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The status of inland and coastal breeding Great Cormorants *Phalacrocorax carbo* in England

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EXECUTIVE SUMMARY

1 Since the establishment of a tree-nesting colony of Great Cormorants *Phalacrocorax carbo* at Abberton Reservoir in Essex in 1981, the inland breeding cormorant population in England has developed considerably through colony growth at Abberton and the establishment of new inland colonies. Up to 2005, cormorants have bred successfully in one or more years at 58 English sites that were not coastal cliffs or offshore islands, and so were defined as "inland". The majority of these colonies were in central and south-east England, with few or no colonies in the north, west or south-west of the country. Whilst cormorants have been actively dissuaded from breeding at a number of these sites, the inland breeding cormorant population in England in 2005 is known to have reached at least 2,059 breeding pairs, although there is some evidence of stabilisation in recent years. This population is thought to have been founded by cormorants of the continental race *P. c. sinensis* mainly from the Netherlands and Denmark, although an increasing proportion of nominate race *carbo* originating from coastal colonies in Wales and England are believed to have contributed to its development.

2 Colony counts for inland breeding cormorants were obtained through a number of sources including County Bird Reports and correspondence with County Bird Recorders, the BTO Heronries Census by courtesy of the British Trust for Ornithology, and personal communication with birdwatchers, bird ringers and reserve or site managers. However, there is currently no coordinated means of obtaining inland colony counts from observers, making the process of collating counts very time-consuming. In addition we do not know to what extent counts represent the maximum numbers of nests. Ideally, nests should be counted several times within the same season, and the maximum number used. Several visits should be made because the observer rarely knows at exactly what time of the season nest numbers can be expected to culminate, and this is likely to vary among years and colonies. An improvement to the quality of the counts could be achieved by identifying a network of volunteers able to make several visits to colonies on an annual basis. Counts would feed then directly into a central database.

3 Between 1986 and 2005, cormorants bred at 80 coastal colonies in England. The majority of these were in the south-west of the country, with a smaller number of colonies in south, north-east and north-west England and the Isle of Man. Estimates for the coastal breeding cormorant population in England 1986-2005, suggest that this population has remained stable over this period, at approximately 2000 pairs. This is in agreement with Mitchell *et al*. (2004), although the absolute level of the population is estimated here to be higher than suggested previously. Particularly large confidence intervals in 1989 and 2003 reflect particularly poor coverage in these years.

4 Colony counts for coastal breeding cormorants have mainly been collated by JNCC's Seabird Colony Team through the Seabird Colony Register (SCR), the Seabird Monitoring Programme (SMP) and the *Seabird 2000* survey. However, only a small proportion of colonies are counted on an annual or near-annual basis. This is mainly a reflection of the difficultly in surveying coastal colonies, which are on coastal cliffs, stacks or offshore islands and in many cases not viewable from land. For many colonies boat-based surveys or aerial surveys would be required. Whilst it would be possible to improve coverage of accessible colonies, the only practicable way to obtain a high level of coverage would be to carry out aerial surveys (for ground-nesting colonies) and boat-based surveys for (cliff-nesting colonies). At the other extreme, it is important to maintain annual monitoring at a sufficient level to avoid the situation in 1989 and 2003, where we have little ability to detect change in the population.

5 The collation of counts for coastal cormorant colonies in England has allowed us to produce revised population estimates for coastal colonies in England and to assess how well we can currently monitor this population through existing schemes. However, because inland waters

in England also support cormorants from coastal breeding populations in Wales and Scotland, it should be considered that the collation of counts and production of population trends using the methods described here is performed for these countries.

INTRODUCTION

In September 2004, the Department for Environment, Food and Rural Affairs (Defra) announced changes to the licensing policy for cormorants that allowed for a greater number of licenses to be issued to fisheries to control cormorants. At present we do not know the likely influence of the changes in licensing on the inland and coastal breeding populations in the UK.

The UK government has an international responsibility under the EU Birds Directive to ensure a favourable conservation status of breeding cormorants in the UK. Inland waters in England support cormorants from a number of breeding populations outside the breeding season. These include coastal *carbo*, mainly from England and Wales, *sinensis* from the continent and both races from the developing inland breeding population in England (Wernham *et al.* 2004).

There is currently no coordinated means of obtaining counts of breeding pairs at inland colonies. For coastal breeding cormorants, counts at colonies have been conducted as part of national seabird censuses, that have taken place at 15 year intervals. Only a small proportion of coastal colonies, however, are counted on an annual or near-annual basis.

The aim of this report is to collate existing data on the population status and trends of breeding cormorants in England, at both inland and coastal sites, in order to support any future assessments of cormorant population change in response to licensed control.

Chapter 1. The status of inland breeding Great Cormorants *Phalacrocorax carbo* in England

1. INTRODUCTION

Before 1981, the Great Cormorant *Phalacrocorax carbo* in England rarely attempted to breed away from coastal cliffs, stacks and offshore islands. This chapter charts the development of nesting at alternative sites (termed "inland", although a number are close to estuaries or open coasts). The first documented occurrence of inland tree-nesting by cormorants in England was in East Anglia in the 1540s (Coward 1928). From this time until the 1940s, inland breeding was reported from five sites comprising one in Suffolk, two in Norfolk, one in Kent, one in Dorset and one in Cumbria (Babington 1884~86; Seago 1977; Taylor *et al*. 1981; Mansel-Pleydell 1888; Stott *et al*. 2002). Pinioned birds and their fully winged offspring are also known to have bred at St James's Park, London (London Natural History Society 1957). At several of these sites, persecution by humans is thought to have halted breeding activity. The relative inaccessibility of coastal colonies in England probably allowed the coastal population to remain at a reasonably high level during this period. Although historical data are scarce, there were an estimated 1,154 pairs of coastal breeding cormorants, all believed to be of the nominate race (*P. c.*) *carbo*, in England in 1969–70 (Cramp *et al*. 1977). Repeat surveys in 1985–88 and 1998–2000 suggested coastal populations of around 1,435 and 1,564 pairs respectively (Lloyd *et al*. 1991; Mitchell *et al*. 2004).

On the near continent, where the breeding race is predominantly (*P. c.*) *sinensis*, population levels were kept low during the 19th and 20th centuries, and distribution restricted, most likely through habitat loss and persecution (van Eerden & Gregersen 1995). Throughout the 20th century there were between 1,000 and 1,200 pairs in the Netherlands, about 1,000 pairs in Denmark and fewer than 400 pairs in Germany (van Eerden & Gregersen 1995). In addition, pesticide contamination during the 1950s and 1960s is thought to have reduced breeding success, causing a further decline in the continental population (Russell *et al*. 1996). Persecution in other parts of Europe is also thought to have reduced breeding numbers; for example, France had fewer than 60 pairs at the turn of the 19th century (Marion 1991). Because of the relatively small size of the continental population, protective legislation was introduced, first in the Netherlands (1965), next in Denmark (1971) and then widely in Europe under Annex 1 of the EC Birds Directive (1979). Protective legislation, for both races *carbo* and *sinensis*, was introduced in Britain under the Wildlife and Countryside Act (1981). The extent of the subsequent population increases were immediate and significant (for a detailed review, see Bregnballe 1996).

In Denmark and the Netherlands the breeding population grew rapidly from 5,800 pairs in eight colonies in 1978 to 61,720 pairs in 116 colonies by 2005 (Bregnballe & Gregersen 1997; van Eerden & Zijlstra 1997; Eskildsen 2005; SOVON unpubl. data). Similar population growth occurred in Sweden from 1980 (Lindell 1997) and in Germany and Poland in the early 1980s (Lindell *et al*. 1995). By the mid 1980s, cormorants were extending their range into central Europe and along the Baltic Sea coast (Lindell *et al*. 1995). During this period, wintering numbers of cormorants in England were increasing (Sellers 1991) and in 1981 an inland tree-nesting colony became established at Abberton Reservoir in Essex (Ekins 1989).

