The status of harbour seals *(Phoca vitulina)* in the United Kingdom

Dave Thompson, Callan D. Duck and Mike E. Lonergan

NERC Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, KY16 8LB, United Kingdom

ABSTRACT

The UK holds approximately 40% of the European harbour seal population, with the majority found around the coasts of Scotland. Harbour seal populations in the UK have been monitored through a series of repeated aerial surveys of animals hauled out during the annual moult in early August. This moult count is used as a consistent index of population size. Survey methods and frequencies vary. The Scottish and English east coast populations mainly haul out in tidal estuaries and are surveyed annually, using fixed wing aircraft and digital photography. Populations in north and west Scotland often haul out on rocky shores and are surveyed less frequently, using helicopters fitted with thermal imagers. Overall, the most recent minimum estimate of the UK harbour seal population is 24,250 seals of which 19,800 are in Scotland, 3,200 in England and 1,250 in Northern Ireland. The results show that the number of harbour seals in eastern England was increasing before the 1988 and 2002 phocine distemper (PDV) epizootic but has not increased since the end of the 2002 epizootic. There is also evidence of a general decline in most of the large harbour seal colonies around Scotland. The populations along the north and northwest mainland coast were an exception, with numbers appearing to be stable. Between 2001 and 2008, the population in Orkney declined by 67% and Shetland declined by 40%, indicating harbour seals in these areas experienced substantially increased mortality or very low recruitment over this period. The widespread declines, ranging from Shetland to The Wash, suggest that the causes may have been present over a large part of the North Sea and waters off western Scotland.

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INTRODUCTION

Current estimates suggest that the UK holds about 40% of the total European harbour seal *(Phoca vitulina)* population, which is distributed between several major regions (Fig. 1). Until recently, around half of the UK harbour seal population was found in Orkney and Shetland, with large numbers also being recorded on the west coast of Scotland, including the Hebrides, and around the main river estuaries on the east coast of Scotland and England (SCOS 2008). They are rare on the south and west coasts of England and effectively absent from Wales. Different components of the UK population have been affected by hunting (Vaughan 1978; Bonner *et al.* 1973), loss of habitat, effects of human disturbance and pollution (Reijnders 1986, Reijnders 1992a, de Swart *et al.* 1994) as well as other phenomena such as the phocine distemper virus (PDV) epizootics (Hall *et al.* 1992, Hall *et al.* 2006; Härkönen *et al.* 2006).

The level of population monitoring around the UK has been variable. The Wash is the largest

estuary in England, and holds the majority of the English harbour seal (Vaughan 1978, Thompson *et al.* 2005). This population has been monitored since the 1960s, using counts of animals hauled out as indices of population size. The survey programme was established to monitor the population during a period of intensive pup hunting. When this hunt ceased in 1973, the monitoring programme was reduced. Annual monitoring was resumed in 1988 immediately before the onset of an epizootic of PDV.

Around Scotland, harbour seals are widely dispersed and generally haul out on intertidal rocks and small islets where they are hard to spot during conventional fixed wing visual surveys. Dispersed populations on rocky shorelines can only be effectively surveyed using helicopters fitted with high-resolution thermal imaging systems. Surveys are expensive and, on account of funding limitations, the entire population can only be surveyed approximately once every 5 years. Surveys of seals in the tidal estuaries on the Scottish east coast, where they are easily seen, have been conducted in most years since 1988.

In this paper we present an estimate of the size of the UK harbour seal populations and summarise the results of surveys of the main harbour seal populations carried out in the U.K. between 1968 and 2008. We present estimates of the likelihoods and sizes of the population changes detected by these surveys and assess the level of threat to these populations suggested by these changes.

METHODS

Aerial surveys of harbour seals at haulout sites provide the most practical and reliable indices of population abundance. The optimal timing of the annual surveys and their timing relative to the tidal cycle were determined by examining the seasonal and daily distributions of the numbers of seals hauled out on particular sites in the Moray Firth in eastern Scotland and using historical survey data from The Wash (details in Thompson *et al.* 2005).

Seals are relatively easy to detect on sandbanks. Fixed-wing aircraft and conventional photography, either vertically with a large format camera or obliquely with a hand-held digital SLR camera, were used in the main estuaries in eastern England and in eastern Scotland (around The Wash, the Firth of Tay and the Moray Firth; see Thompson *et al.* (2005) for detailed methodology).

