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Isle of May seabird studies in 2010

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Summary

After a series of very poor breeding seasons for seabirds on the Isle of May NNR, the 2010 season continued the marked improvement shown in 2009 for most species. Overall the season was one of the most successful in recent years. Of the six species studied intensively, European shag had its highest productivity on record with only black-legged kittiwake and fulmar having productivity below average. All other species studied had their most productive season for at least seven years. European shags had the highest return rate on record while return rates for all other species were the highest since at least 2003. Although lesser sandeels remained the main food of young Atlantic puffins; razorbills and common guillemots fed their young mainly on clupeids, while European shags brought in mainly sandeels aged one year or older. For the first year since this study began clupeids formed a larger biomass than sandeels in the diet of black-legged kittiwakes.

- Northern fulmar breeding success (0.34 chicks per incubating pair) was lower than 2009 and below the long term average.
- European shags had the most successful season on record (2.04 chicks per pair), eclipsing the previous record set last year. Return rate was the highest on record at 95%. Unlike the previous four years, the food was very consistent with sandeels making up 91.5% by mass of the diet. Examination of sandeel otoliths indicated that all were from the adult age classes.
- Black-legged kittiwakes had a poor season with productivity (0.29 chicks per incubated nest) well below the long-term average. However, some plots suffered unusually high predation by a pair of carrion crows during incubation and from gulls during chick-rearing. Adult return rate (89%) was the highest since 1988. The proportion of sandeel in the diet (44% by biomass) was the lowest on record, while the proportion of clupeid (55% by biomass) was the highest.
- Guillemots had a successful breeding season (0.80 chicks leaving per pair), which continued the improvement recorded in 2009 after a series of poor breeding seasons. Similarly, return rate of adults (92.4%) was similar to 2009 and close to the long term average, following low levels the two previous winters. Adults fed their chicks mainly on medium-sized sprats (84% by number).
- Razorbill breeding success (0.68 chicks leaving per pair) was above the long-term average. Adult return rate (95.2%) was the second highest ever recorded on the Isle of May. Chick diet was mainly medium-sized sprats that were present in 67% of the loads.
- Atlantic puffins had a successful season with 0.74 chicks fledging per pair laying. The return rate for adults (90.9%) was high and continued the improvement noted in 2009 following the poor showing over the two previous winters. Chicks were mainly fed 0 group sandeels (68% by number, 54% by biomass). Although sprats made up only 3% by number, their large size resulted in their contributing 40% of the diet by weight.

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1 Background

The Joint Nature Conservation Committee (JNCC) has a responsibility to advise on certain aspects of 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. JNCC has designed a programme that will allow the numbers and breeding success of selected species of seabirds to be monitored at a range of colonies throughout the UK. In addition, selected colonies have been targeted 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 the chosen site in eastern Britain.

The Centre for Ecology and Hydrology (CEH, formerly known as ITE) has had a long-term interest in seabirds on the Isle of May. Since 1986, CEH has received NCC-CSD/JNCC support for a more formalised seabird monitoring programme. Long-term studies on numbers, breeding success, adult survival, and chick food are carried out on up to eight 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, JNCC has a contract with CEH to:

- a) ensure that the breeding success of northern fulmars *Fulmarus glacialis*, European shags *Phalacrocorax aristotelis*, black-legged kittiwakes *Rissa tridactyla*, common guillemots *Uria aalge*, razorbills *Alca torda* and Atlantic puffins *Fratercula arctica* is monitored;
- b) monitor adult survival of black-legged kittiwakes, common guillemots, razorbills and Atlantic puffins. Monitoring of European shag adult survival was also included up to March 1994, was then excluded for the 1994 season, but was reinstated in May 1995;
- c) assess food of young European shags, black-legged kittiwakes, common guillemots, razorbills and Atlantic puffins; and
- d) undertake special studies on species agreed between the nominated officer and the contractor.

Soon after the Seabird Monitoring Programme (SMP) on the Isle of May was initiated, the Danish industrial sandeel fishery started to use the fishing grounds on the Wee Bankie, Marr Bank and Scalp Bank. These lie 30-50 km east of the island and are known to be important feeding areas for many seabirds during the breeding season. Considerable concern has been expressed about the potential impact of this fishery on the top predators in the area. In December 1999, EU Fishery Ministers agreed a ban on fishing for sandeels, effective for 2000, in 20,000 square kilometres of sea off eastern Scotland (including the Wee Bankie grounds) and northeast England. The breeding success of kittiwakes and shags, which had declined whilst the fishery was in operation, increased during the period 2000-2003, suggesting that the industrial fishery on the Wee Bankie had adversely affected this species.

However, from 2004, breeding success and adult return rate declined in several species, including kittiwakes, despite the fishing ban still being in operation. The common guillemot was particularly hard hit, with the period 2004-2008 representing the five worst breeding seasons on record. Particularly poor breeding seasons were recorded in several species in 2004, 2007 and 2008. Over the same period, there were changes in

seabird diet with the sudden appearance of snake pipefish *Entelurus aequoreus* the most dramatic. Although numerous, this prey is difficult to digest and of poor nutritional value (Harris *et al* 2007).

A significant improvement in breeding success and adult survival has occurred in most species in the last two years. Continued monitoring of the Isle of May seabirds is vital to assess whether 2009 and 2010 is the beginning of a recovery after the setback of the previous few years, or an outlier within a sustained period during which poor environmental conditions override any benefit of fishery closure, and catastrophic years such as 2004, 2007 and 2008 become commonplace.

2 Methods

2.1 Breeding success

The standardised methods used involved minimal disturbance of birds and are described in detail in Walsh *et al* (1995).

