POPULATION CHANGE AND RESILIENCE IN GENTOO PENGUINS *PYGOSCELIS PAPUA* AT THE FALKLAND ISLANDS

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SUMMARY

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Data on population size and breeding success of Gentoo Penguins *Pygoscelis papua* at the Falkland Islands have been collected since 1990 as part of the Falkland Islands Seabird Monitoring Programme (FISMP). During the austral summer of 2005/2006, the third five-yearly survey of all Gentoo Penguins breeding in the Falklands Archipelago was undertaken. Results are presented and compared to previous population estimates. The number of breeding pairs in 2005/2006 was estimated at 65,857, a decline of 42% since 2000, which was attributed largely to paralytic shellfish poisoning resulting from a harmful algal bloom event in 2002. Based on a selected number of colonies that were monitored annually, the population increased by over 95% since 2005, and numbered a record high of some 128,500 breeding pairs in 2008. On average, annual breeding success was 1.01 (ranging between 0.51 and 1.44) chicks per breeding pair. Although no particular trend was evident, breeding success was above average between 2004 and 2008 which is likely to contribute towards future population growth.

Key words: Gentoo Penguins, *Pygoscelis papua*, censuses, breeding success, population growth, seabirds

INTRODUCTION

Gentoo Penguins *Pygoscelis papua* have a circumpolar distribution, breeding between 46 and 65°S on sub-Antarctic islands and on the Antarctic Peninsula (Woehler 1993). Numerically, the Falkland Islands' population is of global importance (Croxall 1992, 1994). In the mid-90's they were estimated to comprise 40% of the world population (Woehler & Croxall 1997, Clausen & Huin 2003) and changes in this population will have a large impact on the status of this "Near Threatened" species (BirdLife International 2009).

Situated in the South Atlantic Ocean (between 51-53°S and 57°30'-61°30'W), the two main islands and some 750 smaller islands making up the Falklands archipelago cover an area of 12,173 km^2 (Woods 2001), of which many coastal areas comprise suitable breeding habitat for Gentoo Penguins (Woods & Woods 1997). The population decreased from about 116,000 pairs in 1932/33 (Bennett 1933) to 65,000 pairs in 1995/96 (Bingham 1998). The population subsequently increased to 115,000 breeding pairs in 2000/2001 (Clausen & Huin 2003).

Gentoo Penguins are important top predators in the Southern Ocean, particularly in inshore waters (Williams *et al.* 1992, Clausen & Pütz 2003). Falklands Conservation has been monitoring numbers and breeding success of Gentoo Penguins annually at selected study colonies in the Falklands since 1990 (Thompson & Riddy 1993, Pistorius 2009). Monitoring has been performed, not only to assess their population status, but also as a means of detecting change in the marine environment (Bost & Le Maho 1993). In conjunction with this annual monitoring programme, archipelago-wide surveys of Gentoo Penguins have been undertaken on a five-yearly basis, commencing in 1995/96 (Bingham 1998).

The aim of this paper is to report on results of the survey conducted in 2005/2006 and to describe temporal patterns in breeding numbers and success from selected colonies that are monitored annually. We highlight the rapid population recovery following a mass mortality event, demonstrating a high level of resilience in this population.

METHODS

The archipelago-wide Gentoo Penguin survey was conducted from 2 to 30 November 2005. The islands were divided into three parts, each covered by a different team. The location and number of colonies were known based on previous surveys and consultation with land owners. Only two of these, making up 2% of the total population based on the 2000 survey (Clausen & Huin 2003), were not counted. The timing of the survey and techniques used were consistent between this and the previous two surveys. For the remainder of this document, only the year at the onset of the breeding season will be noted i.e. 2000/2001 will be referred to as 2000.

Direct counts of active nests were performed at each of the Gentoo Penguin colonies. Using tally counters, at least three counts were made, either from a vantage point or by walking slowly around the perimeter of the colony (Thompson & Riddy 1993, Ingham 1998). If counts differed by more than 5%, they were repeated and averaged.

Pre-fledged chicks were counted during January and breeding success was estimated by dividing the number of pre-fledged chicks

produced by the number of incubating pairs, which were counted at the onset of the breeding season. Since 1990, the number of colonies monitored each year varied between two and 17, comprising a total of 20 different colonies. Breeding success estimates are based on the colonies monitored for the respective years.

Since 2000, counts have been undertaken at the same 15 colonies ("annually monitored colonies", Fig. 1), with the exception of Bertha's Beach and Fox Point, which were not counted in 2001, and Steeple Jason, which was not counted in 2001 and 2002. To allow for a comparison of the total number of breeding pairs from these colonies since 2000, estimates for these years were extrapolated from existing data. This was based on calculating the average change between the year from which colony counts were missing and the year prior to this from the remaining colonies. Assuming similar inter-annual variability between colonies, this was then used to estimate the missing values.

