwake Rissa tridactyla, common tern Sterna hirundo, arctic tern, S. paradisaea, guillemot Uria aalge, razorbill Alca torda and puffin Fratercula arctica.

(b) adult survival of shag, kittiwake, guillemot, razorbill and puffin.

(c) food of young shag, kittiwake, guillemot, razorbill and puffin.

(d) feeding frequencies of guillemot and puffin chicks.

The present report summarizes the results obtained in 1991. It does not attempt any detailed synthesis, although the results from previous years are presented for comparison.

For ease of comparison, the format of this report is exactly the same as these for 1989 and 1990. Additional tables are inserted after those presented in 1990.

2 METHODS

2.1 Breeding success

The methods used involved minimal disturbance of birds and are desecribed in detail in 'Development of monitoring of seabird populations and performance' - Final Report to NCC for contract HF3-08-15.

Fulmar: The positions of apparently incubating birds were marked on photographs on 23 and 27 May and 1 June; sites where birds appeared to be incubating on all three visits, or where an egg was seen, were assumed to have been bred at. These sites were checked again on 14 July, and on 12 August when those with a large chick were assumed to have been successful.

Shag: The positions of nests in 14 areas were marked on photographs and the state and contents of these nests were checked weekly from early April until the end of August. Two nests still contained eggs when checks ended in late August. I assumed that all these nests failed and that all the few remaining young survived.

Kittiwake: The position of nests in 15 areas were marked on photographs and the presence or absence of an incubating bird, or the number of young present at each was checked on 22 May, 9 June and just after the first young had fledged on 17 July. The few late nests were checked every 5-7 days to determine their success.

Guillemot, razorbill: Daily checks of the state of breeding of numbered nest-sites in five study plots were made from permanent hides.

Puffin: In each of four areas, samples of 50 burrows where an egg could be felt on 29-30 April (when most pairs had laid) were staked and rechecked on 29-30 June (when chicks were near fledging). All large young were assumed to have fledged as were young from empty burrows where there were many droppings, moulted down and feather sheaths.

Common and arctic terns: Nests with eggs were staked and counted on several dates in May and the cumulative total was taken as an estimate of the population. Regular checks were made of the number of fledged young at the fringe of the colony.

2.2 Adult survival rates

For all species these were based on sightings of individually colour-ringed birds. The areas in which birds were originally marked were checked regularly throughout the season and adjacent

areas where also searched from time to time in an attempt to pick up birds which had moved. Searches were made for birds which had moved out of the study areas. These later searches are extremely time consuming, and superficially unrewarding, but they are essential if accurate estimates of survival are to be obtained.

To investigate how the number and timing of checks influenced the total number of colour-ringed kittiwakes seen during the season, the two study plots were visited 5 and 9 times during incubation and chick rearing respectively. During each check the observer remained until all the birds present had been checked or had refused to stand up. The actual number of birds alive was taken as all those ever seen during the breeding season, that is during these 14 checks, almost daily checks during the pre-incubation stages and opportunistic observations at other times.

2.3 Food of chicks

Food regurgitated by young shags and kittiwakes and loads of fish dropped by adult puffins caught in mist-nest were collected, weighed and the fish identified and, where possible measured (total length to tip of tail). Where necessary, fish otoliths were extracted and examined. Records were kept of fish brought to young guillemots and razorbills and uneaten fish were collected from breeding ledges.

2.4 Feeding frequency

All-day watches were made of marked sites/burrows of guillemot, razorbill and puffin from permanent hides. Observers took 2 hr shifts, recorded the number of feeds brought to each chick and where possible noted the species and size of the fish.

3 RESULTS

3.1 Breeding success

Species accounts are given in Tables 1-4 and a comparison with recent year's results is shown in Table 5.

Fulmar: Breeding success was 0.42 young per incubating pair. Most pairs failed during incubation or when brooding small young.

Shag: Mean breeding success was 1.06 young fledged per incubated nest (Table 2). This high success was unexpected as breeding was late (median laying date c. 1 June) and late breeding is usually associated with low breeding success.