On rocky shores, seals are more difficult to detect because they are well camouflaged and the convoluted coastline is difficult to survey by fixed-wing aircraft. Surveys of most of the Scottish coast were carried out by helicopter (operating at an altitude of 150-250 m and at a distance of 300-500 m offshore) using a thermal imaging camera (Barr and Stroud IR18, thermal accuracy 0.1°C) with a dual telescope (x2.5 and x9 magnification). The thermal imager was mounted on a pan-and-tilt-head and operated out of the helicopter window, with an effective range greater than 3 km.

Both the thermal image and a 'real' image (from a Canon MV3i digital video camcorder) were displayed continuously on a monitor within the helicopter and recorded. The location, time, species and number of all seal sightings were recorded in real time directly onto Ordnance Survey 1:50,000 maps. In addition, since 2007, digital photographs were taken of most groups of seals to confirm species identity and counts.

Harbour and grey seals sometimes haul out together or in similar locations. Grey seals tend to form tight aggregations close to the water, while harbour seals are often more dispersed and further from the water's edge. The two species also differ in thermal profile, size, headshape and coat pattern. Since 2007, species identity and group numbers were reviewed from digital images after every survey.

A population model was developed that independently estimates two types of uncertainty: the inter-annual environmental variability that modifies the growth rate and therefore has persistent effects on the population; and observation error, the shorter-term changes that influence individual surveys separately (Lonergan *et al.* 2007).

Table 1. Minimum estimate of the UK harbour seal population from the most recent regional surveys and from two previous surveys.

Region	Current estimate (year)	Previous estimate (year)	Earlier estimate (year)
Shetland	**3,057** (2006)	**4,883** (2001)	**5,991** (1997)
Orkney	**2,867** (2008)	**3,379** (2007)	**4,256** (2006)
Outer Hebrides	**1,815** (2008)	**1,981** (2003, 2006)	**2,098** (2003)
Highland East & North (Nairn to Cape Wrath)	**884** (2008)	**783** (2005, 2007)	**1,266** (1997, 2004)
Highland West (Cape Wrath to Appin, Loch Linnhe)	**5,043** (2007, 2008)	**4,966** (2005)	**4,947** (1996-7, 2000)
Strathclyde & Firth of Clyde (Appin to Mull of Kintyre to Loch Ryan)	**5,760** (2007)	**7,283** (2000, 2005)	**6,333** (1996)
Dumfries & Galloway (Loch Ryan to English Border at Carlisle)	**23** (2007)	**42** (2005)	**6** (1996)
Grampian (Nairn to Montrose)	**102** (2007)	**113** (2005)	**62** (1997)
Firth of Tay & Firth of Forth (Montrose to Dunbar)	**436** (2007)	**650** (2005)	**749** (1997)
TOTAL SCOTLAND	**19,988**	**24,080**	**25,708**
Blakeney Point	**581** (2008)	**550** (2007)	**719** (2006)
The Wash	**2,010** (2008)	**2,162** (2007)	**1,695** (2006)
Donna Nook	**191** (2008)	**214** (2007)	**299** (2006)
Scroby Sands	**81** (2008)	**71** (2006)	**64** (2004)
Other east coast sites	**347** (2008)	**153** (1994, 2000, 2005)	**235** (1994, 2000, 2003)
South and west England (estimated)	**20**	**20**	
TOTAL ENGLAND	**3,230**	**3,242**	**2,777**
TOTAL NORTHERN IRELAND	**1,248**		
TOTAL U.K (BRITAIN & N. IRELAND)	**24,466**	**28,570**	**29,733**