The change in these cumulative numbers from the 15 colonies was compared to the concurrent change observed for the entire population between the past two island-wide surveys (2000 and 2005). This was done to assess how closely temporal variation in cumulative counts from the monitored colonies reflect similar variation in the entire population.

RESULTS

A total of 84 Gentoo Penguin colonies were counted and numbers ranged from seven to around 7,000 breeding pairs (Fig. 1). The total number of breeding pairs was estimated at 65,857, which represents a decrease of 42% between 2000 (when the population was estimated at 113,571) and 2005. The population estimate in 2005 was similar to the count of 64,426 breeding pairs in 1995 (Fig. 2).

The decrease in numbers was not consistent among colonies, with 21 of the 84 colonies (37%) increasing during this period. In total, 22,604 pairs were located on 17 outlying islands, 20,030 pairs at 36 sites on East Falkland and the remaining 23,223 pairs at 32 sites on West Falkland.

Between 2000 and 2005, counts at the annually monitored colonies followed a similar trend to the population as a whole, decreasing by 42.3% and 42.0% respectively. However, between 1995-2000 the annually monitored colonies increased by 76.2%, whereas the total population increased by 50.4%.

Since 2000, and including 1995, the total number of breeding pairs from the annually monitored colonies varied between 9,956 in 2003 and 21,669 in 2008 (Fig. 2). From 2007 to 2008, the number of breeding pairs in these colonies increased by 53.5%.

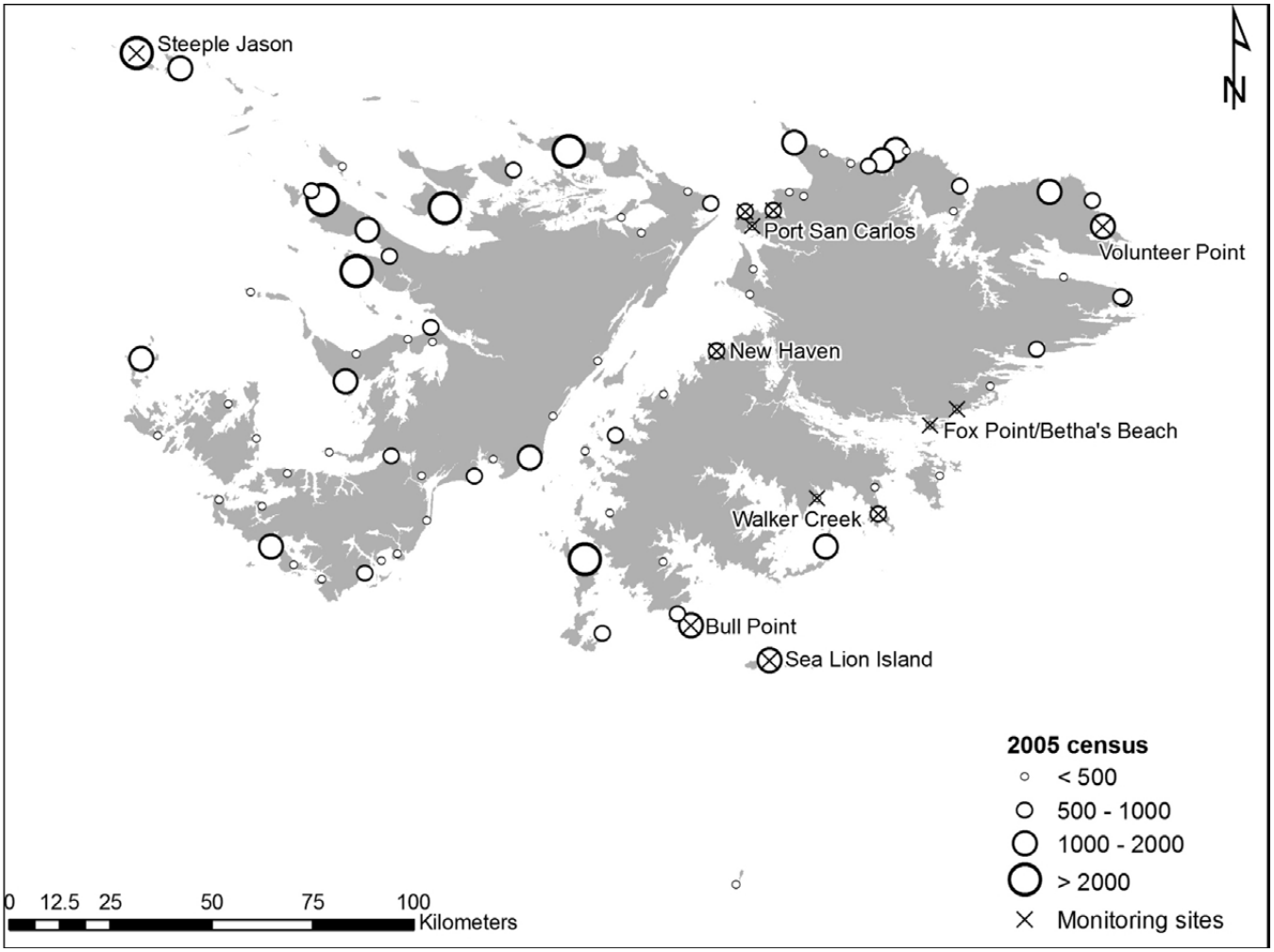

Fig. 1. Distribution of Gentoo penguin colonies and sites that are being monitored annually around the Falkland Islands.