The development of the inland breeding population of cormorants in England between 1981 and 1995 was well documented by Sellers *et al*. (1997). Although a large proportion of inland colonies were monitored between 1998 and 2002 during *Seabird 2000* (Mitchell *et al*. 2004), the development of the inland breeding population in England from 1995 onwards has not been adequately documented. It is of interest here to note that inland breeding has also taken place in Scotland and Wales (in the latter for centuries), and that there are tree-nesting colonies in Ireland. However, these are believed to be of the nominate race *carbo* and are not part of the recent development in England described here.

In this report we update Sellers *et al*. (1997) by presenting an overview of the colonisation and subsequent range expansion of the inland breeding cormorant population in England during 1981–2005. Our current understanding of the origins of inland breeding cormorants in England is discussed in relation to the recent literature, and the findings of some new analyses presented here of ring-recoveries and colour-ringing data.

2. METHODS

2.1 Colony counts

Counts of apparently occupied nests, defined as nests in use and sufficiently finished to hold one or more eggs (Bregnballe & Lorentsen 1998) were obtained through a number of sources: (a) County Bird Reports and correspondence with County Bird Recorders, (b) the BTO Heronries Census by courtesy of the British Trust for Ornithology, and (c) personal communication with birdwatchers, bird ringers and reserve or site managers. Following Bregnballe & Lorentsen (2006) a colony is defined here as a group or groups of nests that are within 2,000 m of one another. Such groups are often referred to as 'sub-colonies'. A single nest is sufficient to be termed a colony as long as it is not located within 2,000 m of other colonies. Whilst considerable effort has been made to compile a complete list of colonies, it is likely that some breeding attempts have been missed, because these have not been reported or details were not available at the time of writing. Despite the large and often conspicuous nest of this species, counts of apparently occupied nests are not necessarily straightforward. Where there was more than one count for a particular site and year, the largest count is reported here. Where observers or recorders have requested it, sites are treated here as confidential.

2.2 Origins of cormorants

Although there are many potential biases in recoveries from metal rings and from colour-ringing data for cormorants, ringing provides an invaluable tool for examining the extent to which different populations contributed to development of the inland breeding population of cormorants in England. We explore here data from two main sources: (a) recoveries from metal rings placed on chicks at coastal colonies in Britain & Ireland (1961–2005), and (b) recoveries and resightings of metal- and colour-ringed cormorants ringed as chicks outside Britain & Ireland (1961–2005).

3. RESULTS AND DISCUSSION

3.1 Availability of inland colony counts

It was possible to obtain counts for almost all known inland cormorant colonies since their establishment until 2005. Inland breeding by cormorants is still a rare occurrence, and for this reason counts of nests are often recorded. In addition, compared with coastal colonies, which can be difficult or impossible to view from land, inland colonies are in most cases easily viewable.

Because we believe that we have obtained close to complete coverage of inland cormorant colonies in England, we do not formally model the trends for this component of the population.

3.2 Development of the inland breeding population

Between 1981 and 2005, cormorants bred successfully in one or more years at 58 inland sites in England, with a maximum of 39 colonies occupied in any one year. Whilst breeding was actively discouraged at a number of these sites, the inland breeding cormorant population in England is estimated in 2005 to have been at least 2,059 breeding pairs (Fig. 1).

During the first seven years of inland colonisation, the breeding population at Abberton grew rapidly from 9 to 310 pairs (Fig. 2). Abberton was the only site at which a colony was successfully established between 1981 and 1988, although successful breeding was reported during these years from a further six sites in Cambridgeshire, Cornwall, Staffordshire, Middlesex and Norfolk (Fig. 3a).

From 1989 to 1994, whereas growth of the colony at Abberton was showing signs of slowing, a further eight colonies were established at Besthorpe Gravel Pits (Nottinghamshire), Stodmarsh (Kent), Dungeness – a ground-nesting colony (Kent), Walthamstow Reservoirs (Essex), Rutland Water (Rutland), Deeping St James (Lincolnshire), Haweswater (Cumbria) and at Lower Derwent Valley NNR (East Yorkshire). Short-lived attempts at colonisation were reported from a further six sites between 1989 and 1994 (Fig. 3b).

The period between 1995 and 2000 was characterised by rapid growth of existing colonies and further colonisation, with colonies established at a further 13 sites. This included the formation of tree-nesting colonies at Harrold Odell Country Park (Bedfordshire), Aldermaston Pits (Berkshire), Chain Corner (Ouse Washes, Cambridgeshire), Drakelow Wildfowl Reserve (Derbyshire), Rye Harbour (East Sussex), Swithland Reservoir (Leicestershire), Holkham NNR (Norfolk), Earl's Barton Gravel Pits (Northamptonshire), Dix Pit (Oxfordshire), a confidential site in Staffordshire, Loompit Lake (Suffolk), Coombe Abbey Country Park (Warwickshire) and at Wheldrake Ings (East Yorkshire). Successful but short-lived breeding was reported from a further 17 sites between 1995 and 2000 (Fig. 3c). These include Willington Gravel Pits (Derbyshire) in 1998 where breeding on a pylon was reported for the first time in England (James & Key 1999), although breeding here was subsequently discouraged. Illegal shooting of cormorants at the colonies of Besthorpe and at Deeping St James, in 2000 at least, are thought to have influenced breeding numbers at these sites.

During 2001–05, colony growth at the older colonies of Abberton Reservoir, Paxton Pits and Besthorpe Gravel Pits stabilised or declined, severely in the case of the colony at Abberton Reservoir, whilst growth continued at the main colonies established during the previous five years. During this time further colonies were established at Rostherne Mere (Cheshire), at a confidential site in Norfolk and at Castle Howard (North Yorkshire). Short-lived breeding was reported from a further 14 sites between 2001 and 2005 (Fig. 3d).

3.3 Origin of inland breeding cormorants

Population modelling work examining the growth rate of the Abberton colony during 1981–1988 showed that there must have been significant immigration into the developing population at this time

(Newson 2000). Evidence for movement to inland sites in England from the continent during the non-breeding and breeding season is provided by recoveries and resightings of metal- and colour-ringed cormorants ringed at *sinensis* colonies principally in the Netherlands and Denmark (Figs. 4 & 5). These include 16 cormorants ringed at colonies in the Netherlands, six in Denmark and one in Sweden that have been present or reported breeding at established tree-nesting colonies in England (April to June).

Whilst there is believed to be a considerable continental *sinensis* influence to the development of the inland breeding cormorant population in England, ringed cormorants from British nominate *carbo* colonies have also been observed at inland colonies during the breeding season (April to June), including three birds from St Margaret's Island (Pembrokeshire) and one from the Farne Islands (Northumberland). The origin of all colour- and metal-ringed birds found to be breeding at inland colonies in England is shown in Fig. 5. Considering the small number of cormorants that have been colour-ringed at coastal colonies in England and Wales, the influence of British *carbo* is likely to be far greater than suggested here. The mixed *carbo* / *sinensis* status of inland cormorant colonies in England at Abberton Reservoir, and at least four other more recently founded inland colonies has been further confirmed by Goostrey *et al*. (1998) using DNA analysis (microsatellite markers) to compare the genotypes of individuals, using feather samples taken from 78 chicks in 1997. Further confirmation has been provided through mitochondrial DNA sequencing (Winney *et al*. 2001). Assessment in the field in 1998 based on physical differences between the two races also suggested a mixed population at Abberton (Newson 2000). Newson *et al*. (2004) have described the museum work examining anatomical differences between *carbo* and *sinensis.*

However, there is evidence that the proportion of *carbo* and *sinensis* breeding at Abberton and now at other inland colonies in England may have changed over time. The percentage of *carbo* at six inland colonies in 1998 shows a relationship with the age of the colony, with older colonies such as Abberton having a higher proportion of *carbo* (Fig 6, from Newson 2000). This may suggest a mechanism whereby inland colonies are founded by *sinensis*, but an increasing proportion of *carbo* join these colonies as they develop. Without monitoring the change in the proportions over time however, it is not possible to prove that there was not a difference from the outset.