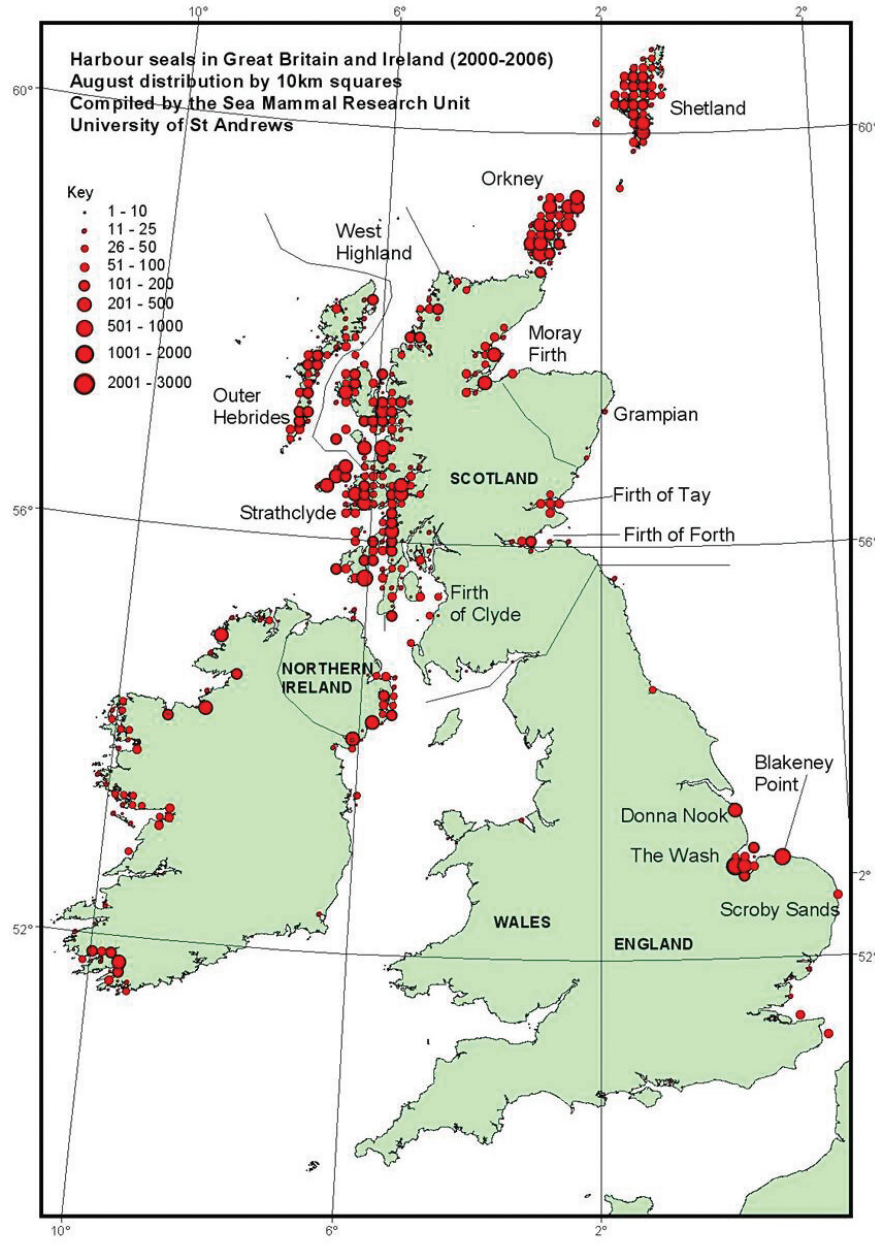

Fig. 1. *The August distribution of harbour seals in Great Britain and Ireland, by 10 km squares. These data are from surveys carried out between 2000 and 2006.*

The count data provide little information for estimating the expectation of the proportion of the population observed during surveys. Independent estimates of the proportion of different sexes hauled out during the survey period are currently under investigation using flipper-mounted satellite transmitters. Instead of directly estimating this proportion, we have used the number counted as an index of population size.

RESULTS

Timing of Surveys

Seals were present in the water around and above the haulout site before the banks were exposed. The numbers ashore increased steadily as the banks were exposed, reached a plateau and then declined as the banks were submerged. The estimated number ashore exceeded 90% of the maximum count during the period 2 hours