Kittiwake: Breeding success varied greatly from plot to plot (0-0.7 young fledged per completed nest; Table 3). The overall mean success, 0.27, was 50% up on that in 1990 but was still the second lowest since monitoring commenced (Table 5).

The whole island nest count was c.20% lower than that in 1990 (see report to NCCS). This appeared to be due to many pairs not breeding. The clutch-size (mean = 1.86, n = 125) was similar to that in 1989 (2.04, n = 130) and 1990 (1.82, n = 98). 17% of 49 completed and lined nests (which would have been included in the nest-count) had no eggs which contrasts with the situation in previous years when virtually all completed nests held clutches. The first egg was seen on 6 May, which compares with 2 May 1990 and 27 April 1989. Breeding was very synchronized due to few late pairs laying. Many eggs failed to hatch when birds ceased incubation and some small young died.

Relatively few broods were left unattended (2% of single chicks, 13% of two chicks) compared with recent years (e.g. 31% and 66% in 1988; Table 12).

It appeared therefore, that kittiwakes were short of food early in the season but conditions seemed to improve from early June onwards. During July flocks of feeding kittiwakes, were often visible from the island suggesting that birds were able to feed close to the colony.

Guillemot: Laying commenced early (first egg 19 April) but was more prolonged than usual. Success was high (0.81 young leaving per pair laying).

Razorbill: Breeding appeared normal and success was good (0.75 young leaving per pair laying).

Puffin: Breeding occurred at the normal time. As far as could be judged hatching success was quite good but puffins appeared

to suffer a fairly severe food shortage in early July when some young died (C. Wernham, see Table 11). The success rate of 0.78 chicks per egg laid although higher than that in 1990 (0.66) was still much lower than usual.

Terns: A total of 628 nests were counted. Observations of incubating birds indicated a ratio of Arctic:Common terns of 2.2:1. At least 100-200 young fledged. For more details see Wardens' Report.

3.2 Adult survival

Not every adult alive is seen each year and thus the survival rates between 1990 and 1991 of 82.8% for shag, 84.2% for kittiwakes, 91% for guillemot, 79.6% for razorbill and 71.4% for puffin are likely to be minimum estimates.

The figure for puffins was very low despite considerable effort being put into looking for colour-rings and Chris Wernham attempting to catch all the puffins nesting in the main study colony in front of Little Hide. Time will tell whether these missing birds had indeed died or missed a year's breeding. The fact that in 1991 we recorded 34 (52% of those missing) puffins not seen in 1990 suggests that some established breeders may not breed annually.

In 1991 9 (out of 38) kittiwakes seen in 1989 but not seen in 1990 were recorded, as were 16 (of 44) missing shags and 34 (of 65) missing puffins. Incorporating these records increases the 1989-90 survival figures for these three species to 83.7% (from 79%) 83.4% (from 74%) and 82.5% (from 63.3%), respectively.

During 1991 a further 12 kittiwakes, 32 shags, 79 puffins 18 razorbills and 62 guillemots were colour-ringed.

3.2.1 A check on the efficiency of finding colour-rings

A total of 147 colour-ringed kittiwakes were seen at the two study colonies in 1991. With 5 checks during incubation only 57 (39%) of individuals were seen, 9 checks during chick rearing yielded 118 (80%) of the maximum. These results indicate that without a considerable committment of time throughout the season, it is impossible to obtain a reliable estimate of survival from the previous year. Taken at face value, the figures imply survival rates of 78%, 33% and 67% using checks prior to laying, during incubation and during chick rearing respectively. These compare with a figure of 84% for the combined checks.

1991 was rather an unusual breeding season for kittiwakes which makes it difficult to draw general conclusions from results obtained in this year. However, our experience in

previous seasons also indicated that the pre-incubation stage does seem to be the most efficient time to make checks. Some additional later checks are, however, needed to record adults which return late but these late-returners are often easy to see as many do not breed but stand on rocks above and near the colony.