Considering the influence of individuals fledged from inland breeding colonies in England to the continued development of the inland breeding population, analyses of colour-ringing data from Abberton has shown that birds from this colony at least have played an important role in the establishment and development of other colonies during the period 1989–94 (Ekins 1996). Cormorants are very faithful to their natal colonies. As a colony grows towards its carrying capacity (the maximum that it can support), however, an increasing proportion of individuals, in particular younger birds, breed at other already established colonies or attempt breeding at new sites. Analysis of colour-ringing data from Abberton has estimated that between 1993 and 1996 about 7% of cormorants hatched in this colony dispersed to attempt breeding elsewhere (Newson 2000). However, in 1997 and 1998, the proportion of individuals dispersing to breed or attempting to breed away from Abberton increased to 12% in 1997 and 18% in 1998 (Newson 2000).

The establishment of new inland colonies tends to be at sites already used by cormorants as night roosts and often increasingly during the summer months by immature birds (Newson 2000). Observations of cormorants displaying, carrying sticks and of nest building attempts by young birds are often made in years prior to successful breeding. Also, perhaps because of the similarity in breeding requirements between cormorants and Grey Heron *Ardea cinerea*, a large proportion of cormorant colonies have been established within or alongside heronries.

3.4 Recommendations for future monitoring

There is currently no coordinated means of obtaining inland colony counts from observers, making the process of collating counts very time-consuming. In addition we do not know to what extent counts represent the maximum numbers of nests. Ideally, nests should be counted several times within the same season, and the maximum number used. Several visits should be made because the observer rarely knows at exactly what time of the season nest numbers can be expected to culminate, which is likely to vary among years and colonies (Newson *et al.* 2005). It should be noted that the maximum number of nests at any one time may be lower than the total number of nests built in the colony. Nests may disappear and new nests built in the colony before the maximum count is made (Harris & Forbes 1987). An improvement to the quality of the counts could be achieved by identifying a network of volunteers able to make several visits to colonies on an annual basis. This would allow counts to be fed directly into a central database. An alternative approach that might be considered would be to relate the number of visits to the % nests observed over time, using data collected from a small number of intensively monitored sites. This information could be used to estimate the number of unobserved nests.

Chapter 2. Status of coastal breeding Great Cormorants *Phalacrocorax carbo* in England

4. INTRODUCTION

Whilst the inland breeding cormorant population in the UK, predominantly of the continental race *sinensis*, has grown considerably since 1981, our long-established coastal breeding population of nominate *carbo* is believed to have remained relatively stable or to be declined in parts of its range (Debout *et al*. 1995; Budworth *et al*. 2000; Mitchell *et al*. 2004). Simple population models suggest that coastal colonies, which fledge considerably fewer chicks per brood (Newson *et al*. 2005) and have lower annual survival (Newson 2000) than the ‘new’ inland breeding colonies, are more susceptible to natural variation in these parameters.

The aim of this chapter is to assess how well we are currently monitoring the coastal breeding cormorant population in England, and to produce a new set of population estimates for this population. In the past annual population indices have been derived for cormorants using log-linear model with Poisson error terms, where counts are modelled as a function of site and year effects or using a simple chain index (e.g. Mavor *et al*. 2004). In this paper we apply an alternative approach developed by Thomas (1993) that is less prone to bias and uses all available data to estimate annual population changes. This approach has already been applied successfully to data from the BTO Heronries Census (Marchant *et al*. 2004). This method is based on Mountford’s (1982) use of weighted averages of indices, calculated over a moving window spanning a few years before and after each survey year, although Thomas extended this method to estimate missing colony counts.

5. METHODS

5.1 Colony counts

Counts of apparently occupied nests (Bregnballe & Lorentsen 2006) for the period 1986-2005 were available from a number of sources: (a) Joint Nature Conservation Committee (JNCC) Seabird Monitoring Programme (SMP), (b) JNCC Seabird Colony Register (SCR), (c) JNCC/RSPB *Seabird 2000* (Mitchell *et al*. 2004), and (d) County Bird Reports. The selection of counted colonies has depended on the availability of volunteer observers and their choice of sites. Whilst all colonies extant in England between 1986 and 2005 are believed to have been surveyed in one year or more over this period, monitoring is largely unstructured. More systematic surveys were conducted as part of the Seabird Colony Register (SCR) conducted mostly in 1985-88 and for *Seabird 2000*, carried out between 1998 and 2002. Whilst several colonies are visited almost every year, other sites have been visited in only a few years of the series. The resulting count data are patchy and not sufficiently extensive in any single year to allow a reliable estimate to be made of the total population size. Where there was more than one count made in a particular year, we use what is believed to be the most reliable count or the maximum count where this distinction cannot be made.

A further complexity with coastal colonies is that the location of breeding birds may shift noticeably in part or completely between years, between sites termed here 'complementary colonies', which can be several kilometers from one another (Sellers & Hughes 1996). It would be best to treat complementary colonies as single sites for the purposes of analyses, where data are available for the same or the majority of years. However, there are no obvious complementary colonies in England, for which counts have been collected concurrently.

For purposes of analyses, colonies not surveyed in a particular year are assigned to one of four mutually exclusive categories: (i) 'not started' if it is known that the colony did not become established until a later year; (ii) 'not counted' if the site was known to be active but not counted; (iii) 'missing' if there was not known whether the colony was still occupied; or (iv) 'extinct' if the colony is known to have become extinct, for example if its count falls to zero and is then followed by a series of 'missing' codes.

Between 1986 and 2005, there were 80 colonies for which at least one annual count had been made. Annual numbers of sites in each of the categories of not started, extinct or missing are shown in Fig. 7. This Figure highlights the increase in coverage in 1987 and 1999-2000 as a result of systematic surveys in these years.

5.2 Analytical approach

If y_{pq} is a count made at colony *p* in year *q*, then an estimate Y_{ij} for a colony *i* not visited in year *j* can be based on a count made at the same colony when surveyed in year *q*. This is $Y_{ij} = y_{iq}r_{qj}$, where r_{qj} is the ratio estimate (Cochran 1977)

$$r_{qj} = \frac{\sum y_{tj}}{\sum y_{tq}} \tag{1}$$

The summations are carried out over colonies *t* counted in both years *j* and *q*. The years do not need to be consecutive and can be based on any appropriate year *q*. Thomas (1993) combined these into a single estimate by combining them in a weighted average, thus

$$Y_{ij} = \sum a_{iq} y_{iq} r_{qj} \tag{2}$$

where the summations are carried out over the n_q years, which may be before or after year j, that provides a valid ratio estimate r_{qj}. In this work we use a simple arithmetic mean, i.e. $a_{iq} = 1/n_q$. In this way, counts can be estimated for unsurveyed sites. These can then be used to produce an estimate of total population size. To do this we assume that all colonies have been surveyed at least once over the period of interest. We evaluate the population Y_j, in year *j* by adding up the observed counts y_{ij} , where counts have been made, and a weighted sum of the estimated counts Y_{ij} where no count was made (but there was no information that the colony had become extinct, or had not yet become established) as follows

$$Y_j = \sum_{observed} y_{ij} + \sum_{active} Y_{ij} + \sum_{missing} p_j Y_{ij} \qquad (3)$$

where the summations refer to the counts actually observed, the estimated counts for colonies not surveyed but known to be active, and counts for colonies not surveyed but of uncertain occupancy for which an annual weighting p_j is included. Sites that are not yet established or are known to be extinct in a given year do not contribute to the index for that year. In this model we assume that all colonies extinct at the end of the series have been identified, and that new colonies are established at such a rate that they balance extinctions and the number of active colonies remains constant. To do this we use the weighting p_j to set the number of sites that were either extinct or yet to establish to be equal to the number of extinct colonies recorded in 2005. This weighting is required because it is impossible to know how many observations refer to the absence of colonies or which colonies are active.