Northern fulmar

The positions of apparently incubating birds in ten areas were marked on photographs on 1, 4 and 7 June. At sites where birds appeared to be incubating on three consecutive visits, or where an egg was seen, breeding was assumed to have occurred. These sites were checked again on 11 July to determine those that had hatched eggs. A final check was made on 17 August, when chicks present were assumed to have fledged successfully.

European shag

The positions of nests constructed in nine areas were marked on photographs and the state and contents of these nests were checked weekly from 20 March until 17 August. Young (medium-sized or larger) that remained on 17 August were assumed to have fledged successfully. Success was estimated both by averaging across the plots and summing over plots.

Black-legged kittiwake

The positions 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 noted. Because of the long-term decline in kittiwake numbers on the Isle of May, the extent of the plots at Greengates and Cornerstone were increased in 2005 with new plots also put in place at South Horn and Hide Face and these were continued in 2010. Checks of nests were made on 23 May when regular checks of sample areas showed that most pairs had constructed nests. The first fledged young was seen on 12 July and a complete check of nests was made on 13 July. Further checks of the nests with small chicks on 13 July were made on 16 and 19 July. Chicks alive on 19 July were assumed to have fledged. Successes are given averaged across the plots and summed over the plots.

Common guillemot and razorbill

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

Atlantic puffin

Samples of 50 burrows where an egg was present were staked in each of four areas on 29 April to 1 May (by when most pairs had laid). The staked burrows were re-checked on 24-27 June at the start of fledging.

2.2 Adult survival rates

Estimates of adult survival rates were based on sightings of individually colour-ringed birds and are therefore, strictly speaking, return rates. The areas in which birds were originally marked were checked regularly throughout the season and adjacent areas were searched from time to time in an attempt to locate any individuals that had moved. Searches were periodically made of the whole island for birds that had moved out of the study areas. These latter searches are very time-consuming, and superficially unrewarding, but are essential if accurate estimates of survival are to be obtained. Observations on the survival of adult Atlantic puffins were concentrated at Little Hole (where many burrows are individually numbered). As in recent years, the area used for monitoring survival of adult black-legged kittiwakes included East Tarbet, Rona (North Horn Gully), Low Light Gully, Little Hole, Cornerstone and its nearby cliffs.

2.3 Food of chicks

Food regurgitated by young European shags, young black-legged kittiwakes and adults of both species feeding young, and loads of fish dropped by adult Atlantic puffins caught in mist-nets were collected. Regurgitates and food loads were weighed, fish identified and, where possible, measured (total length, snout to tip of tail). Fish otoliths were extracted from regurgitates, identified and measured. The lengths of the fish from which they came were calculated using regressions derived from the otoliths of fish of known length where possible collected from birds on the island in 2010, otherwise from previously published relationships. Observations were made of fish brought to young common guillemots and razorbills during two all-day watches, as well as opportunistically on most other days throughout the chick-rearing period. Uneaten fish were collected from breeding ledges to confirm identifications and size assessments of common guillemot diet. Fish sizes for razorbills were assessed against the bird's bill but were essentially orders of size as it was not possible to collect samples directly from this species.

3 Results

3.1 Breeding success

Appendix 1 provides species summaries are given in Tables 1- 4 and a comparison with recent years' results is shown in Table 5. Long-term averages presented do not include the current year.

Northern fulmar

Breeding success at 0.34 chicks fledged per incubating pair (Figure 1) was a decrease from 2009 (0.44) but still higher than the previous two seasons. This compared to the long-term average of 0.39 (CI=0.35-0.43).

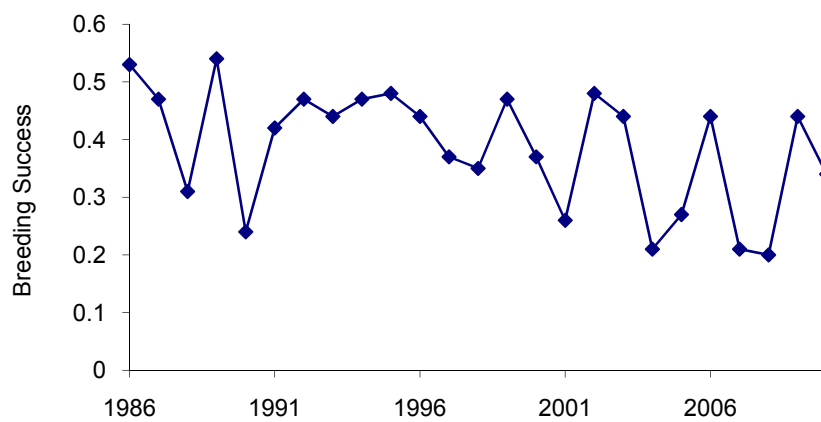


Figure 1. Breeding success (young reared per pair breeding) of Northern fulmar on the Isle of May 1986 – 2010

European shag

Of the 77 nests completed, all pairs laid and raised a total of 157 chicks to fledging. Productivity at 2.04 chicks per nest built was the highest on record (Figure 2). The 1986-2009 average was 1.00 (CI=0.79-1.21).

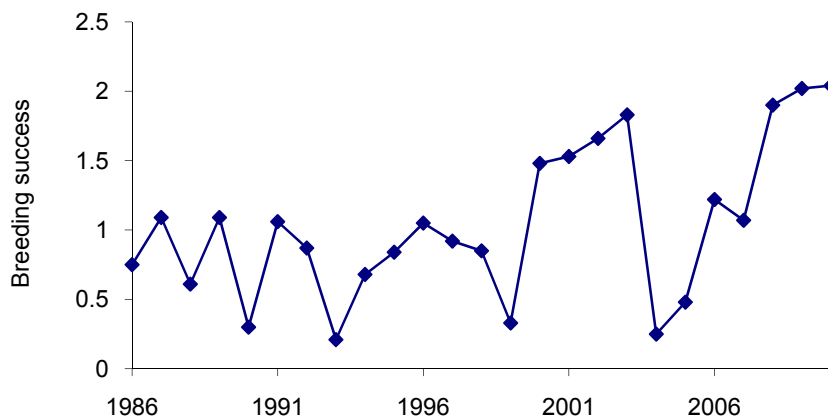


Figure 2. Breeding success (young reared per pair breeding) of European shag on the Isle of May 1986 – 2010