3.3 Food of young

Sandeels were the only prey recorded from young shags and were the the commonest food of young kittiwakes (71% by weight) (Table 7). Most sandeels in kittiwake regurgitates were 4-6 cm long (i.e. 0-group or young of the year) while 30% of those from shags were longer than 10 cm (calculated from 100 otoliths). Sandeels contributed c. 50%by weight of the kittiwake regurgitations, the other 50% coming from whiting (16, 17 cm long), herring (6 cm) and unidentified gadoids of a similar size to the whiting. As kittiwakes appeared to be short of food I limited disturbance to the colonies, hence the small sample size.

Of 577 fish delivered to young Guillemots, 443 (77%) were sandeels (Table 8); most of these were 9-12 cm long and it was calculated that sandeels made up 74% of the diet by weight. The remaining 26% was small to medium sized clupeids.

Razorbills brought mainly large loads of sandeels 5-6 cm long with a few very small Clupeidae and Gadidae (?saithe) (Table 9).

Puffins fed their young on small sandeels and 87% of the fish were less than 10 cm long (Table 10). No sprats and few herring (all small) were recorded. The mean weight of a load of fish was 8.3 g, which is the lowest annual mean recorded since 1976.

3.4 Feeding frequency

Two all-day watches on different groups of guillemot chicks, one watch on razorbill chicks and seven watches of puffin burrows indicated that the feeding frequencies was about four feeds per chick per day for all three species (Table 11). However, the total of only 17 feeds brought to 25 young puffins on 7 July was extremely low.

4 CONCLUSIONS

4.1 When compared with recent years and studies elsewhere, the 1991 breeding season was very good for shag, guillemot and razorbill, moderate for terns, fulmar and puffin and very poor for kittiwake (although still better than 1990).

Conditions were poor in the early part of the season (shags delaying breeding, guillemots having a prolonged laying period after an early start, many kittiwakes not breeding and many of those which did failing during incubation or the early chick stage) but much better later on (high breeding success of shags despite the late laying, few kittiwake broods were left unattended, many more kittiwakes and gannets Sula bassana feeding around the island than in recent years). The abrupt severe food shortage apparently suffered by puffins in early July was not noted in other species.

The general impression is that whereas conditions in the 1980s appeared uniformly good for breeding, they are now more variable or unpredictable.

4.2 Assuming that the normal proportion of 1991 missing birds of all species are found in future years, the adult survival rates of guillemot, razorbill, kittiwake and shag from 1990 to 1991 were normal.

Updated estimates of survival rates for these few species in recent years are given in Table 15. Those for shag range 82.8-92.5, close to the average of 85.4% calculated for 1965-82 (Aebischer 1986; J. Anim. Ecol. 55, 613-629). The figures for kittiwake 84.2-98.7 are markedly higher than the 30 year mean of 78% for males and 82% for females and a combined-sex annual mean of 65% for 1982-85, at North Shields (Aebischer & Coulson 1990; J. Anim. Ecol, 59, 1063-1071). The few comparable data for guillemot and razorbill suggest that the Isle of May survival rates are also high.

4.3 The current estimates of annual survival rates of breeding puffins are 80-90%. These compare with an average figure of 96% in the 1970s which was obtained by the same methods in the same study areas. Simple modelling indicates that the species is unlikely to be able to maintain its numbers on the Isle of May unless (a) immature survival has increased substantially, (b) the age of first breeding has declined or (c) there is substantial immigration. The available data suggest that none of these has occurred. A separate project is addressing this problem.

4.4 It is easy to colour-mark large numbers of adult seabirds but much sustained effort is needed to find them again. In birds with

high survival rates even a few missed individuals can result in great proportional error in the estimated survival. My approach is to make a major effort (by daily searches) to find colour-rings early in the season when birds are easily seen and to carry out searches for specific missing birds later in the season. As many of these birds nest in front of permanent hides and/or are used for other studies many areas are under daily surveillence. There is a growing amount of evidence which suggests it is impossible to be sure that a bird is not present but that a small (and annually variable) proportion of adults which have bred at least once do not breed each year, although some may visit the colonies later in the season or, in the case of the shag, return to roost during the subsequent autumn.

It is difficult to assess objectively the effort put into searching for colour-rings but our check on kittiwakes suggests that at least 10 thorough checks must be made to obtain a reasonable survival estimate.