Confidence intervals are produced using a bootstrapping procedure, where for N colonies 1,000 bootstrap replicate samples of size N are drawn with replacement and the model fitted to each. Because it is assumed that sampling is complete, in that every colony is recorded at some point in the time series, rather than being a sample of a wider population, we produce bootstrapped confidence intervals that reflect the uncertainty in the estimation of missing counts, but not the variation between different sets of observed counts sampled from the data. This is performed by calculating $R_j = Y_j / \sum y_{ij}$, the ratios of the estimated indices to the annual counts, and derive percentiles for these. These were then multiplied by the actual counts to produce confidence intervals.

6. RESULTS AND DISCUSSION

6.1 Population estimates for coastal breeding cormorants

Between 1986 and 2005, cormorants bred at 80 colonies in England. The majority of these are in the south-west of the country, with a smaller number of colonies in south, north-east and north-west England and the Isle of Man (Fig. 8).

Estimates for the coastal breeding cormorant population in England 1986-2005, suggest that this population has remained stable over this period, at approximately 2,000 pairs (Fig. 9). This is in agreement with Mitchell *et al*. (2004), although the absolute level of the population is estimated here to be higher than suggested earlier. Particularly large confidence intervals in 1989 and 2003 reflect particularly poor coverage in these years. In Fig. 10, population size estimates are shown in comparison to the number of apparently occupied nests counted.

To examine whether it was possible to produce regional trends, the data were divided into colonies in Northern and Southern England, for which there is a clear split in distribution. The data were sufficient to produce trends for Southern England (Fig. 11.), which have remained relatively stable, but it was not possible to do the same for Northern England.

6.2 Recommendations for future monitoring

Colony counts for coastal breeding cormorants have mainly been collated by JNCC's Seabird Colony Team through the SCR, SMP and *Seabird 2000*. However, only a small proportion of colonies are counted on an annual or near-annual basis. This is mainly a reflection of the difficulty in surveying coastal colonies, which are on coastal cliffs, stacks or offshore islands and in many cases not viewable from land. For many colonies boat-based surveys or aerial surveys would be required. Even where the colony is accessible, the observer may also be forced to count at a suboptimal time because of poor weather conditions, or to skip counting a colony completely in a particular year. Whilst it would be possible to improve coverage of accessible colonies, the only way to obtain a high level of coverage would be to carry out aerial surveys (for ground-nesting colonies) and boat-based surveys for (cliff-nesting colonies). At the other extreme, it is important to maintain annual monitoring at a sufficient level to avoid the situation in 1989 and 2003, where we have little ability to detect any change in the population. Because inland waters in England also support wintering cormorants from coastal breeding populations from Wales and Scotland, repeating this work for these countries also should be considered.

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Figure 1. Population growth (line) and number of inland cormorant colonies active (columns) in England between 1981 and 2005.

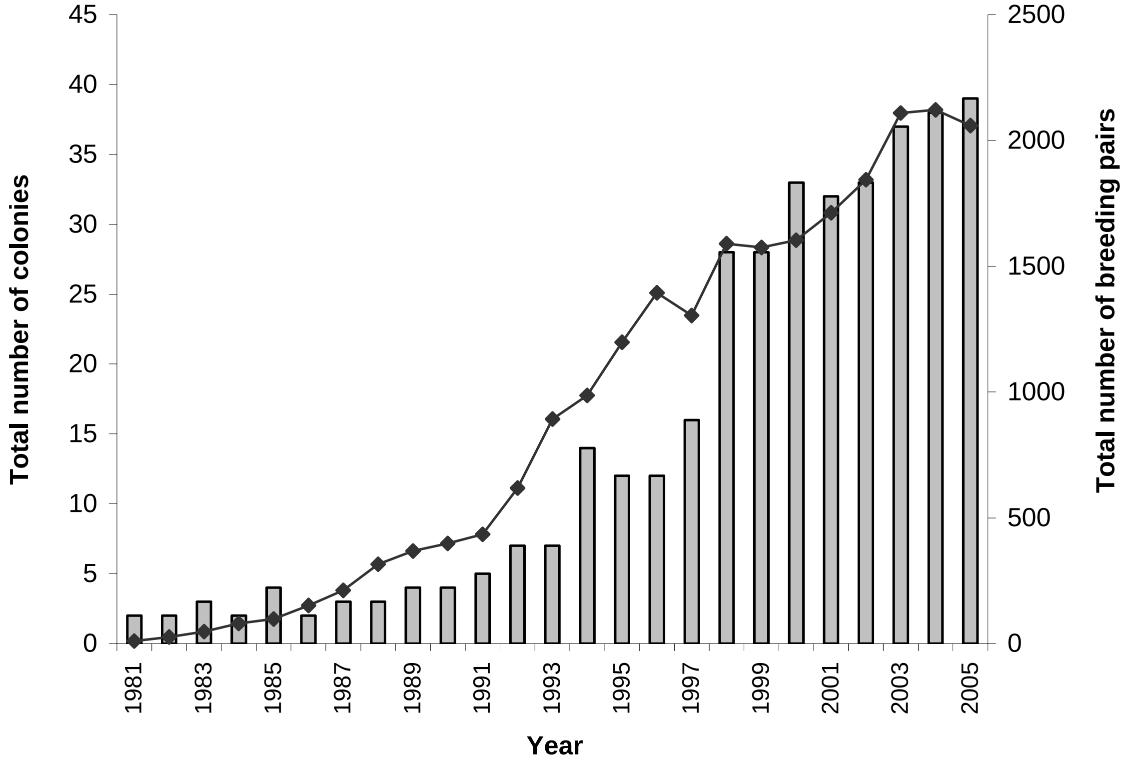


Figure 2. Colonisation and development of the cormorant colony at Abberton Reservoir, Essex (1981–2005).