Black-legged kittiwake

Mean breeding success was 0.22 (\pm se 0.06) chicks per completed nest, averaged across the plots, 0.29 after pooling areas (Figure 3). This value was well below the 95% Confidence Interval for the 1986-2009 average (0.53, CI=0.39-0.68) and a major drop after the productive season in 2009 (0.70). Breeding success was very variable between plots which may have been down to high predation levels in some areas. Although predation by gulls, particularly herring gulls, has been suspected in past years it has been very noticeable in the previous two years and appeared to increase further in 2010. Both herring and lesser black-backed gulls were observed removing large chicks from various locations around the island including North Lochside, Rona, Cornerstone and Hide Face. In addition a pair of carrion crows, that reared young within the study areas, systematically removed eggs as soon as they were laid along a section of cliffs which included Pilgrim's Haven, South Face and Colony 4 plots and caused a complete failure in these areas.

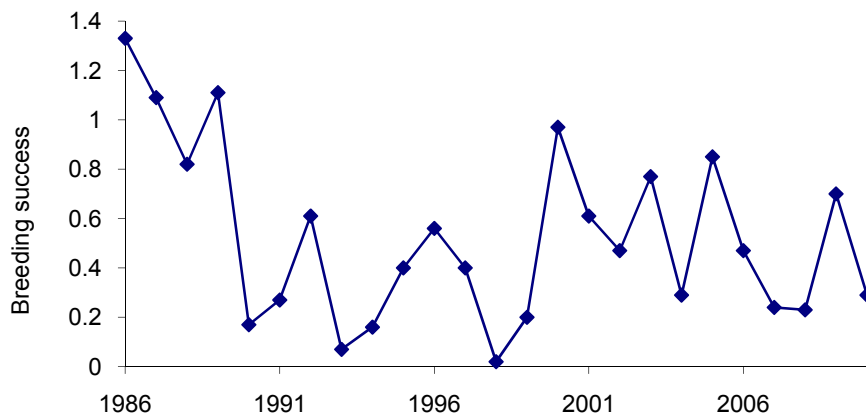


Figure 3. Breeding success (young reared per pair breeding) of black-legged kittiwake on the Isle of May 1986 – 2010

Common guillemot

Breeding success (0.77 per pair laying for the plot average and 0.80 for the summed total continues the improvement noted in 2009 (0.77 for both measures) after a run of poor years (Figure 4).

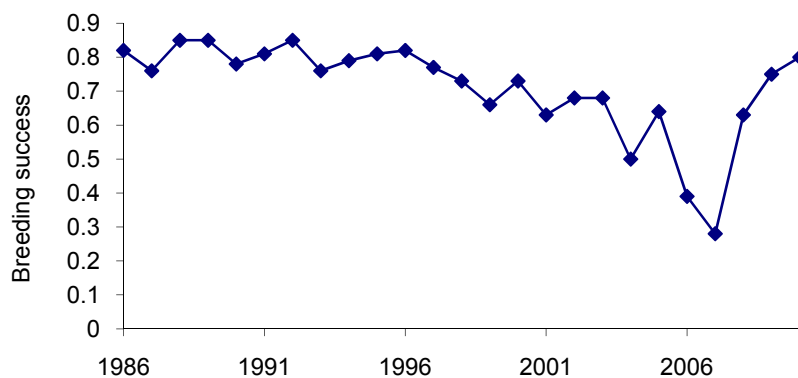


Figure 4. Breeding success (young reared per pair breeding) of common guillemot on the Isle of May 1986 – 2010

Razorbill

Mean breeding success (0.695 per pair laying for the plot average and 0.68 for total pairs laying), was the highest since 1997 (Figure 5).

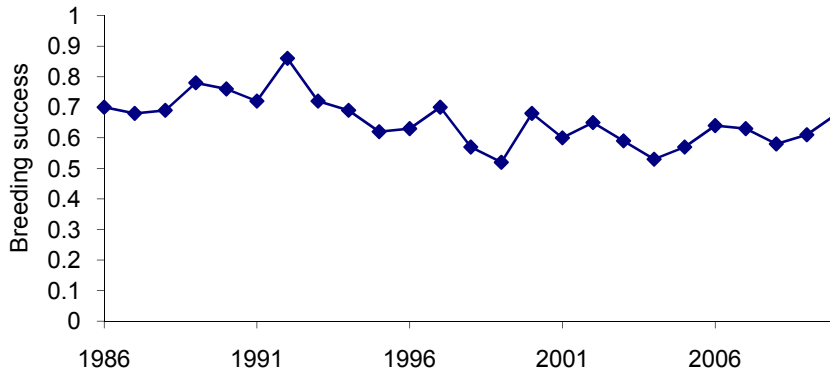


Figure 5. Breeding success (young reared per pair breeding) of razorbill on the Isle of May 1986 – 2010

Atlantic puffin

The mean breeding success based on chicks alive on 24-27 June was 0.74 chicks per egg laid (Figure 6). This continued the improvement noted in 2009 (0.72) after the poor years of 2007 (0.29) and 2008 (0.48).