4.5 Sandeels accounted for 70% or more (by weight) of the food fed to young of shag, guillemot, razorbill and puffin and about half of that to young kittiwakes. There is a suggestion that sandeels are becoming less dominant in the diet of young kittiwakes (Table 13) which might conceivably be linked with lower nesting success. The rest of the diet of young kittiwakes and puffins consisted of Gadidae (whiting and saithe, respectively) which are relatively low energy value prey. The alternative prey of guillemots (and razorbills) was Clupeidae.

Although the feeding frequency of auks has been fairly high in 1986-91, there has been a marked reduction in the food intake of young guillemots, and perhaps also of young puffins (Table 14). As yet this has not been mirrored in a reduction in breeding success but there is little scope for any further reduction before breeding must be adversely effected.

5 THE FUTURE

5.1 During the 1970s and for most of the 1980s conditions were very favourable for seabirds in the North Sea. in the North Sea. Conditions started to change in the north in the early 1980s with reductions in numbers and/or breeding success of a range of species. There is good evidence that, at least for guillemots (Harris (1991): Population changes in Common Murres), that change started in the north and gradually moved south. Population declines started significantly earlier and were fastest in nothern colonies.

5.2 Conditions appear to be changing in the Firth of Forth as shown by low survival of young puffins, low recruitment of young guillemots, poor breeding of kittiwakes, delayed (and ?irregular) breeding of shags, reduction in the intake of young guillemots and sporadic food shortage in several species.

5.3 The seabird studies on the Isle of May have been criticized in the past as being 'too academic' as they were concerned with populations which were expanding. However, we do have a solid base against which to assess changes in biology and survival which are now occurring in a range of species. Only by detailed studies in such circumstances can we hope to understand the processes, and hence the likely causes, involved in population declines and breeding failure.

5.4 BP and NERC are supporting research into the puffin, and a major part of this is a new initiative into the recruitment of the puffin.

5.5 A separate study on guillemot recruitment has shown that this is the critical link in the population dynamics of the species on the Isle of May. This work has been carried out by Duncan Halley in 1990 and 1991 but he is now writing up his PhD. Additional funding must be found to continue this work.

5.6 In 1991 several Danish fishing vessels were trawling for sandeels at the Marrs and Cockenzie Banks to the northeast of the Isle of May. There is no evidence that such fishing has an adverse effect on the availability of food for seabirds. However, if such a fishery develops it will be important to continue the monitoring of seabird breeding and food of seabirds on the Isle of May.

5.7 NCCS are now financing the monitoring of the breeding populations of all seabird species on the Isle of May. The Isle of May is one of JNCCs main seabird biological monitoring sites. Hopefully they will continue to give adequate financial support for it to continue.

6 ACKNOWLEDGEMENTS

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7 PUBLICATIONS ON ISLE OF MAY SEABIRDS

The following have either been published since the last report or are in press.

Harris, M.P. & Wanless, S. 1991. Population studies and conservation of Puffins Fratercula arctica. In 'Bird Population Studies' (eds. Perrins, Lebreton & Hirons). Oxford Univ. Press. pp. 230-248.

Harris, M.P. 1991. Population changes in British Common Murres and Common Puffins 1969-1988 in "Studies of higher latitude seabirds", eds. Gaston & Elliot Occ. paper Wildl. Serv. Ottawa, pp. 52-61.

Wanless, S., Burger, A.E. & Harris, M.P. 1991. Diving depths of Shags Phalacrocorax aristotelis breeding on the Isle of May. Ibis 133: 37-42.

Wanless, S. Harris, M.P. & Morris, J.A. 1991. Foraging range and feeding locations used by Shags Phalacrocorax aristotelis during chick-rearing. Ibis 133: 30-36.

Harris, M.P., Towll, H., Russell, A.F. & Wanless, S. 1990. Maximum dive depths attained by auks feeding young on the Isle of May, Scotland. Scottish Birds 16: 25-28.

Wanless, S. & Harris, M.P. in press. Activity budgets, diet and breeding success of Kittwiakes Risssa tridactyla on the Isle of May. Bird Study.

Harris, M.P. & Wanless, S. in press. The importance of the lesser sandeel Ammodytes marinus in the diet of the Shag Phalacrocorax aristotelis. Ornis Scandinavica.

