

# The status of grey seals in Britain

C.D. Duck and D. Thompson

*NERC Sea Mammal Research Unit, Gatty Marine Laboratory, University of St. Andrews, St. Andrews, KY16 8LB, United Kingdom*

## ABSTRACT

Grey seal pup production in Scotland was estimated through annual aerial surveys of the main grey seal breeding colonies. Between 3 and 7 counts of pups were obtained for each colony at intervals through the course of the breeding season. Pup production for individual colonies was estimated from the series of counts using a maximum likelihood model. At 3 colonies, 2 in England, annual pup production was estimated using ground counts. Between the early 1960s and the early 1990s, grey seal pup production progressively increased. At colonies in the Inner and Outer Hebrides, production appeared to stabilize during the 1990s and has remained so. Pup production at colonies in Orkney and in the North Sea has continued to increase but in recent years the rate of increase has declined. This may imply that the UK grey seal population is reaching some limit to its size. The observed changes in pup production imply that some density dependent factors are affecting the British grey seal population. Changes in either juvenile survival and/or female fecundity are the most likely options. Without knowing which of these, or what combination of these factors, is operating, estimating total population size is complicated.

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## INTRODUCTION

The population of grey seals in Britain, based on using pup counts as an index of abundance, has been increasing steadily since records began in the early 1960s (Summers 1978). Each year, the Sea Mammal Research Unit (SMRU) in St. Andrews, Scotland conducts aerial surveys of the major grey seal breeding colonies in Britain to determine the number of pups born (pup production; Duck 2004). These colonies, most of which are in Scotland, account for about 85% of total British pup production. The total number of seals associated with these regularly surveyed sites is estimated by applying a population model

to the estimates of pup production (Thomas and Harwood 2004). Estimates of the total number of seals at other breeding colonies that are surveyed less frequently are then added in to give an estimate of the total British grey seal population.

In Britain, grey seals breed mainly on islands in the Hebrides and in Orkney (Fig. 1) but they are increasingly occupying sites on the mainland, principally in the northern and east coasts of Scotland. The aim of this paper is to describe the current and historical trends in the abundance of grey seals in Britain.



**Fig. 1.** Grey seal breeding colonies in Britain.

## METHODS

Numbers of pups born (pup production) at the regularly surveyed colonies have been estimated each year using a combination of counts derived from the aerial photographs and a model that takes into account the distribution of births and dispersal of animals throughout the pupping season (Hiby *et al.* 1987, Matthiopoulos *et al.* 2004, Duck *et al.* in press). The methods used have remained unchanged since 1983. These involve making repeated photographic surveys of the colonies throughout the pupping season. To model the distribution of births, in order to determine the total number of animals born at a colony, a lognormal distribution was fitted to counts from the colonies surveyed 4 or more

times during a breeding season and a normal distribution to colonies surveyed on 3 occasions.

New locations where grey seal pups (Fig.2) were seen or reported, or which appear to be suitable for colonization, were surveyed on a 2 or 3 yearly cycle. Normally, between 4 and 6 surveys were flown each year over the main colonies in the Inner and Outer Hebrides, Orkney and the Firth of Forth during each breeding season.

Annual ground counts of pups born at the Farne Islands were carried out by the National Trust staff. Similar counts at Donna Nook were made by staff of the Lincolnshire Wildlife Trust and at



**Fig. 2.** A moulting grey seal pup, approximately 3 weeks old. (Photo: Sonja Reder)

South Ronaldsay, in Orkney, by staff of Scottish Natural Heritage. Ground counts for South Ronaldsay since 2002 were modeled in the same manner as counts from aerially surveyed colonies to estimate the total pup production. From 2003, the South Ronaldsay data have been included with the main Orkney production estimates. These counts can then be used to provide information about population size (Thomas *et al.* 2005).

## RESULTS

### Estimated pup production

Total pup production in 2003 at all annually monitored colonies was estimated to be 39,436, an increase of 7.4% from the 2002 production of

36,704 (Table 1). The trajectory of pup production, with 95% confidence limits, at all the major breeding colonies in England and Scotland combined (excluding Loch Eriboll, Helmsdale and Shetland) between 1984 and 2003 is shown in Fig. 3a. Figure 3b shows the pup production trajectories at the main island groups from 1960 to 2003. Pup production at the main island groups is shown in more detail in Fig. 4a (Inner and Outer Hebrides and Orkney) and Fig. 4b (North Sea colonies). The time series of production estimates for these 4 island groups is in Table 2.