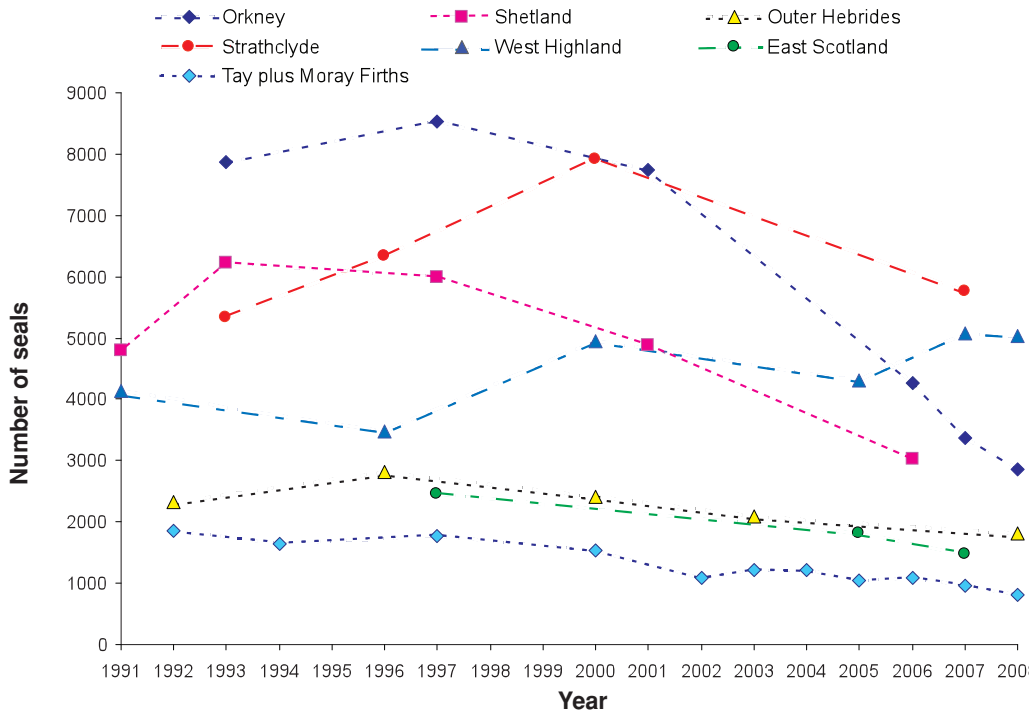

Fig. 2. *Trends in counts of harbour seals around Scotland.*

before to 2 hours after low water. In practice, synoptic surveys require 3-4 hours to be carried out reasonably efficiently, so the flights were restricted to this 4-hour window (details in Thompson *et al.* 2005).

Surveys carried out at irregular intervals within The Wash estuary between 1968 and 1982 and one year of intensive counts in the Beauly Firth indicated a peak in numbers onshore in early August. The August peak count was approxi-

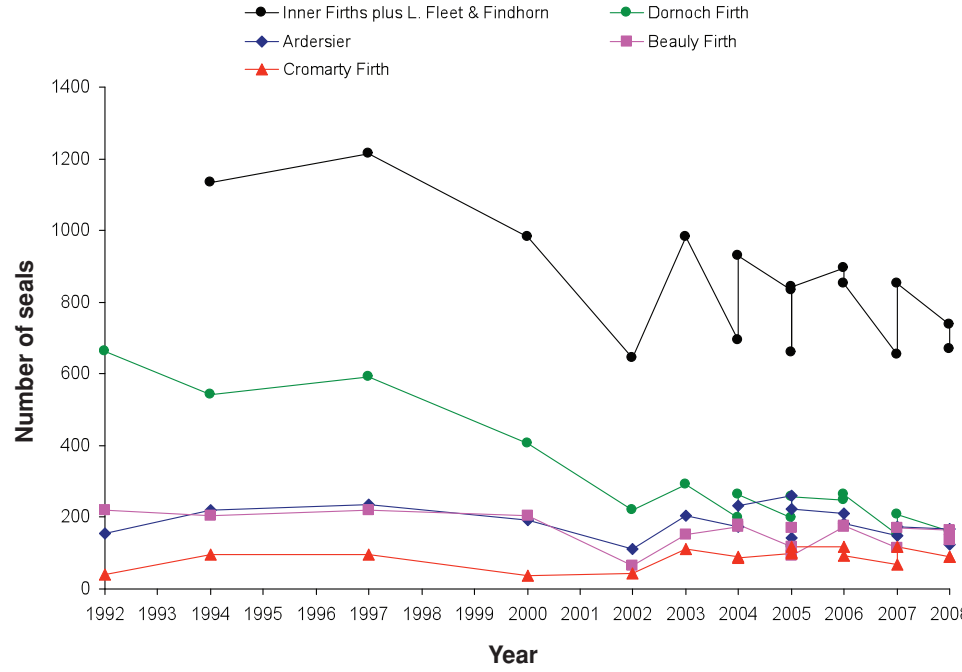

Fig. 3. *The number of harbour seals counted in the Moray Firth, between 1992 and 2008.*