Harris, M.P. & Bailey, R.S. in press. Mortality rates of puffin and guillemot and fish numbers in the North Sea. Biological Conservation.

Hislop, J.R.G., Harris, M.P. & Smith, J.G.M. 1991. Variation in the calorific value and total energy content of the lesser sandeel (Ammodytes marinus) and other fish preyed on by seabirds. J. Zool., Lond. 224: 501-517.

Harris, M.P. & Wanless, S. 1990. Breeding status and sex of Common Murres (Uria aalge) at a colony in autumn. Auk 107: 603-605.

Harris, M.P., Webb, A. & Tasker, M.L. 1991. Growth of young Guillemots Uria aalge after leaving the colony. Seabird 13.

Table 1. Fledging success of fulmars on the Isle of May in 1991.

	Area	Incubating birds	No. probably hatched	Young fledged
1	Cleaver	9	9	7
2	Pilgrim's Haven	2	2	1
3	Cornerstone	8	7	2
4	Loch (S)	42	28	16
5	Greengates	24	16	9
6	Horse Hole	8	7	6
7	Rona	2	0	0
8	Tarbet	11	8	4
9	Low Light	3	2	1
10	Colm's Hole	1	0	0
	TOTAL	110	79	46

0.42 fledged/pai

Notes: Incubating birds were those sitting tight on three checks or where an egg was seen. Chicks present on 12 August were assumed to have fledged.

Checks were made by J. Calladine.

Table 2. Fledging success of shags on the Isle of May in 1991. The last check was made on 31 August.

	Area	Total incubated	Young fledged 1	2	3	Other nests	Total young fledged	Mean young fledged per incubated nest
1	Lady's Bed (South)	7	0	1	1	1	5	0.71
2	Lady's Bed (Mid)	8	0	3	0	1	6	0.75[1])
3	Maidens	16	1	6	2	1	19	1.19
4	South Horn	4	0	4	0	0	8	2.00
5	Chatterstanes	5	1	1	0	1	3	0.60
7	South Face	5	2	1	1	0	7	1.40
8	Mill Door (N)	12	4	4	1	6	15	1.25
9	Mill Door (S)	20	4	8	1	5	23	1.15
10	Bishops Cove	3	2	1	0	0	4	1.33
11	Rona	10	0	4	0	2	8	0.80[2])
12	Tarbet	41	7	15	4	3	49	1.20
13	Colm's Hole (S)	16	0	5	0	1	10	0.63
14	Colm's Hole (N)	40	6	5	5	7	31	0.78

Mean ± SE = 1.06+0.11

Notes: [1]) One incubating (c/2) on 31 August

[2]) One incubating (c/2) on 31 August

Table 3. Fledging success of kittiwakes on the Isle of May in 1991.

	Area	Completed nests	Trace nests	fledged/young nest 0	1	2	Total young produced	Fledging success per completed nest	All pairs (incl. trace nests)
1	Cleaver	40	0	27	13	0	13	0.32	0.32
2	Pilgrim's Haven	28	0	10	16	2	20	0.71	0.71
3	South Face	32	2	24	4	2	8	0.25	0.24
4	Colony 4	120	2	92	26	2	30	0.25	0.25
5	Cornerstone	123	8	95	23	5	33	0.27	0.25
6	Loch (S)	126	25	105	19	2	23	0.18	0.15
7	Loch (N)	78	11	55	22	1	24	0.31	0.27
8	Greengates*	132	5	76	54	2	58	0.44	0.42
9	Bishops Cove	74	3	45	28	1	30	0.40	0.39
10	Horse Hole	11	0	11	1	0	1	0.09	0.09
11	Iron Bridge*	58	2	42	16	0	16	0.28	0.27
12	Rona	60	1	44	16	0	16	0.27	0.26
13	Tarbet	183	16	176	6	1	8	0.04	0.04
14	Low Light	80	6	80	0	0	0	0	0
15	Colm's Hole	27	5	22	5	0	5	0.19	0.15
							Mean	0.27	0.25
							SE	0.05	0.05

Notes: No broods of three were fledged anywhere on the island.
*slightly different photographs from 1989

Table 4. Breeding success of auks on the Isle of May in 1991.