The confidence limits for the Outer Hebrides for 2003 were unusually large (Figs 3a and 4a) compared with those in previous years. This

**Table 1.** Pup production estimates for grey seal breeding colonies in Scotland and England. The percentage change between 2002 and 2003 and the average annual percentage changes over successive 5-year intervals are shown. These average annual changes represent the exponential rate of change in pup production. Note that pup production in 1999 was unusually low at all the main island groups.

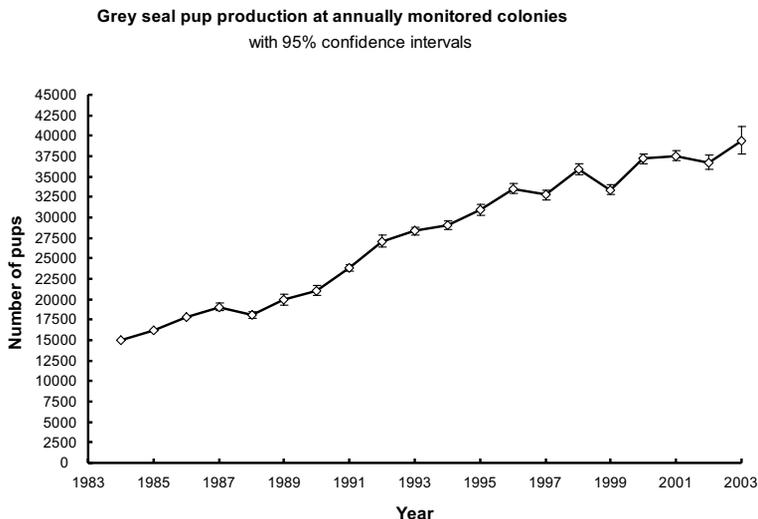
Location	2003 pup production	Annual rate of change in pup production (%)			
		2002-2003	1989-1993	1994-1998	1999-2003
Inner Hebrides	3,386	+9.4	+12.0	+2.7	+3.6
Outer Hebrides	12,741	+13.3	+7.5	+0.3	-0.1
Orkney	18,652	+4.0	+7.3	+8.5	+4.8
Isle of May + Fast Castle	2,599	+3.6	+10.4	+15.7	+5.0
Farne Islands	1,266	+5.5	+3.1	+6.9	+8.7
Donna Nook	792	+11.7	+20.1	+9.2	+11.0
North Sea (i.e. previous 3 locations)	4,657	+5.4	+7.8	+11.7	+6.9
<b>Total</b>	<b>39,436</b>	<b>+7.4</b>	<b>+10.0</b>	<b>+4.9</b>	<b>+3.2</b>

was probably due to the first count being the highest for the season. In previous years, the first survey of the Outer Hebrides colonies was carried out on the same date as the first survey for the Inner Hebrides, in mid to late September. For all islands other than the one (Stockay) where seals breed earliest, the first counts were always very low. To reduce costs (flying time, film processing and counting time) the first survey in late September 2003 was omitted. Unfortunately, the films from the first survey in early October were lost. The combination of these events meant the first available count for 2003 was from the middle of the breeding season. The island with the largest pup production (of just under 6,000 pups) made the biggest contribution to the large confidence limits.