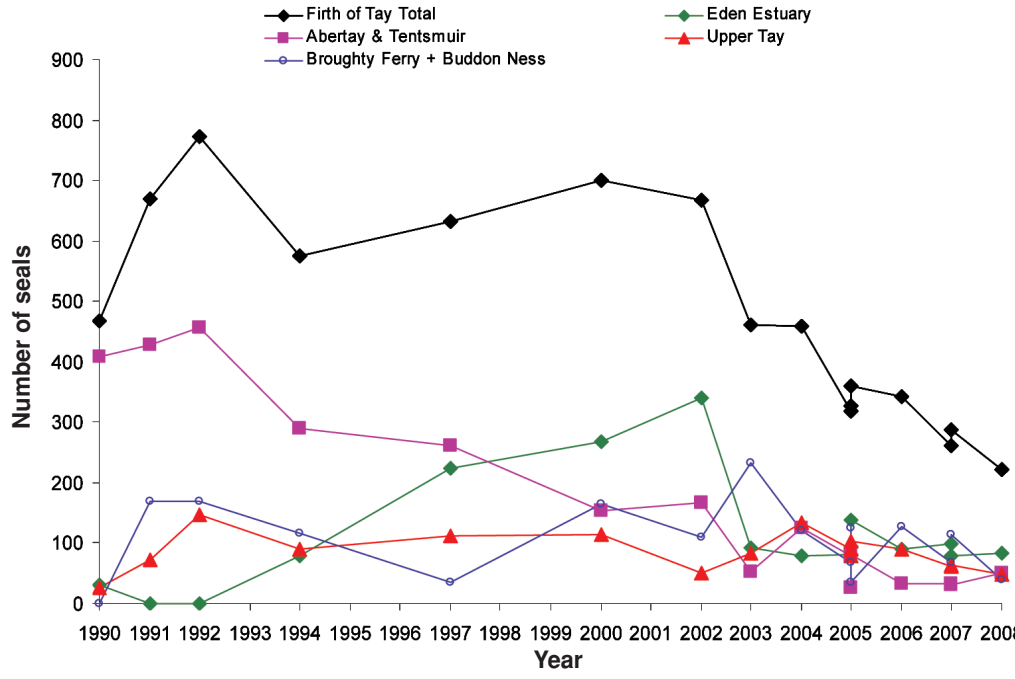

Fig. 4. *The number of harbour seals counted in the Firth of Tay, between 1990 and 2008.*

mately 50% higher than that in winter and the coefficients of variation are likely to be lower (details in Thompson *et al.* 2005).

Data from the Beauly Firth suggested that there may be a small, but statistically s ignificant, effect of time of day with more animals being observed at low tides in the early afternoon than at other times. There is no indication of diurnal patterns in the variability of counts (details in Thompson *et al.* 2005).

Minimum estimate of the size of the UK harbour seal population

The overall distribution of harbour seals around the UK, from surveys carried out between 2000 and 2006 is shown in Fig. 1. For ease of viewing at this scale, counts have been aggregated into 10 km squares. The most recent minimum estimate of the number of harbour seals in Scotland is 19,800 from surveys carried out between 2006 and 2008 (Table 1). This is 18% lower than the previous aggregate total for Scotland (24,100) from surveys carried out

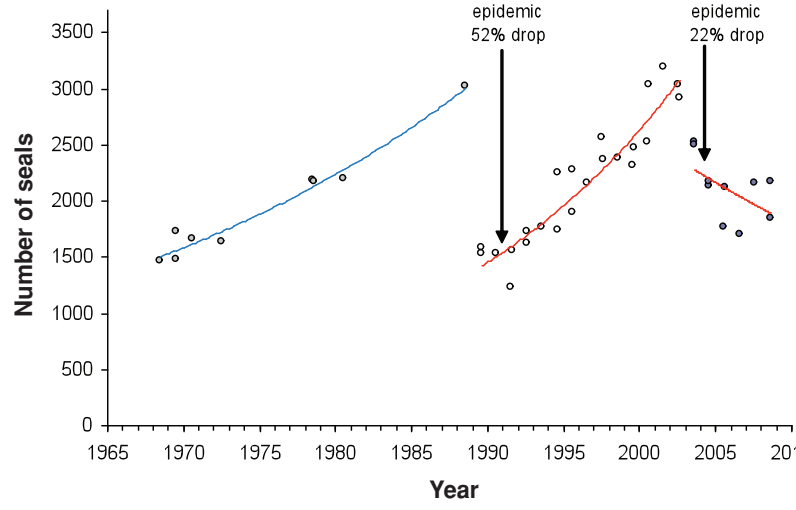

Fig. 5. *Counts of harbour seals in The Wash in August, 1967 - 2008. These data are an index of the population size through time. Fitted lines are exponential growth curves (growth rates given in text).*