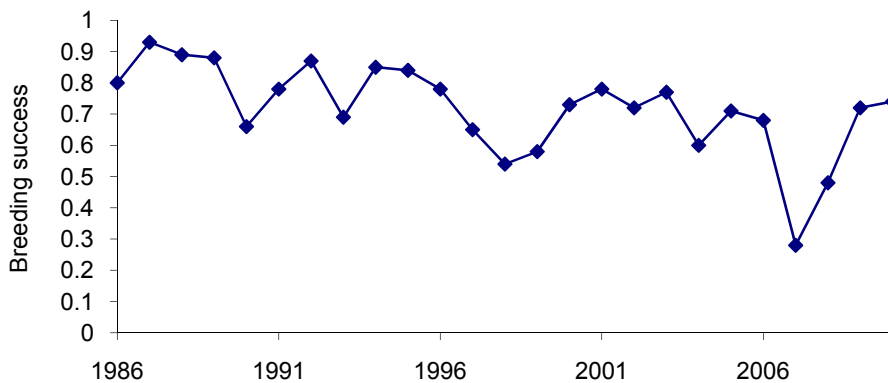


Figure 6. Breeding success (young reared per pair breeding) of Atlantic puffin on the Isle of May 1986 – 2010

3.2 Adult survival 2009-2010

Not every adult alive is seen each year and thus return rates for 2010 presented here need to be treated as minimum estimates of survival of birds seen in 2009. The results are compared with those of previous years in Appendix 2. During 2010 an additional 5 European shags, 13 black-legged kittiwakes, 18 Atlantic puffins, and 2 common guillemot were colour-ringed. The long-term averages presented in this section do not include the current year.

European shag

The return rate for 2010 (95.0%) was the highest on record and well above the long-term average (78.1%, 95% CI = 70.2-86.0) (Figure 7).

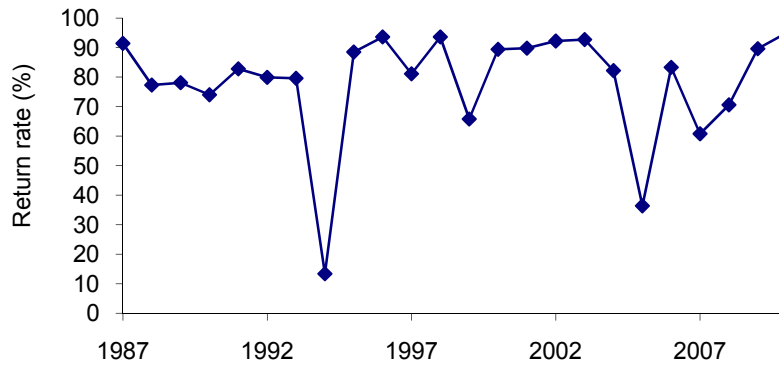


Figure 7. Annual return rates of adult European shag on the Isle of May 1987 – 2010

Black-legged kittiwake

The return rate of black-legged kittiwakes (89.0%) was the highest since 1989 and well above the 1986-2009 average (77.7, 95% CI =74.5-81.0) (Figure 8).

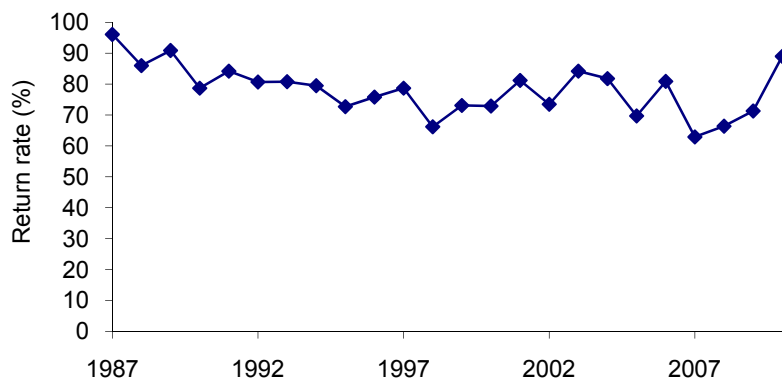


Figure 8. Annual return rates of adult black-legged kittiwake on the Isle of May 1987 – 2010

Common guillemot

The return rate for common guillemot was 92.4%, a marked contrast to the very low values recorded in 2008 (75.0%) and 2007 (75.2%) and above the value for 2009 (88.7%) but within the 95% Confidence Interval for the 1986-2006 average (91.4, 95% CI = 89.9-92.9) (Figure 9).

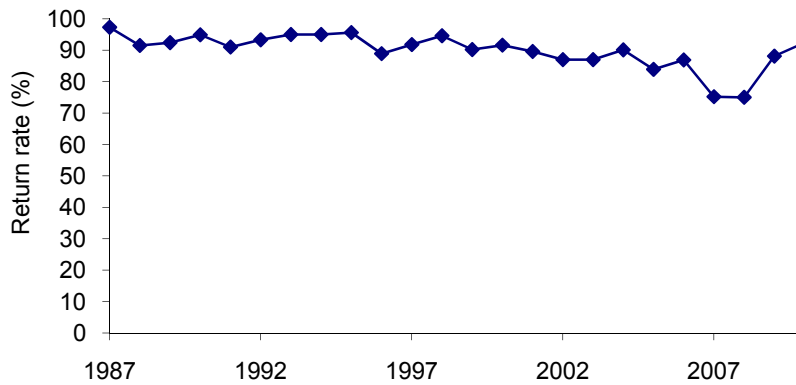


Figure 9. Annual return rates of adult common guillemot on the Isle of May 1987 – 2010

Razorbill

The return rate of razorbills (95.2%) was the second highest recorded, being exceeded only by the 97.3% in 2009 (figure 10).