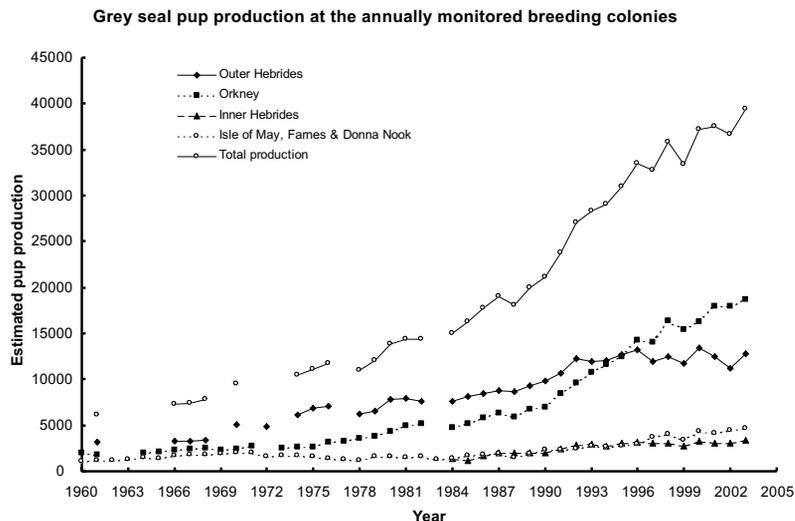
### Trends in pup production

Total pup production has increased steadily since records began and recent data suggest this trend is continuing (Figs 3a and 3b). However, based on data since the mid 1990s it appears that the earlier exponential increase has given way to a declining rate of increase and greater variability in pup production between years (Fig. 3a). The reasons for this change appear to be connected with stability in pup production in the Inner and Outer Hebrides since the early 1990s and a recent decline in the rate of increase in Orkney colonies (Figs 3b and 4a).

**Fig. 3a.** Total estimated pup production, with 95% confidence limits, for all the major, annually monitored grey seal breeding colonies in Scotland and England from 1984 to 2003.



**Fig. 3b.** Grey seal pup production trajectories for the main island groups from 1960 to 2003.



**Table 2.** Estimates of pup production for colonies in the Inner and Outer Hebrides, Orkney and the North Sea, 1960-2003.

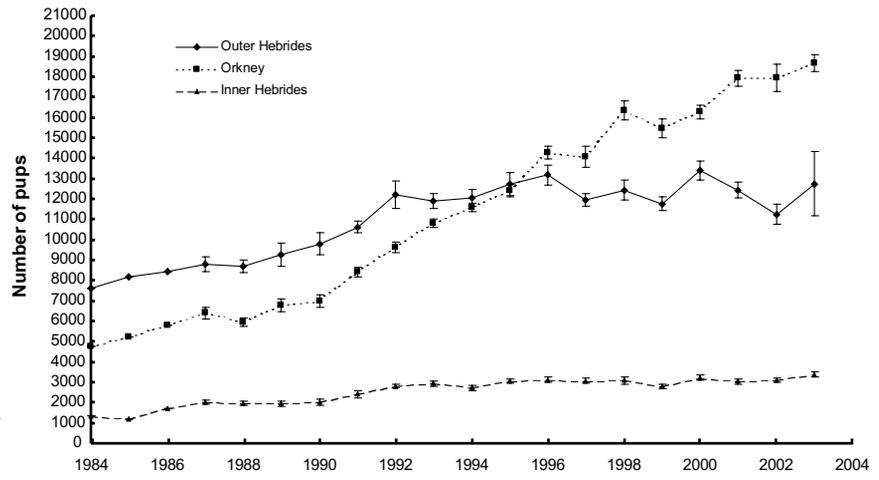
YEAR	Inner Hebrides	Outer Hebrides	Orkney	North Sea	Total
1960			2,048	1,020	
1961		3,142	1,846	1,141	
1962				1,118	
1963				1,259	
1964			2,048	1,439	
1965			2,191	1,404	
1966		3,311	2,287	1,728	7,326
1967		3,265	2,390	1,779	7,434
1968		3,421	2,570	1,800	7,791
1969			2,316	1,919	
1970		5,070	2,535	2,002	9,607
1971			2,766	2,042	
1972		4,933		1,617	
1973			2,581	1,678	
1974		6,173	2,700	1,668	10,541
1975		6,946	2,679	1,617	11,242
1976		7,147	3,247	1,426	11,820
1977			3,364	1,243	
1978		6,243	3,778	1,162	11,183
1979		6,670	3,971	1,620	12,261
1980		8,026	4,476	1,617	14,119
1981		8,086	5,064	1,531	14,681
1982		7,763	5,241	1,637	
1983				1,238	
1984	1,332	7,594	4,741	1,325	14,992
1985	1,190	8,165	5,199	1,711	16,265
1986	1,711	8,455	5,796	1,834	17,796
1987	2,002	8,777	6,389	1,867	19,035
1988	1,960	8,689	5,948	1,474	18,071
1989	1,956	9,275	6,773	1,922	19,926
1990	2,032	9,801	6,982	2,278	21,093
1991	2,411	10,617	8,412	2,375	23,815
1992	2,816	12,215	9,608	2,437	27,075
1993	2,923	11,915	10,790	2,710	28,338
1994	2,719	12,054	11,593	2,652	29,018
1995	3,050	12,713	12,412	2,757	30,932
1996	3,117	13,176	14,273*	2,938	33,504
1997	3,076	11,946	14,051	3,698	32,771
1998	3,087	12,434**	16,367*	3,989	35,877
1999	2,787	11,759**	15,462*	3,380	33,388
2000	3,223	13,396	16,281*	4,303	37,210
2001	3,032	12,427**	17,938*	4,134	37,531
2002	3,096	11,248**	17,942*	4,418	36,714
2003	3,386	12,741**	18,652*	4,657	39,436