Species	Area	Pairs laying	Young hatched	Young 'fledged'		Young leaving/ pair
Guillemot	Dense	268	238	227		0.85
	Hide/White	82	67	65		0.79
	Colony 4	217	192	183		0.85
	South	45	36	32		0.71
	Cornerstone	142	123	121		0.85
					Mean	0.81
Razorbill	Hide/White	18	15	14		0.78
	Colony 4	33	28	28		0.85
	South	14	9	8		0.57
	Cornerstone	39	29	25		0.64
	Total	104	81	75		0.72
Puffin	Lady's Bed	41	?	35		0.86*
	Kirkhaven	39	?	28		0.72
	Burrian	32	?	23		0.72
	Rona	41	?	33		0.80
	Total	153	?	119		0.78

*Could be a slight overestimate as many chicks were rather small when the burrows were checked.

Table 5. Breeding success (young reared per pair breeding) of some seabirds on the Isle of May 1986-91.

Species	1986	1987	1988	1989	1990	1991
Fulmar	0.53(79)	0.47(69)	0.31(64)	0.54(93)	0.24 (66)	0.42 (100)
Shag	0.75(223)	1.09(288)	0.61(221)	1.09(234)	0.30 (154)	1.06 (187)
Kittiwake	1.33(1133)	1.09(1291)	0.82 (1278)	1.11(1327)	0.17(1095)	0.27 (1172)
Guillemot	0.82(785)	0.76(800)	0.85(732)	0.85(757)	0.78(748)	0.81 (754)
Razorbill	0.72 (84)	0.71(64)	0.70(98)	0.74(97)	0.76(100)	0.72 (104)
Puffin	0.80(136)	0.93(62)	0.89(157)	0.88(164)	0.66(176)	0.78 (153)

Notes: The number of pairs followed is given in brackets. Details of methods, etc. can be found in this and previous reports to NCC.

Table 6. Annual survival of adult seabirds on the Isle of May 1986-91.

Species	No. alive in 1990	No. seen in 1990	% Survival 1990/91	1989/90	1988/9	1987/8	1986/7
Shag	157	130	82.8	74.0	78.1	77.3	91.4
Kittiwake	165	139	84.2	78.7	90.9	86.0	96.1
Guillemot	381	347	91.0	94.9	92.4	91.5	97.3
Razorbill	49	39	79.6	75.0	90.5	88.1	92.1
Puffin	227	162	71.4	63.3	85.2	76.1	81.2

Notes 1. Only birds which had definitely bred in 1990 or earlier are included.
2. Directly comparable figures for adult survival in earlier seasons are given. These have not been corrected for missing birds seen in later years, and so are serious underestimates of survival.
These figures should not be used for population dynamic calculations without consultation with M P Harris
3. Details of earlier estimates are given in previous reports to NCC.

Table 7. Food fed to young kittiwakes and shags on the Isle of May in 1991.

	Kittiwake	Shag
No. of regurgitations	9	20
Range of dates	19 June–11 July	4–18 July
Total weight (g)	91	697
% regurgitations with sandeels	67	100
% (by weight) of sandeels in sample	c.50	100
% (by numbers) of sandeels in sample	71	100
Lengths (cm) of majority of sandeels	4–6	7–14
Other prey remains	2 whiting 1 herring 4 Gadidae	None

Note: 1) Samples collected from chicks or adults brooding chicks
2) Counts and lengths of fish were based on otoliths in the regurgitations

Table 8. Food of young guillemots on the Isle of May in 1991.

	minute/ larval	Number of sandeels			Number of Clupeidae		
		small	medium	large	small	medium	large
Length (cm)	6	9	12	16	8	10	12
8 June	6	88	101	12	24	42	3
22 June	1	39	49	4	7	11	0
Other days							
22 May–1 July	6	93	37	7	23	18	16
TOTAL	13	220	187	23	54	71	19

Note: Lengths were based on visual estimates against the bird's bill checked by samples of dropped fish collected from the breeding ledges.

Table 9. Food of young razorbills on the Isle of May in 1992.