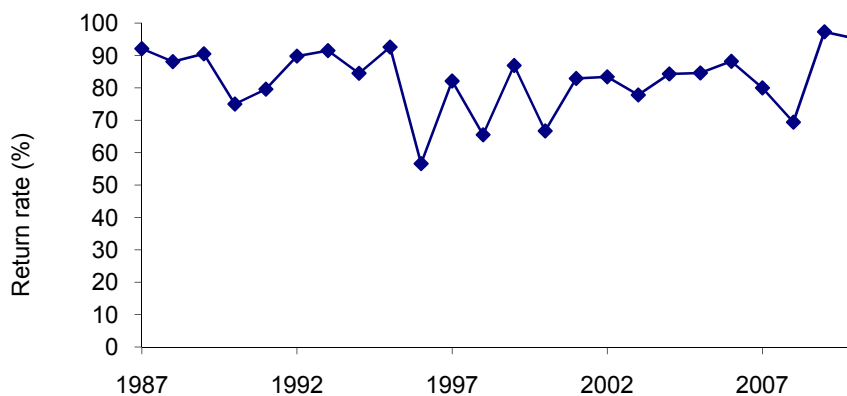


Figure 10. Annual return rates of adult razorbill on the Isle of May 1987 – 2010

Atlantic puffin

In 2010, the return rate of Atlantic puffins was 90.9%. This follows a good return in 2009 (84.7%) These are dramatic improvements over the 56.9% and 59.4% in 2007 and 2008, respectively (Figure 11).

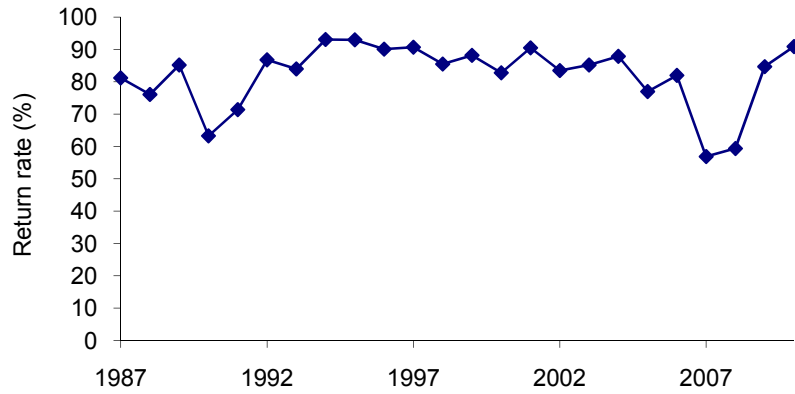


Figure 11. Annual return rates of adult Atlantic puffin on the Isle of May 1987 – 2010

3.3 Food of young

Appendix 3 provides species summaries and a comparison of sandeel biomass data with recent years' results.

European shag

The most frequent prey (by occurrence in a regurgitate) in the 62 regurgitations was sandeel *Ammodytes marinus* which occurred in 96.8% of samples (Figure 12), followed by Gadidae in 6.5% (Table 7). Sandeels constituted 91.5% of the biomass, the highest for seven years. The remains of other items found were crustacea (2), mollusc (2), dragonet (2), eelpout (1), wrasse (1), small flatfish (1) and polychaete worm (1). For the third consecutive year, no pipefish were found. In five of the last six years an unusually high proportion of 0 group sandeels occurred in the diet during chick-rearing but in 2010 all sandeels were older (1+).

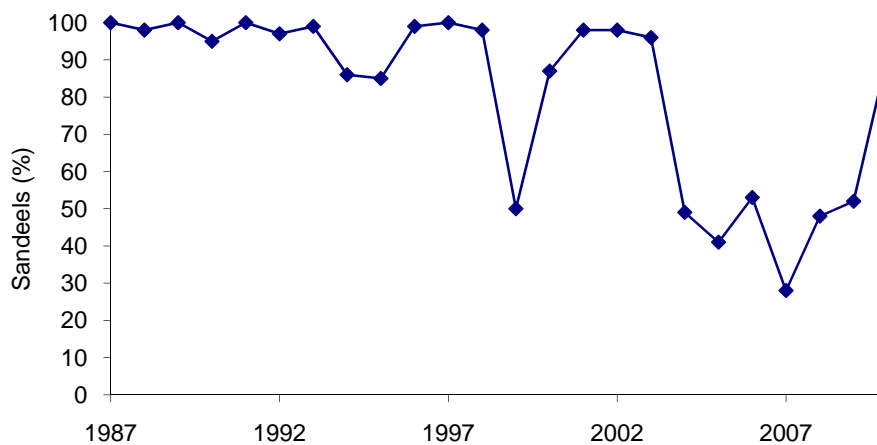


Figure 12. Percentage of sandeels (by weight) in the diet of young European shag on the Isle of May, 1987-2010

Black-legged kittiwake

Of the 65 food samples, 56.9% contained sandeels (Figure 13). Of 1,491 otoliths examined, 89.1% were from 0 group sandeels and 0.01% from 1+ group sandeels, with average length of 6 cm, a decrease of 1cm from 2009. In terms of biomass, 0 group and older sandeels contributed 33.6% and 10.1% by mass of the diet, respectively. Although the proportion of older sandeels was high the overall sandeel biomass proportion was the lowest on record. Clupeid (mainly sprat *Sprattus sprattus*) contributed 54.7% of the biomass and was the highest on record and occurred in 61.5% of regurgitations. The remains of other items found were Gadidae (in 3 regurgitates) and pipefish (1). No samples contained rockling despite occurring in 8% of samples in 2009.