between 2001 and 2007 (Table 1). The most recent minimum estimate for England is 3,230, which is almost identical to the 2007 count of 3,242. Including 1,250 harbour seals counted in Northern Ireland in 2002, the minimum size of the U.K. harbour seal population in 2008 was 24,250.

Current status

Scotland

Results from surveys carried out in 2006 found an apparent decline in abundance in Orkney and Shetland of 42% (95% confidence intervals 10%-62%; Lonergan *et al.* 2007) compared with 2001(Fig 2). Results from surveys in 2007 and 2008 confirmed the magnitude of the decline in Orkney. The 2007 count was 33% lower than in 2006 and the 2008 count 15% lower than in 2007. These latest results suggest that the Orkney harbour seal population has declined by 67% since the late 1990s and has been falling at an average rate of over 13% p.a. since 2001 (Table 1).

The 2007 results also suggested that a similar decline (25%) occurred in Strathclyde since 2001. However, unlike other surveyed regions, the 2001 count for Strathclyde was much higher than previous counts so that there has been little overall change in numbers since the mid 1990s. (Table 1, Fig. 2).

Results from surveys of the Outer Hebrides in 2008 did not indicate a major decrease when compared with results from an incomplete survey carried out in 2006. However, the 2008 count was 35% lower than the peak count in 1996 and regular surveys over the intervening period suggest that there has been a sustained but gradual decline of approximately 3% p.a. since 1996 (Fig. 2). However, surveys in 2007 and 2008 confirmed that harbour seal populations on the west and north-west coasts did not show any decline.

Aerial surveys of the Moray Firth began in August 1992. In 2008, both counts were lower than counts from both 2006 and 2007 (Fig. 3). In 2008, the Firth of Tay count was the lowest recorded (222) and represents a continuation of a rapid decline over the past decade (Fig. 4). Numbers in this Special Area of Conservation (SAC) are approaching 33% of the number counted between 1990 and 2002. There were 147 harbour seals in the Firth of Forth in 2007. These two groups may form one single population, but even if this is the case, numbers have declined considerably in recent years.

England

Overall, the combined count for the English East coast population (Donna Nook to Scroby Sands) in 2008 was 4.5% lower than in 2007. However, it was 3.1% higher than in 2006 and within the range of counts over the previous 3 years (Fig. 5).

Between 1968 and 1988, the moult counts increased at 3% pa (95% CI: 2.1-4.1) (Fig. 5). The count fell by approximately 50% (95% CI: 44-59) following the 1988 PDV epizootic. After 1989, counts increased at 6% pa (95% CI: 4.8-6.7), approximately double the annual rate of increase before the epizootic, until the recurrence of the PDV epizootic in August 2002. The dates of the surveys and the disease outbreak in 2002 were almost exactly the same as in 1988. However in 2002, mortality was lower than in 1988, at around 22% (95% CI: 9-33). Since the 2002 epizootic, the English harbour seal population has apparently continued to decline or, at least, has failed to recover.

DISCUSSION

Population Trends

Scotland

Different components of the Scottish harbour seal population have shown different dynamics over the last 10 to 15 years (Lonergan *et al.* 2007). The population on the mainland coast of north-west Scotland and in the northern Inner Hebrides are apparently stable. Populations on the east coast of Scotland have been declining gradually for the past 15 years. Until recently the largest concentrations of seals in the UK were in Orkney and Shetland. Both populations have shown major declines. As a result of the low frequency of surveys, the decline was not noticed before 2006 by which time a substantial proportion of the population had disappeared.

An apparent decline in numbers of harbour seals at Eynhallow, in Orkney, had been recorded before the current decline (Thompson *et al.* 2001). However Orkney-wide surveys indicated that this could be explained by local redistribution of individuals within the archipelago (Lonergan *et al.* 2007).