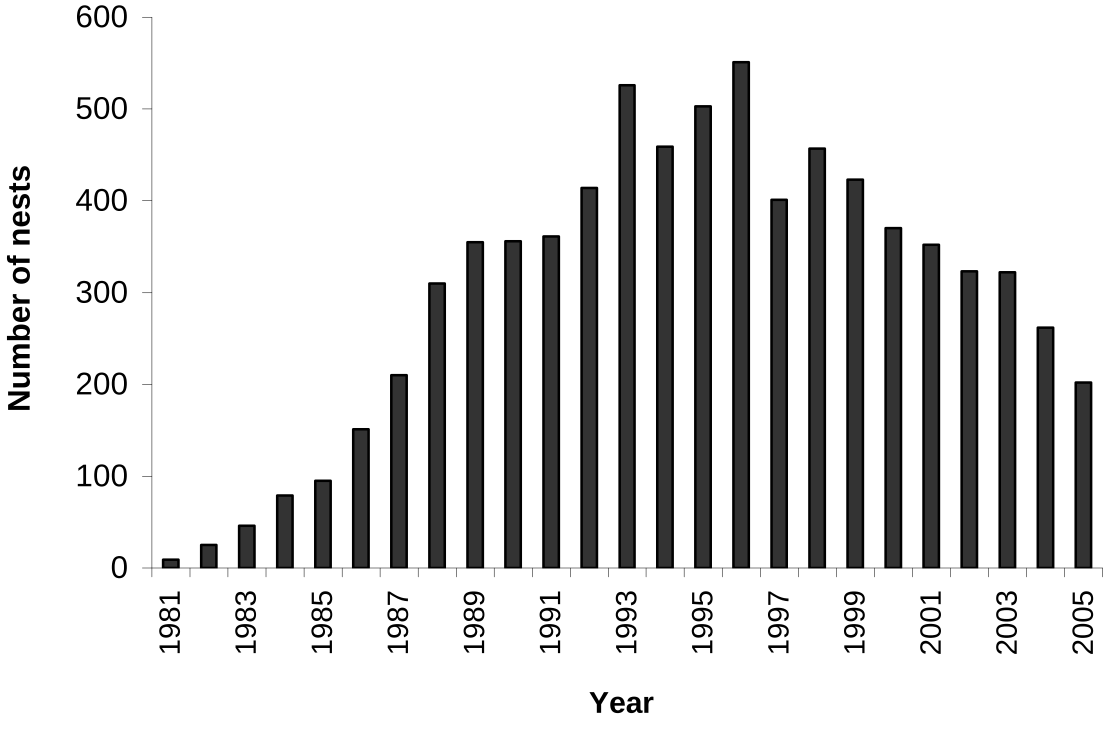
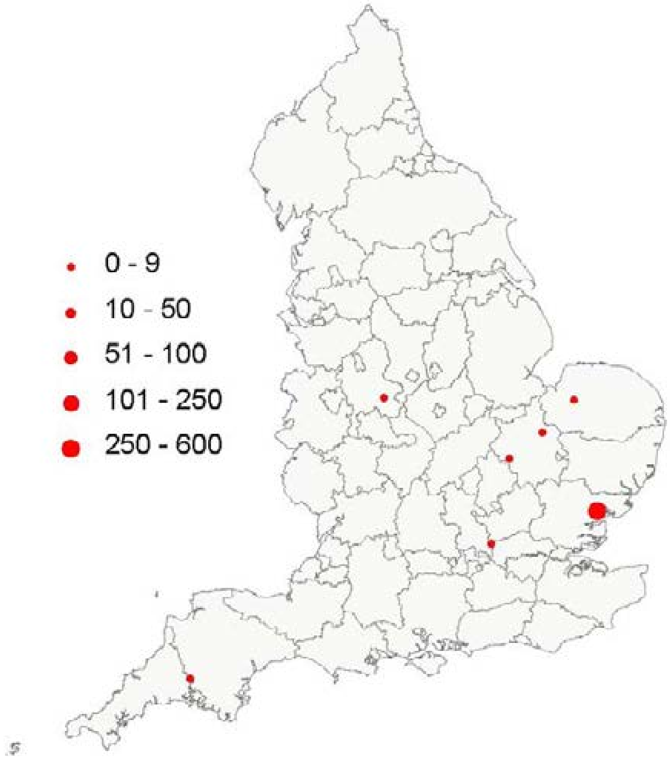
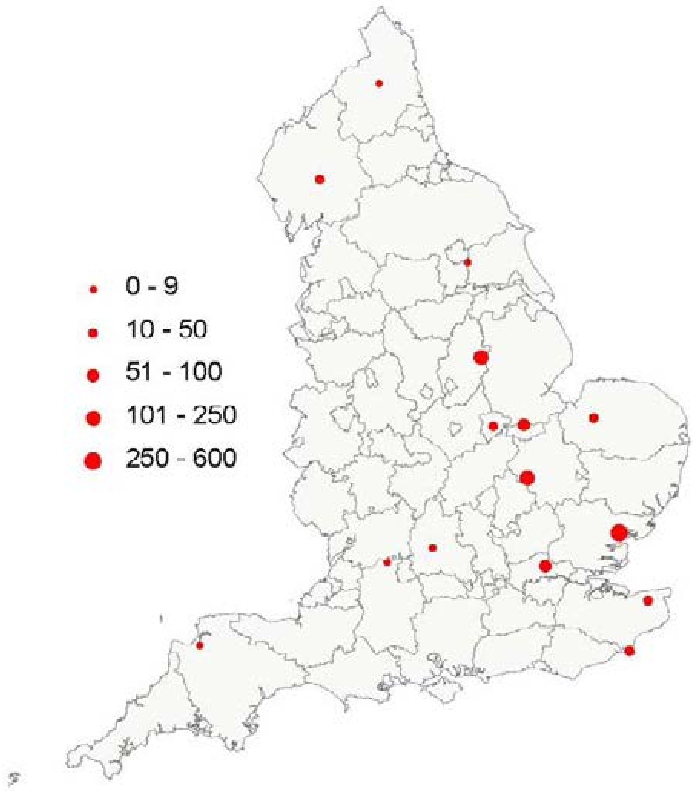


Figure 3. Inland cormorant colonies in England with successful breeding in one or more years: dot size indicates number of apparently occupied nests at each site. Confidential sites are shown centrally within their counties.