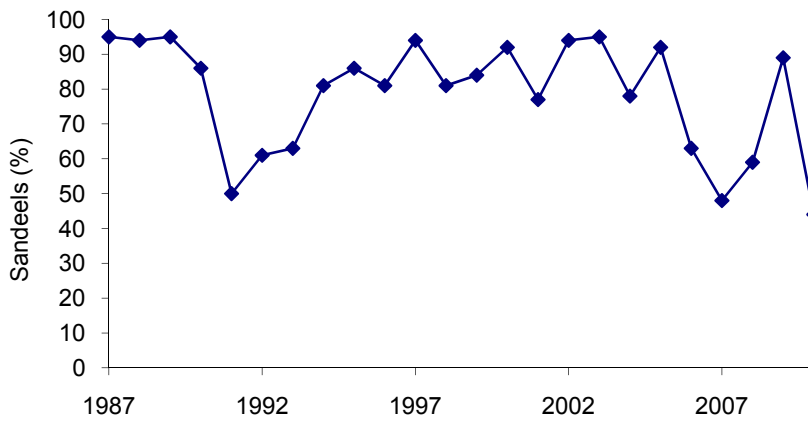


Figure 13. Percentage of sandeels (by weight) in the diet of young black-legged kittiwakes on the Isle of May, 1987-2010

Common guillemot

About 84% of the 1045 food items delivered to chicks were clupeids and all were thought to be sprat. Most were assigned to the medium (10 cm) or large (12 cm) size categories (Appendix 3, Table 8). About 16% of the fish were sandeels (Figure 14), all but two of which appeared to be 1 group or older. Clupeids made up 93% of the diet by weight.

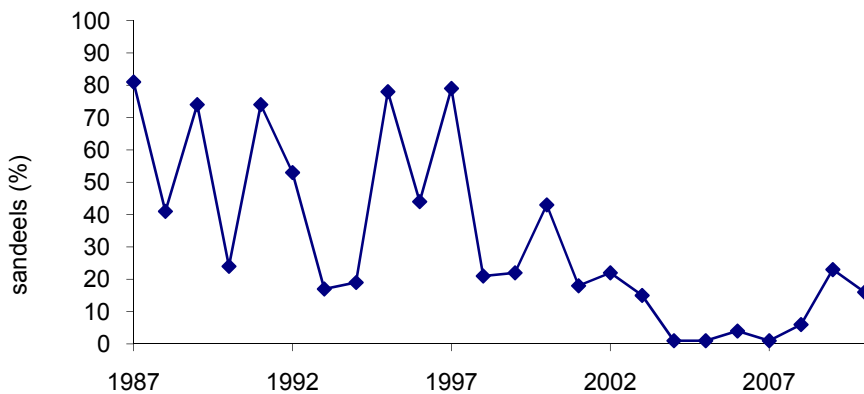


Figure 14. Percentage of sandeels (by weight) in the diet of young common guillemot on the Isle of May, 1987-2010

Razorbill

Clupeids made up the bulk of the fish, being the only species present in 99 (66.9%) of the 148 feeds where the fish were clearly seen. All these clupeids were probably sprats. The sizes of fish refer to fish normally carried by razorbills and are not directly comparable with the sizes of fish brought in by guillemots. Of the 48 loads containing sandeels, 15 (31%) were thought to consist of 0 group fish. One load of medium sandeels also contained a single small sandeel. There was a single load of rockling.

Atlantic puffin

Sandeels made up 68% by number and 54% by biomass in the diet of young Atlantic puffins (Figure 15). All but 30 of 1296 sandeels examined were 0 group, mostly between 5 and 7 cm long (Table 10). Most of the remainder of the diet was made up of sprat (3.4% by number, but 40.0% by mass due to their large size) and rockling (27.3% by number, 3.9% by mass). The mean load size of 8.7 g was just below the average of 9.0 g for the previous 37 years.

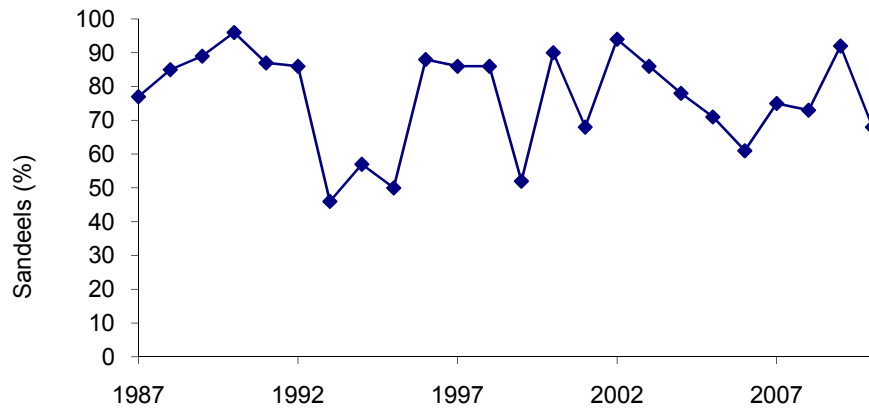


Figure 15. Percentage of sandeels (by weight) in the diet of young Atlantic puffin on the Isle of May, 1987-2010

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5 Further reading

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6 Appendices

Appendix 1: Breeding success

Table 1. Breeding success of northern fulmars on the Isle of May in 2010

<i>Area</i>	<i>Incubating birds</i>	<i>Young fledged</i>
Cleaver	10	6
Pilgrim's Haven	3	3
Cornerstone	3	1
Loch (S)	84	29
Greengates	36	10
Horse Hole	11	3
Tarbet	16	4
Low Light	8	2
Colm's Hole	4	2
Rona	1	0
Total	176	60
Overall mean		0.34 fledged/ pair

Notes:

Incubating birds were those sitting tight on three checks or where an egg was seen. Chicks present on 17 August were assumed to have fledged.

Table 2. Breeding success of European shags on the Isle of May in 2010

	<i>Total incubated</i>	<i>Other nests</i>	<i>Young fledged</i>				<i>Total</i>	<i>Fledging success per completed nest</i>
			<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>		
Maidens	5	0	0	3	1	1	13	2.60
South Horn	1	0	0	1	0	0	2	2.00
Pilgrim's Haven	6	0	1	0	4	0	13	2.17
Mill Door (N)	9	1	1	4	2	0	15	1.67
Mill Door (S)	7	0	0	2	4	0	16	2.29
Horse Hole	11	0	0	2	4	1	20	1.82
North Horn	18	0	3	3	10	0	39	2.17
Tarbet	13	1	1	4	4	1	25	1.92
Low Light	7	1	2	0	4	0	14	2.00
Mean ± se								2.07±0.09
Total	77	3	8	38	99	12	157	2.04

Notes:

No nests were built in the plots at South Ness, Lady's Bed Stack, Chatterstones, North of Pilgrim's Haven, South Face, Bishop's Cove or Colm's Hole in 2010.