\* Production estimates for North Flotta, South Westray, Sule Skerry and South Ronaldsay included in the Orkney total for the first time.

\*\* Production estimates for Mingulay, Berneray and Fiaray (latter 2 off Barra) included in the Outer Hebrides total for the first time.

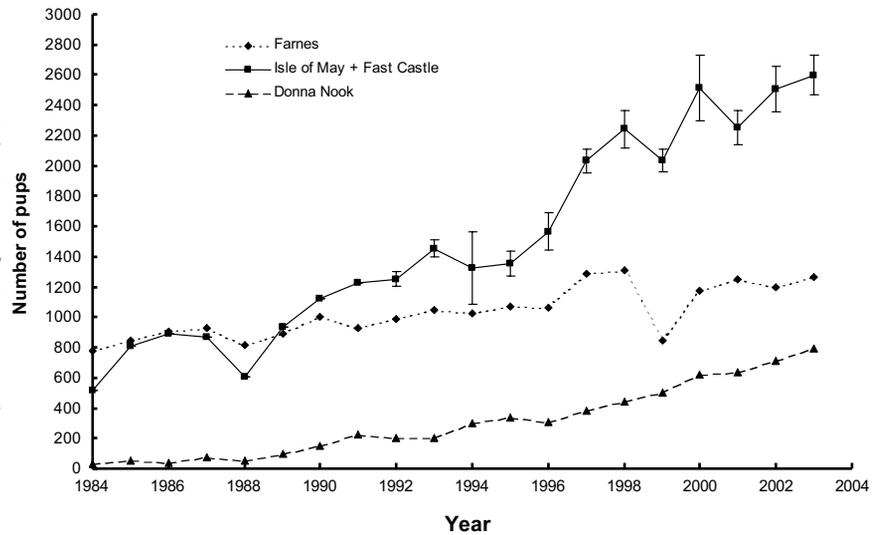
Sule Skerry, Berneray and Fiaray colonies have been removed from Table 4 and included in the estimates for the main colonies for the appropriate island group shown in this table. North Flotta and South Westray were new Orkney colonies surveyed for the first time in 2003.

a) Grey seal pup production at the main island groups



**Fig. 4.** Trends in pup production at the major grey seal breeding colonies from 1984 to 2003. Production values are shown with their 95% confidence limits where these are available. These limits assume that the various pup development parameters involved in the estimation procedure remain constant from year to year. Although they therefore underestimate total variability in the estimates, they are useful for comparison of the precision of the estimates in different years. a) The main island groups: Outer Hebrides, Orkney and Inner Hebrides; b) The North Sea colonies: the Farne Islands, Isle of May, Fast Castle and Donna Nook. Note that Figures 4a and 4b differ in scale by an order of magnitude.

b) Grey seal pup production at North Sea colonies



Total pup production at annually monitored colonies increased by 7.4% between 2002 and 2003 but the increase varied from 3.6% at the Isle of May and Fast Castle, in the Firth of Forth, to 13.3% in the Outer Hebrides (Table 1). This was one of the biggest increases in production in the Outer Hebrides colonies in recent years.