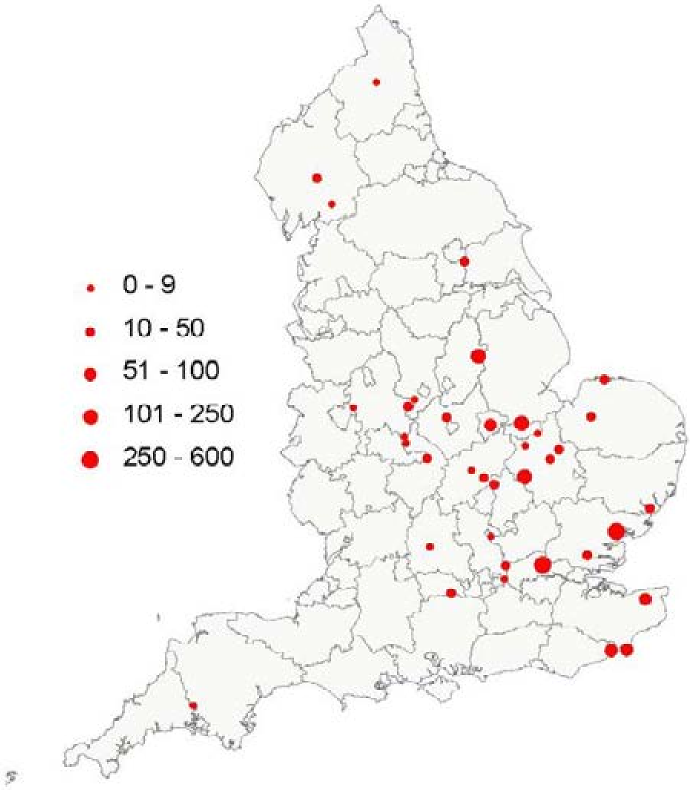
a) 1981–88



b) 1989–94



c) 1995–2000



d) 2001–05

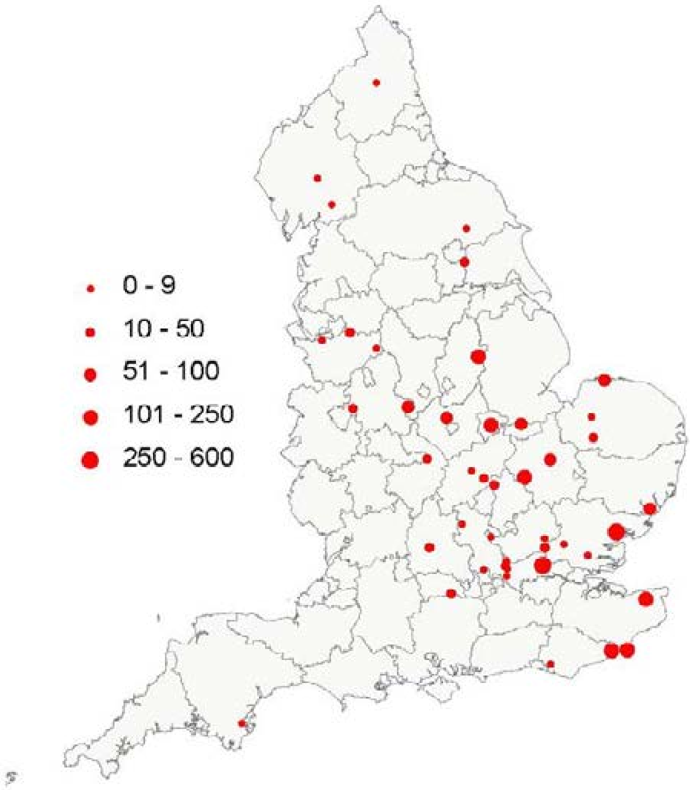
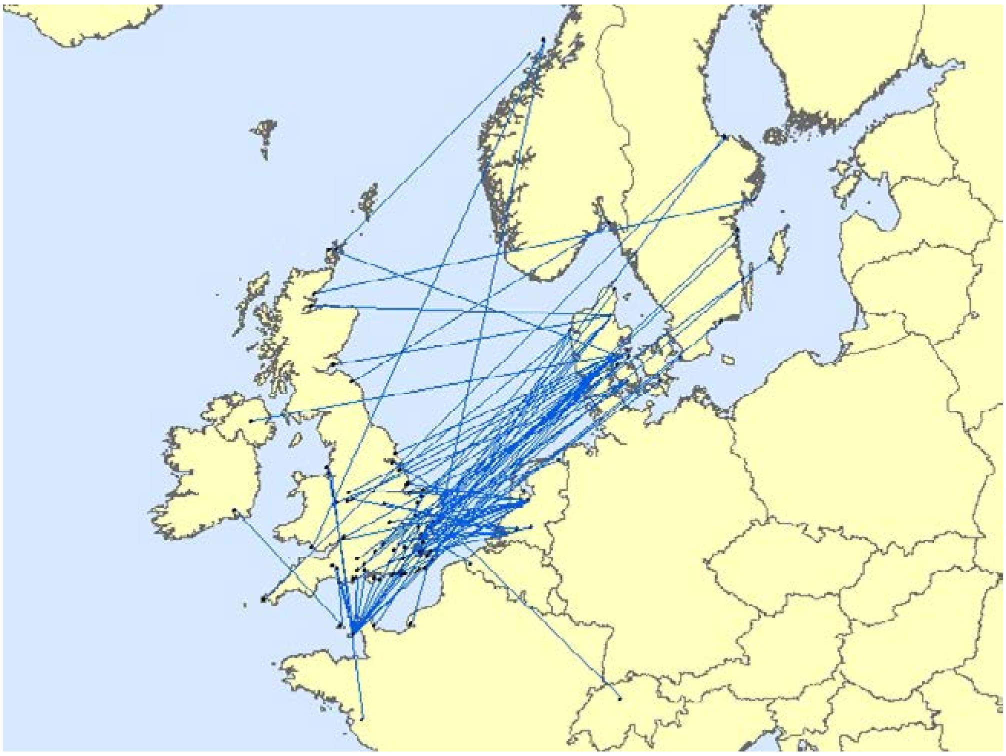


Figure 4. Recoveries and resightings of cormorants ringed in predominantly *P. c. sinensis* colonies on the continent and reported in Britain or Ireland outside the breeding season, between July and March. This will include cormorants on spring and autumn passage as well as wintering birds.

a) Cormorants metal–ringed on the continent.



b) Cormorants colour-ringed on the continent.

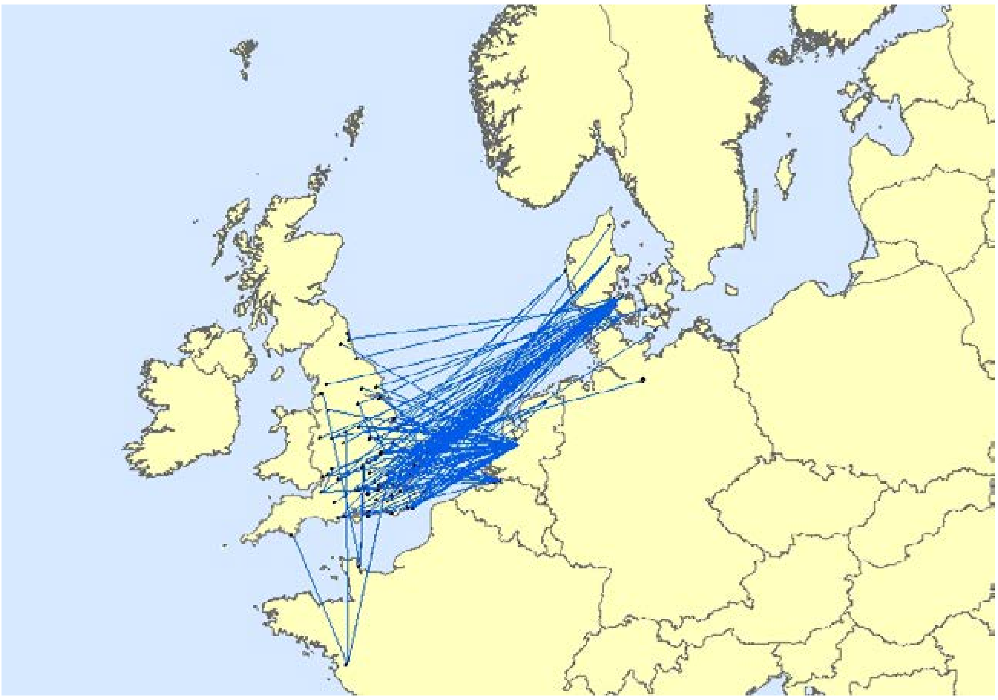


Figure 5. Origin of cormorants ringed at coastal *P. c. carbo* colonies in Wales or *P. c. sinensis* colonies in the Netherlands or Denmark and breeding or present at inland colonies in England during the breeding season (April–June).

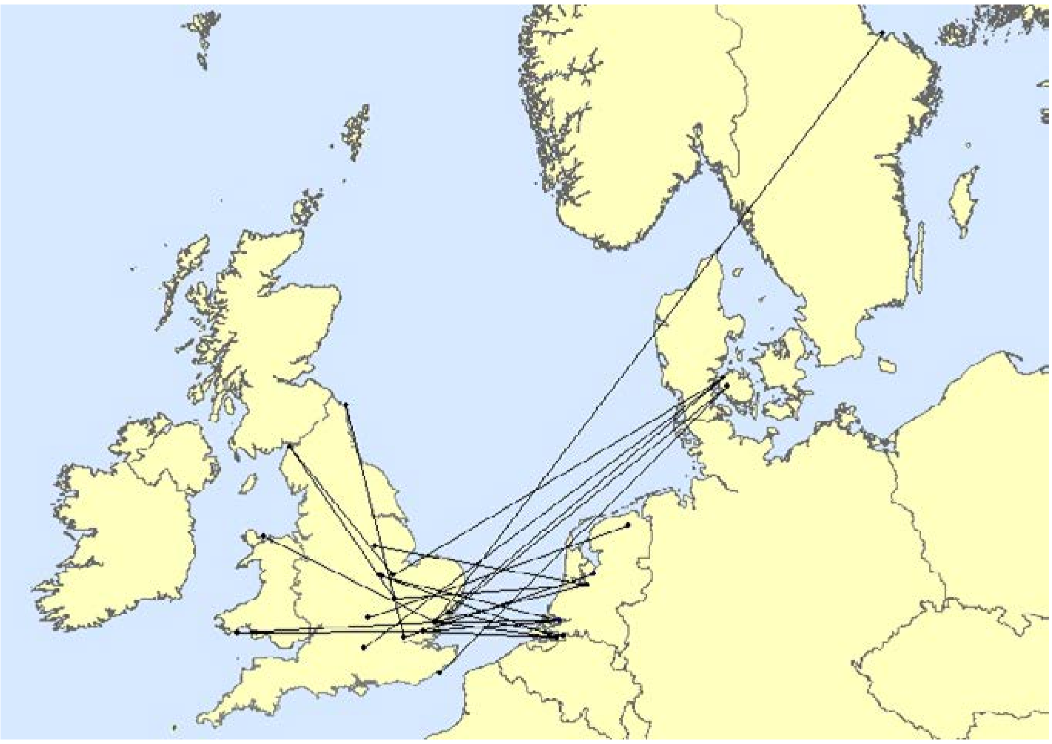


Figure 6. Relationship between years since establishment of inland cormorant colonies in England and percentage of *P. c. carbo*, based on field observations during the 1998 breeding season (Spearman rank-order correlation: $r_{1,5} = 0.98$, $P < 0.001$). Taken from Newson 2000.