Table 3. Breeding success of black-legged kittiwakes on the Isle of May in 2010

Area	Completed nests	Trace nests	Other pairs with site	Fledged young per completed nest				Total young produced	Fledging success per completed nest
				0	1	2	3		
Cleaver	16	0	1	13	3	0	0	3	0.19
South Horn	45	1	1	31	11	3	0	17	0.38
Pilgrim's Haven	15	0	3	15	0	0	0	0	0.00
South Face	14	0	4	14	0	0	0	0	0.00
Colony 4	40	0	8	40	0	0	0	0	0.00
Hide Face	31	1	1	15	15	1	0	17	0.55
Cornerstone	74	0	1	42	27	5	0	37	0.50
Loch (N)	38	0	0	0	0	0	0	0	0.00
Greengates	50	0	0	21	26	3	0	32	0.64
Bishop's Cove	35	0	0	18	14	3	0	20	0.57
Iron Bridge	29	0	2	25	4	0	0	4	0.14
Rona	42	0	0	35	8	0	0	8	0.19
Tarbet	46	0	0	24	6	0	0	6	0.13
Low Light	8	0	0	8	0	0	0	0	0.00
Colm's Hole	11	0	0	11	0	0	0	0	0.00
Mean ± se									0.22 ± 0.06
Total	494	2	21	312	115	17	0	144	

Notes:

There were no nesting attempts in the Horse Hole and Loch (S) plots in 2010.

Table 4. Breeding success of auks on the Isle of May in 2010

<i>Species</i>	<i>Area</i>	<i>Pairs laying</i>	<i>Young "fledged"</i>	<i>Young leaving / pair</i>
Guillemot	Dense	261	228	0.87
	Hide / White Ledge	85	66	0.78
	Colony 4	229	166	0.73
	South	41	27	0.66
	Cornerstone	230	191	0.83
	Mean ± se			
	Total	846	678	0.80
Razorbill	Hide / White Ledge	32	22	0.69
	Colony 4	57	34	0.60
	South	20	15	0.75
	Cornerstone	68	50	0.74
	Mean ± se			
	Total	177	121	0.68
Puffin	Lady's Bed	36	23	0.65
	Kirkhaven	46	38	0.83
	Burrian	49	38	0.78
	Rona	38	26	0.68
	Mean ± se			
	Total	169	125	0.74

Table 5. Breeding success (mean number of young reared per breeding pair) of seabirds on the Isle of May, 1997-2010

<i>Species</i>	<i>1997</i>	<i>1998</i>	<i>1999</i>	<i>2000</i>	<i>2001</i>	<i>2002</i>	<i>2003</i>
Northern fulmar	0.37 (136)	0.35 (120)	0.47 (115)	0.37 (143)	0.26 (134)	0.48 (131)	0.44 (109)
European shag	0.92 (109)	0.85 (125)	0.33 (58)	1.48 (127)	1.53 (135)	1.66 (130)	1.83 (156)
Black-legged kittiwake	0.40 (822)	0.02 (683)	0.20 (616)	0.97 (545)	0.61 (459)	0.47 (477)	0.77 (423)
Common guillemot	0.77 (842)	0.73 (852)	0.66 (870)	0.73 (942)	0.63 (975)	0.68 (955)	0.68 (1014)
Razorbill	0.71 (132)	0.57 (134)	0.52 (142)	0.68 (149)	0.60 (167)	0.65 (167)	0.59 (177)
Atlantic puffin	0.65 (166)	0.54 (179)	0.58 (181)	0.73 (132)	0.78 (185)	0.72 (174)	0.77 (195)
	<i>2004</i>	<i>2005</i>	<i>2006</i>	<i>2007</i>	<i>2008</i>	<i>2009</i>	<i>2010</i>
Northern fulmar	0.21 (97)	0.27 (135)	0.44 (139)	0.21 (141)	0.20 (121)	0.44 (147)	0.34 (176)
European shag	0.25 (103)	0.48 (42)	1.22 (81)	1.07 (57)	1.90 (60)	2.02 (61)	2.04 (77)
Black-legged kittiwake	0.29 (476)	0.85 (675)	0.47 (613)	0.24 (609)	0.23 (485)	0.70 (491)	0.29 (494)
Common guillemot	0.50 (984)	0.63 (945)	0.41 (932)	0.28 (850)	0.63 (807)	0.75 (824)	0.80 (846)
Razorbill	0.54 (190)	0.55 (200)	0.62 (190)	0.63 (188)	0.58 (170)	0.61 (180)	0.68 (177)
Atlantic puffin	0.60 (196)	0.71 (184)	0.68 (166)	0.29 (158)	0.48 (179)	0.72 (176)	0.74 (169)

Notes:

The number of pairs followed is given in brackets. Details of the monitoring methods for these species can be found in this and previous reports to JNCC.