Despite these increases, the results from 2003 continue to support the trends observed in recent years. Firstly, the rate of increase in grey seal pup production did not appear to be as high as it was during the late 1980s and early 1990s (Table 1). Secondly, production continued to appear to be more variable from year to

year than previously (Fig. 3b). Thirdly, although production in the Outer Hebrides increased in 2003, there is still no apparent overall change since 1992 (Figs 3b and 4a). Fourthly, the increased number of pups born in Orkney was relatively small despite the inclusion of 4 new colonies (Figs 3b and 4a). Once again, it appears that the rate of increase in Orkney has slowed. There was a significant increase in the number of pups counted along the far north-east coast of Scotland, at Helmsdale and Berriedale (Fig. 1). On a single photographic survey in 2003, 947 pups were recorded compared with 676 in 2001.

<b>Table 3. Pup production estimates for breeding colonies surveyed less regularly.</b>		
<b>Location</b>	<b>Date and location of last survey</b>	<b>Pup production</b>
Mainland Scotland*	Helmsdale and Berriedale (Duncansby Head to Helmsdale) 2003 (single count)	947
	**Loch Eriboll, Eilean nan Ron (Tongue) 2003 (modeled, 4 counts)	966
Other colonies ***	Various	759
Shetland	1977	1,000
South-west Britain	South-west England, Wales 1994	1,750
<b>Total</b>		<b>5,422</b>

\* South Ronaldsay has been included with the main Orkney breeding colonies.

\*\* Loch Eriboll and Eilean nan Ron (Tongue) are aerially surveyed annually and production estimates obtained using the same modeling process as the main breeding colonies.

\*\*\*Other colonies are detailed in Table 4

Between 1984 and 1996, pup production estimates from annually monitored colonies showed a fairly consistent annual increase, with the notable exception of 1988 (Figs 3 and 4). There were further declines in pup production in 1997 (mainly due to a reduction in the number of pups born in the Outer Hebrides), 1999 (in all island groups) and in 2002 (again, mainly in the Outer Hebrides). In the years following each of these declines, there was a marked increase in total pup production (by 9.5%, 11.5% and 7.4% in 1998, 2000 and 2003 respectively).

The overall annual percentage change in pup production at each of the main island groups between 1999 and 2003 is shown in Table 1. These changes varied from -0.1% at the Outer Hebrides to +11% at the small colony at Donna Nook. The overall change, for all colonies combined, was +3.2%. The changes for the 2 preceding 5 year intervals are shown for comparison.

Pup production fluctuates between years but since 1996, the fluctuations have been more variable than previously (Figs 3a and 3b). This is also reflected in the annual rate of change in production between years. It is difficult to determine what causes these changes but they could indicate that the grey seal population is approaching the limits of size. To even out these fluctuations, the average percentage rate of annual change in pup production for 5 yearly intervals since 1989 are shown in Table 1. These figures probably provide the best indication of the current trend in pup production.

### **Pup production at colonies less frequently surveyed**

Approximately 15% of all pups are born at colonies not surveyed each year (Tables 2 and 4). Production estimates are from single counts so confidence limits cannot be calculated. Loch Eriboll and Eilean nan Ron (Tongue) were surveyed 4 times and production estimated using a lognormal distribution. The results are in Table 3 (under Other colonies) which include the total counts from the colonies listed in Table 4. These and other potential breeding locations are checked when flying time, weather conditions and additional circumstances permit. Approximately 5,500 pups are born at colonies not surveyed annually (Table 3).

## **DISCUSSION**

### **Pup production model assumptions**

The model used to estimate pup production from aerial survey counts of whitecoat and moulted pups assumes that the parameters defining the distribution of birth dates are variable from colony to colony and from year to year, but that those defining the time to moult and the time to leave the colony remain constant (Duck *et al.* in press). The pup production estimate is sensitive to the value used for the latter parameter and there is, therefore, an argument for allowing this parameter to vary between colonies.

### **Confidence limits**

Ninety-five percent confidence limits on the pup production estimates varied from being within