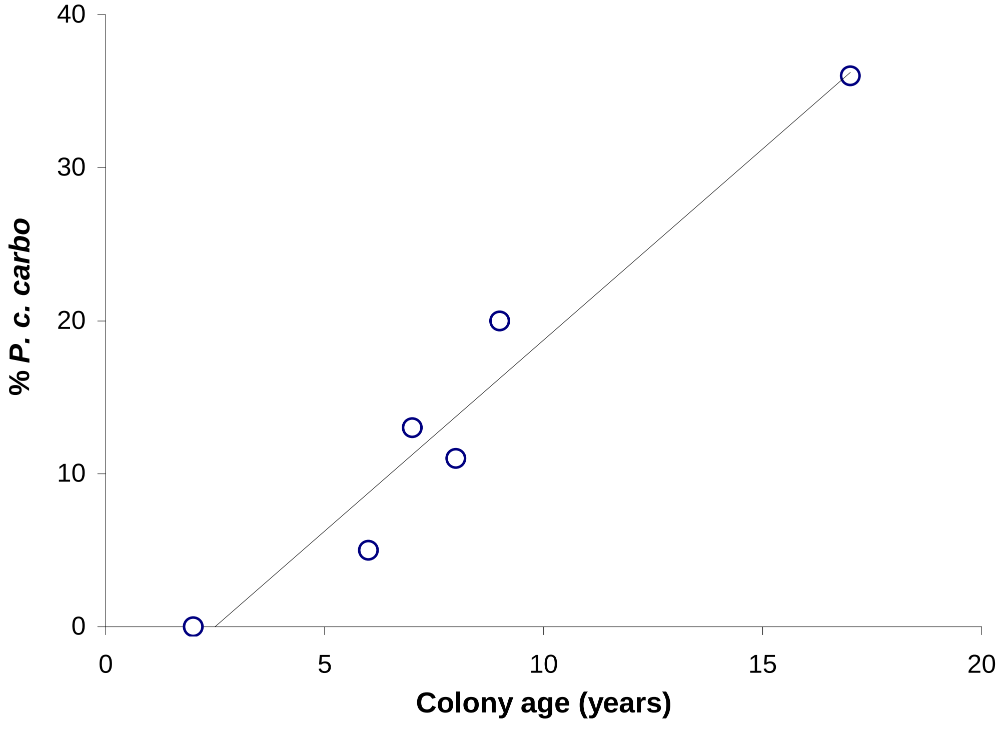


Figure 7. Number of coastal cormorant colonies in England during the period 1986-2005 classified according to the status categories extinct, not started and missing.

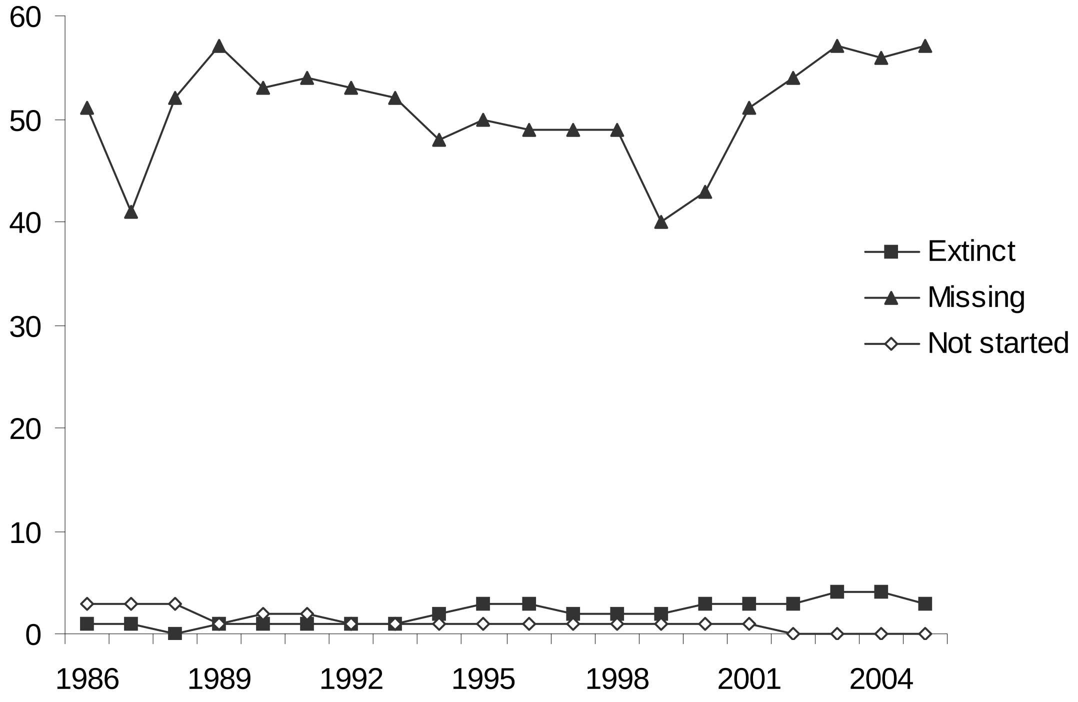


Figure 8. Coastal cormorant colonies in England where breeding occurred in one or more years between 1986 and 2005.

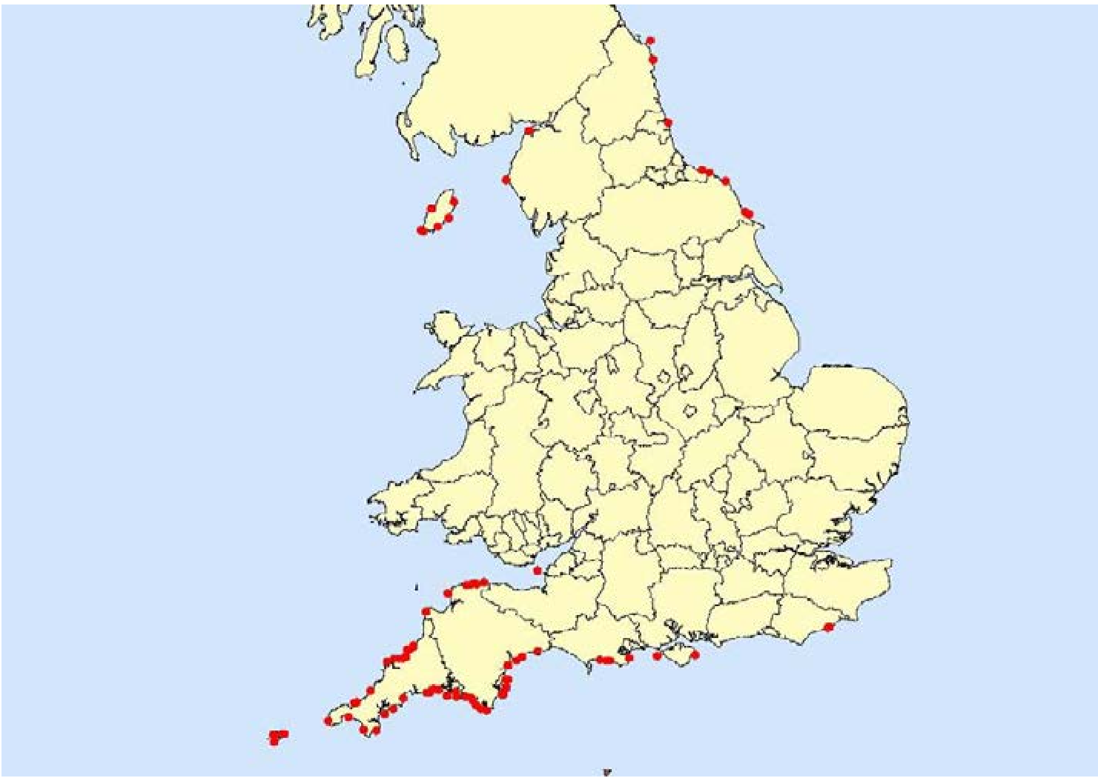


Figure 9. Estimates of coastal breeding cormorant population in England: 1986-2005, with 95% confidence intervals.