	Number of loads of				
	single sandeel		several sandeels		Other small fish
	large	smaller	medium	small	
8 June	5	2	5	10	1[2])
22 June	4	4	3	8	1[3])
Other dates					
19 June-1 July	0	2	0	3	
TOTAL	9	8	8	21	2

Notes 1) Results from 8 and 22 June came from all-day watches of chicks
2) Larval fish
3) Possibly saithe

Table 10. Food of young puffins on the Isle of May 1991.

		Sample size	Mean	S.E.
a)	Load weight (g)	127	8.3	0.34
b)	Fish/load	127	7.6	0.43
c)	Numbers and lengths of fish (mm)			
	Sandeels Ammodytes sp.	826	70.3	0.65
	Herring Clupea harengus*	52	56.2	1.32
	Rockling probably Gaidropsarus ciliata	6	36.3	1.2
	Saithe Pollarchius virens	38	58.0	1.4
	Cod Gadus morhua	4	59	7.0
	Unidentified Gadidae	2	62,72	
	Squid	1	57	

*includes some unidentifiable small Clupediae

Table 11. Feeding frequencies of young auks on the Isle of May in 1991

Species	Date	No. of young	Mean (±S.D.) feeds/chick/day
Guillemot	8 June	73	4.1±1.4
	22 June	15	4.1±1.3
Razorbill	8 June	6	4.0±1.1
Puffin	3 June	33	5.5±2.7
	9 June	38	4.6±2.5
	16 June	39	5.4±2.4
	23 June	41	2.2±1.8
	29 June	33	4.5±2.7
	7 July	25	0.7±1.2
	15 July	16	3.2±2.2
	Mean		3.7

Notes 1) Based on all-day watches by observers taking 2 hr shifts

2) Puffin feeding frequencies were from watches organised by C. Wernham as part of her own research and the study funded by BP and NERC

Table 12. Proportions of kittiwake broods of one and two chicks which had no adults present during daily checks in the middle of the day.

Year	% unattended Broods of one young	% unattended Broods of two young
1986	1	7
1988	31	66
1989	13	32
1990	21	45
1991	2	13

Note: Figures are based on 50-100 broods in the same areas each year. These are means of daily checks made between the dates the first neglected chick was noted and the start of fledging. (Details in Wanless & Harris, Scott. Birds 15 (1989): 156-161).

Table 13. Percentage of sandeels (by weight) in the diet of young seabirds on the Isle of May, 1986-91.

	1986	1987	1988	1989	1990	1991
Shag	97	100	98	100	95	100
Kittiwake	98	95	94	95	86	50
Guillemot	90	81	41	74	24	74
Puffin	83	77	85	89	96	87

Notes: 1) Dates and sample sizes can be found in the contract report for respective years.
2) Sandeels also made up the bulk of the food of young razorbills in all years but it is extremely difficult to assess the proportions in terms of biomass.

Table 14. Annual measures of daily feeding frequency and food intake (g) of seabirds on the Isle of May 1986-91.

		1986	1987	1988	1989	1990	1991
Guillemot	Feeds/day	3.9	3.7	3.5	6.2	6.1	4.1
	Intake/day	33	37	39	25	20	17
Razorbill	Feeds/day	2.0	2.8	-	5.1	6.9	4.0
Puffin	Feeds/day	4.0	3.9	5.1	5.7	4.9	3.7
	Intake/day	36	43	47	53	42	31

Table 15. Updated estimates of survival of breeding seabirds on the Isle of May 1986-91.

	1986-87	1987-88	1988-89	1989-90	1990-91
Shag	92.5 (146)	83.9 (168)	86.2 (152)	83.4 (170)	82.8 (157)
Kittiwake	98.7 (176)	92.0 (176)	92.6 (163)	83.7 (179)	84.2 (165)
Guillemot	99.9 (327)	92.2 (385)	96.2 (373)	95.9 (363)	91.0 (381)
Razorbill	96.4 (56)	92.4 (61)	93.4 (61)	80.6 (62)	79.6 (49)
Puffin	89.7 (175)	86.5 (163)	91.0 (145)	82.5 (177)	71.4 (227)