<b>Table 4. Scottish grey seal breeding colonies that are not surveyed annually.</b>				
<b>Location</b>		<b>Survey method</b>	<b>Last surveyed, frequency</b>	<b>Number of pups</b>
<b>Inner Hebrides</b>	Loch Tarbert, Jura	SMRU visual	2003, every 3-4 years	10
	West coast Islay	SMRU visual	1998, every 3-4 years	None seen
	Ross of Mull, south coast	SMRU visual	1998, infrequent	None seen
	Treshnish small islands, incl. Dutchman's Cap	SMRU photo and visual	annual	~20 in total
	Staffa	SMRU visual	1998, every other year	~5
	Little Colonsay, by Ulva	SMRU visual	1998, every 3-4 years	6
	Meisgeir, Mull	SMRU visual	1998, every 3-4 years	1
	Craig Inish, Tiree	SMRU photo	1998, every 2-3 years	2
	Cairns of Coll	SMRU photo	2003, every 2-3 years	22
	Muck	SMRU photo	1998, every other year	36
	Rum	SNH ground	2003, annual	10-15
	Canna	SMRU photo	2002, every other year	54
	Rona	SMRU visual	1989, infrequent	None seen
	Ascrib Islands, Skye	SMRU photo	2002, every other year	60
	Oigh-sgeir, Dubh Artach, Skerryvore	SMRU visual	1995, every other year 1989, infrequent	None None
<b>Outer Hebrides</b>	Sound of Harris islands	SMRU photo	2002, every 2-3 years	358
	St Kilda	Warden's reports	Infrequent	Few pups are born
	Shiantas	SMRU visual	1998, every other year	None
	Flannans	SMRU visual	1994, every 2-3 years	None
	Benera, Lewis	SMRU visual	1991, infrequent	None seen
	Summer Isles	SMRU photo	2002, 2003	50, 58
	Islands close to Handa	SMRU visual	2002	10
	Faraid Head	SMRU visual	1989, infrequent	None seen
	Eilean Hoan, Loch Eriboll	SMRU visual	1998, annual	None
	Rabbit Island, Tongue	SMRU visual	1998, every other year	None seen
<b>Orkney</b>	Sanday, Point of Spurness	SMRU photo	1999, 2002	62, 10
	Sanday, east and north	SMRU visual	1994, every 2-3 years	None seen
	Papa Stronsay	SMRU visual	1993, every 3-4 years	None seen
	Holm of Papa, Westray	SMRU visual	1993, every 3-4 years	None seen
	North Ronaldsay	SMRU visual	1994, every 2-3 years	None seen
	Eday mainland	SMRU photo	2000, 2002	8, 2
<b>Others</b>	Firth of Forth islands, Inchcolm; Craigleith (by North Berwick)	SMRU photo, Forth Seabird Group	Infrequent, 1997, 2003	<14,86
<b>Total</b>				<b>759</b>

4.3% of the point estimate in Orkney to 24.5% in the Outer Hebrides (Figs 4a and 4b). The value for the Outer Hebrides was considerably greater than in any previous years and is likely to be due to the lack of early counts for the bigger colonies. Repeating the estimation process using a normal distribution produced similarly large confidence limits. However, by introducing an artificial first count in September when only a small number of pups would have been born, production estimates were similar to, but lower than the originals (5,812 and 5,540 for the island with the biggest effect) while confidence limits were similar to those in previous years.

### Population size

Pup production is used in a model of the grey seal population that provides an estimate of the total population size. While pup production was increasing steadily year-on-year, it was reasonable to use a simple model that assumed that the population growth rate was not affected by density. However, there are now strong indications that the rate of increase in pup production is slowing and a new population model that includes the likely effects of density on growth rate has been developed (Thomas *et al.* 2004, Thomas and Harwood 2004). Based on pup production figures from 2003 and the assumption that the slow-down in pup production is caused by reduced juvenile survival, the total UK grey seal population associated with regularly-monitored colonies is estimated to be between 77,100 and 120,800 with a point estimate of 96,200 (SCOS 2004). Adding in seals from colonies that are monitored less frequently gives a point estimate of 113,300 grey seals. The majority of these seals, approximately 91%, are associated with colonies in Scotland and the remaining 9%, with colonies in England and Wales.

### Uncertainty in the estimates

The estimate of total grey seal population size depends critically on whether the recent deceleration in pup production is due to increased pup mortality or reduced fecundity. An analysis of changes in pup production at individual colonies suggests that incorporating reductions in either the reproductive rate or pup survival in the model provides equally good explanations of observed changes in pup production but produces widely different population estimates (Thomas and Harwood 2004). There is little information to differentiate between the 2 models, but the pup survival model produced more plausible estimates of reproductive and survival rates. The population estimates presented here are therefore based on density-dependent pup survival, but further work is required to determine which processes are operating, either solely or in combination.

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