The proximate causes of a decline on the scale reported here could only be a sustained high level of reproductive failure or by increased rates of mortality or some combination of these two causes. A rate of decline of 10% per annum is equivalent to almost no recruitment, equating to the sustained loss of complete cohorts. The observed rates of sustained decline therefore indicate a serious threat to these populations.
The counts presented here are treated as indices of population size. Based on data from The Wash in England and the Moray Firth in Scotland, they represent the highest seasonal counts with the lowest c.v. They will be an unbiased index and will accurately represent the trends in population if the proportion of the harbour seal population available to be counted during the moult has remained constant throughout the period covered by this study. If seals of different ages and sexes behaved very differently during the moult and the population structure changed, or behaviour had changed (for example in response to changes in food availability or patterns of disturbance) the trends in indices would not represent the true population trends. Although changes in timing of the moult and breeding season have been observed in other populations of harbour seals these have been the direct result of differential mortality leading to a change in relative magnitudes of different age classes. To produce the declines observed in Scottish populations would require very large changes in population structure which could only happen if large parts of the population were removed. Currently there are no data to suggest that such changes are responsible for the observed trends in population size. Preliminary results from comparative studies using small satellite transmitters to examine pup survival and flipper-mounted satellite transmitters to examine adult haulout behaviour during the moult, indicate that neither of these factors is likely to explain the different dynamics of stable versus declining populations of harbour seals in Scotland (SMRU unpublished data).

The declines in Scotland occurred over the period incorporating the 2002 PDV epizootic. However, it is unlikely that a mass mortality of the type associated with PDV would have gone un-noticed in either Orkney or Shetland and, although a small number of affected seals were identified in the Scottish east coast population, there was no evidence of significant mortality (Lawson and Jepson 2003). In addition, the continued declines in all of these cases suggest that some more general, longer lasting process or processes are responsible.

England
The population of harbour seals in the Wash was increasing during the period 1970 to 1988, but then fell by approximately 50% during the 1988 PDV epizootic. Adjacent European populations in the Wadden Sea and the Kattegat-Skagerrak suffered similar declines (Dietz *et al.* 1989; Reijnders 1992b). After the epizootic, The Wash population showed evidence of a gradual recovery with a post-epizootic growth rate approximately double the pre-epizootic rate. The population was then clearly impacted, but to a lesser extent, by the recurrence of the PDV epizootic in 2002.

Although the overall level of mortality in 1988 (0.50 %) was similar to that seen throughout the European population, the 2002 mortality was apparently lower (0.22), approximately half the level suggested for the Wadden Sea (0.47) (Reijnders *et al.* 2003) and Kattegat-Skagerrak (0.49) populations (Harding *et al.* 2002). As the population estimates and the timing of the epizootic in The Wash were similar in 1988 and 2002, it is not clear why the mortality rate should have been lower in east England in 2002. It is interesting to note that PDV linked mortality in other British harbour seal populations was also much lower in 2002 than in 1988 (Lawson and Jepson 2003).

The rates of increase in The Wash population were clearly lower than in the Wadden Sea,

both before and after the 1988 epizootic. It is not clear why there should be such a discrepancy. The observed growth rates in several, apparently closed, harbour seal populations have approached 12-13% p.a. (Heide-Jørgensen and Härkönen 1988; Reijnders 1992b; Boveng *et al.* 2003; Härkönen *et al.* 2002; Jeffries *et al.* 2003). This probably represents the intrinsic rate of increase of an undisturbed and unconstrained harbour seal population in the absence of density dependent effects. It is obvious that the rate of increase in England, both before and after the PDV epizootics, was constrained in some way. However, there were no indications that growth rates were decreasing and therefore no indications of density dependent effects before either the 1988 or 2002 epizootics (Thompson *et al.* 2005). Since the 2002, epizootic the disparity between the failure of the English east coast population to recover and the continued rapid growth of the Wadden Sea population has become more pronounced.

The European sub-species of harbour seal is classified as "Least Concern" in the recent IUCN listings. (IUCN 2009). However, under the OSPAR Convention several UK subpopulations are identified as Ecological Quality Objective (EcoQO) indicators with the associated EcoQO that there should be no decline in harbour seal population size ≥10% over a five year period (OSPAR 2007). Clearly this rate of decline has been exceeded in Orkney, Shetland, the Moray Firth and the Firth of Tay. The scale and widespread nature of the declines in UK harbour seal populations is a cause for concern.

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