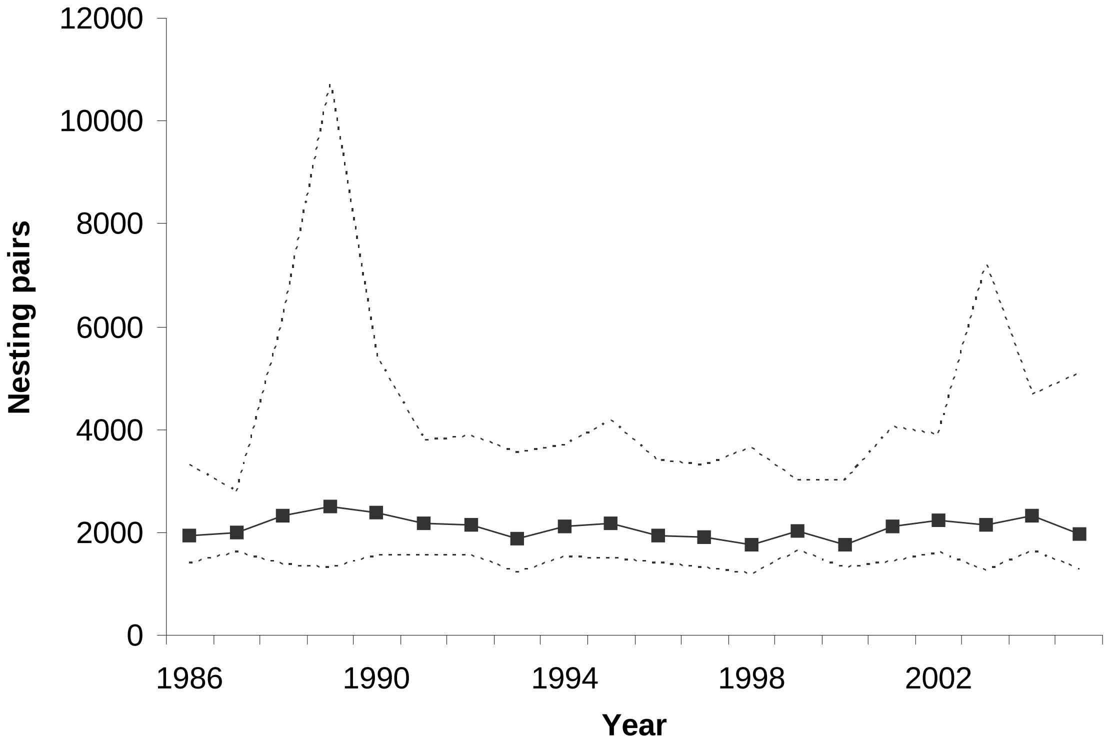


Figure 10. Estimates of coastal breeding cormorant population in England in relation to the number of apparently occupied nests counted: 1986-2005.

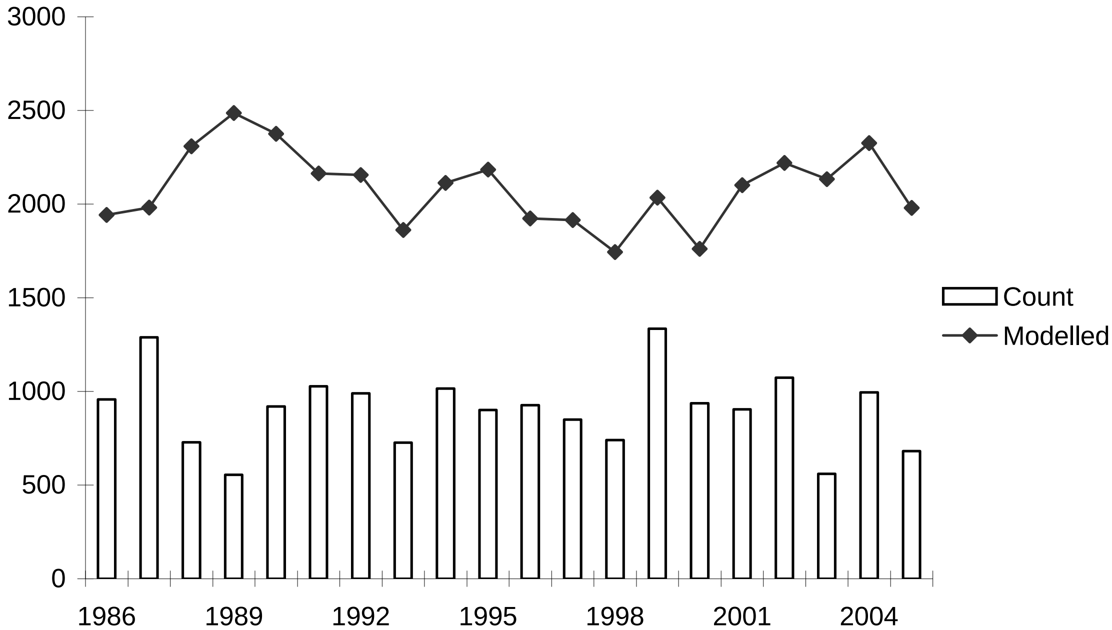
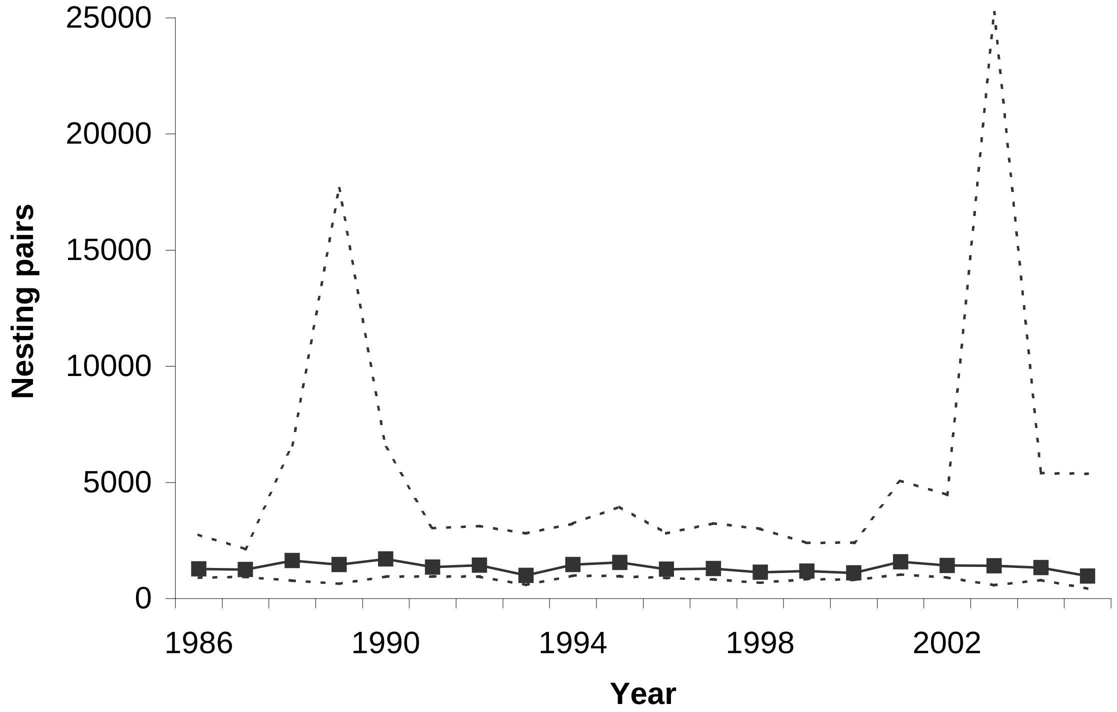


Figure 11. Estimates of coastal breeding cormorant population in Southern England: 1986-2005, with 95% confidence intervals.


25000
20000
15000
10000
5000
0
Nesting pairs
1986
1990
1994
1998
2002
Year