Appendix 2: Annual return rates

Table 6. Annual return rates of adult seabirds on the Isle of May, 1994-2010

<i>Species</i>	<i>No. seen</i>	<i>No. seen</i>	<i>Return rate (%)</i>						
	<i>in</i>	<i>in</i>	2009-10	2008-09	2007-08	2006-07	2005-06	2004-05	2003-04
	2009	2010							
Kittiwake	91	81	89.0	71.3	66.4	62.9	80.9	69.7	81.8
Guillemot	213	197	92.4	88.1	75.0	75.2	86.9	83.9	90.1
Razorbill	42	40	95.2	97.3	69.4	80.0	88.2	84.6	84.3
Puffin	154	140	90.9	84.7	59.4	56.9	81.8	77.0	87.9
Shag	180	171	95.0	89.6	70.6	60.8	83.3	36.4	82.2
	<i>2002-03</i>	<i>2001-02</i>	<i>2000-01</i>	<i>1999-00</i>	<i>1998-99</i>	<i>1997-98</i>	<i>1996-97</i>	<i>1995-96</i>	<i>1994-95</i>
Kittiwake	84.2	73.5	81.2	72.9	73.1	66.2	78.7	75.8	72.7
Guillemot	87.0	87.0	89.6	91.6	90.2	94.6	91.8	88.9	95.6
Razorbill	77.8	83.8	82.9	66.7	86.9	65.5	82.1	56.6	92.6
Puffin	85.2	83.5	90.5	82.8	88.2	85.5	90.7	90.1	93.0
Shag	92.7	92.2	89.8	89.4	65.8	93.6	91.1	93.6	88.5

Notes:

Only birds which had definitely bred in 2009 or earlier are included.

Directly comparable figures for earlier seasons are given. These have not been corrected for missing birds seen in later years, and for some species may severely under-estimate actual survival rates.

A mistake in the return rate for Guillemot in 2009 has been corrected

These figures should not be used for population dynamics calculations without consultation with S Wanless.

Appendix 3: Chick diet

Table 7. Food of young black-legged kittiwakes and European shags on the Isle of May during chick-rearing in 2010

	<i>Black-legged kittiwake</i>	<i>European shag</i>
No. of regurgitations	65	62
Range of dates	1 June-08 July	7 May-24 July
Total weight (g)	1065	2536
% regurgitations with sandeels	56.9	96.8
with Gadidae	0.05	6.5
with Clupeidae	61.5	1.6
with flatfish	0	1.6
with pipefish	0.02	0
% (by weight) of sandeels in sample	43.7	91.5
% (by number) of sandeels in sample	90.5	96.5
Lengths of most sandeels (cm)	6	14
Other remains identified		crustacea (2), mollusc (2), dragonet (2), eelpout (1), flatfish (1), wrasse (1), polychaete worm (1).

Notes:

Samples were collected from chicks or adults during the chick-rearing period. Counts and lengths of fish were based on otoliths retrieved from the regurgitations.

Table 8. Food of young common guillemots on the Isle of May in 2010

	<i>No. of sandeels</i>				<i>No. of Clupeidae</i>				<i>Gadidae</i> <i>small</i>
	<i>minute</i>	<i>small</i>	<i>medium</i>	<i>large</i>	<i>minute</i>	<i>small</i>	<i>medium</i>	<i>large</i>	
Length (cm)	6	10	12	14	6	10	12	14	6
All-day watches									
12 June	0	24	12	1	6	211	54	0	0
18 June	1	4	1	0	0	59	13	0	0
Other records									
22 May-30 June	4	87	31	0	1	363	169	2	1
Total	5	115	44	1	7	633	236	2	1

Notes:

Lengths were based on visual estimates against the bird's bill checked by measurements of dropped fish.

There was also a single small unidentified fish.

Table 9. Food of young razorbills on the Isle of May in 2010

	<i>Sandeels</i>			<i>Single Clupeidae</i>			<i>Several Clupeidae</i>		
	<i>small</i>	<i>medium</i>	<i>large</i>	<i>small</i>	<i>medium</i>	<i>large</i>	<i>Small</i>	<i>medium</i>	<i>large</i>
All-day watches									
12 June	8	10	5	0	6	36	2	7	2
18 June	0	4	4	0	4	26	3	0	0
Other records									
1-29 June	7	1	9	0	1	7	1	3	1
Total	15	15	18	0	11	69	6	10	3

Notes:

One load of medium sandeels includes one small sandeel

There was also one load of small rockling

The sizes of fish refer to fish normally carried by razorbills and are not directly comparable with the sizes of fish brought in by guillemots.

Table 10. Food of young Atlantic puffins on the Isle of May, 23 May to 20 July 2010

	<i>Sample size</i>	<i>Mean</i>	<i>s.e</i>
a) Load weight (g)	172	8.2	0.4
b) Fish/load	171	12.9	0.7
c) Numbers and lengths of fish (mm)			
Sandeels <i>Ammodytes sp.</i>	1296	59.3	0.4
Unidentified Clupeid (<i>Clupeidae</i>)	16	52.2	3.8
Sprat <i>Sprattus sprattus</i>	65	113.9	1.4
Saithe <i>Pollachius virens</i>	9	42.6	3.8
Rockling <i>sp.</i> (<i>Gadidae</i>)	522	29.4	0.2
Whiting (<i>Merlangius merlangus</i>)	1	52	
Cod <i>Gadus morhua</i>	1	47	
Unidentified <i>Gadidae</i>	4	49.8	2.7

Note: There was also one small squid included in the fish/load figure.

Table 11. Percentage of sandeels (by weight) in the diet of young seabirds on the Isle of May, 1991-2010

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Shag	100	97	99	86	85	99	100	98	<50	87
Kittiwake	50	61	63	81	86	81	94	81	84	92
Guillemot	74	53	17	19	78	44	79	21	22	43
Puffin	87	86	46	57	50	88	86	86	52	90

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Shag	95	98	96	49	41	53	28	48	52	91
Kittiwake	76	94	91	79	92	63	48	59	89	44
Guillemot	18	22	15	2	1	4	1	6	23	7
Puffin	68	94	86	78	71	61	75	72	92	54

Notes:

Dates and sample sizes can be found in the contract reports for the respective years.

Sandeels also made up the bulk of the food of young razorbills in all years except 2004, but it is extremely difficult to assess proportions in terms of biomass