Since 1990, breeding success of Gentoo Penguins fluctuated between 0.51 and 1.44 chicks per breeding pair, averaging 1.01 (Fig. 3). Breeding success was above average between 2004 through 2008 (averaging 0.27 chicks per pair more during this period compared to the entire study period).

DISCUSSION

With the exception of King Penguins *Aptenodytes patagonicus*, most monitored penguin populations in the sub-Antarctic have been decreasing over the past few decades (Woehler *et al.* 2001, Crawford *et al.* 2003, Delord *et al.* 2004, Lescroël & Bost 2006). Until recently the same pattern held for Gentoo Penguins, but several populations in the South Atlantic Ocean, including the South Orkney Islands (Forcada *et al.* 2006) and throughout the Antarctic Peninsula (Lynch *et al.* 2008) have been increasing recently. This is in part related to the southward expansion of their breeding and foraging ranges due to the contraction of sea ice around Antarctica (Forcada & Trathan, 2009). Although the Bird Island population at South Georgia has shown a long-term decrease (Woehler & Croxall 1997), there have been some indication since that this population may now also be on the increase (British Antarctic Survey, unpublished results).

Although the Falklands' population of Gentoo Penguins has been increasing since 2003, numbers have fluctuated widely from 64,426 in 1995, increasing by 79% to 113,571 in 2000, and decreasing by 42% to 65,857 in 2005. The 1995 estimate was relatively low and followed a period of decrease (Bingham 1998). Reasons for this are unknown, although egging and competition with commercial fisheries have been suggested (Woods & Woods 1997, Bingham 1998). The decrease from 2000 to 2005 can be attributed largely to mass mortality from paralytic shellfish poisoning resulting from a harmful algal bloom event in November 2002 (Huin 2003, Uhart *et al.* 2004). Poor recruitment into the adult population due to low breeding success during most years between 1998 and 2000 (Fig. 3) may also have contributed to the decline in numbers. Following 2003, the population increased sharply, and based on the patterns observed from the monitored colonies, numbers at present are 13.3% higher than in 2000. This would imply a population of some 128,500 breeding pairs (the highest on record), almost doubling (95.4% increase) since the 2005 survey. Between the past two surveys, changes in numbers of breeding birds at the monitored colonies varied to the same extent as the total island population, lending some confidence to the above population estimate. It is, however, important to note that such interpolated data, especially from species with large temporal and spatial variability in breeding numbers, should be treated with caution. This similarly applies to the 2001 and 2002 cumulative estimates of breeding numbers from the monitored colonies, in which case counts were interpolated for some colonies for which counts were not performed.

Using a conservative world population estimate of some 317,000 pairs (Ellis *et al.* 1998), the Falklands Gentoo Penguin population made up about 21% of the world population of this species in 2005. Based on the increase in the Falklands population since 2005, and not taking into account changes in other populations since 1998, the world population is now closer to 380,000. Currently (in 2008) the Falklands probably represents the largest population (followed by South Georgia, 90,000 pairs; Williams 1995), making up 34% of the world population. As is the case at the Falklands, large fluctuations (inter-annual to decadal scales) in Gentoo Penguin numbers have been observed elsewhere (Woehler & Croxall 1997, Woehler *et al.* 2001) making the world population, and the proportions of its constituent populations, particularly dynamic.

Gentoo Penguin breeding success ranged widely, with almost a three-fold difference between the lowest estimate of 0.51 in 1990 and 1.44 in 2007. This variation not only translates into large fluctuations in breeding numbers but also contributes to the high resilience observed for this species. Other estimates of breeding success include 1.38 for an increasing population on the Antarctic Peninsula (Quintana & Cirelli 2000), 0.64-0.71 and 0.38 for the decreasing populations on Iles Kerguelen (Lescroël & Bost 2006) and Marion Island (Crawford *et al.* 2003) and 0.93 for the population of uncertain status on Macquarie Island (Holmes *et al.* 2006). Assuming a mean age of first breeding of three, adult survival of 85%, and survival in the first two years of 80% (Croxall & Davis 1999), a breeding success of 0.55 is required to maintain population equilibrium (Crawford *et al.* 2003). During this study, the Falklands population has far exceeded this in terms of reproductive output, with the lowest estimate being slightly lower than 0.55. Based on this, and the large population fluctuations reported here, it appears that survival rather than fecundity has been limiting population growth. This is in contrast to neighbouring South Georgia where the population is disproportionately affected by the consequences of infrequent years of very low breeding success (Croxall & Rothery 1995). The high breeding success observed in

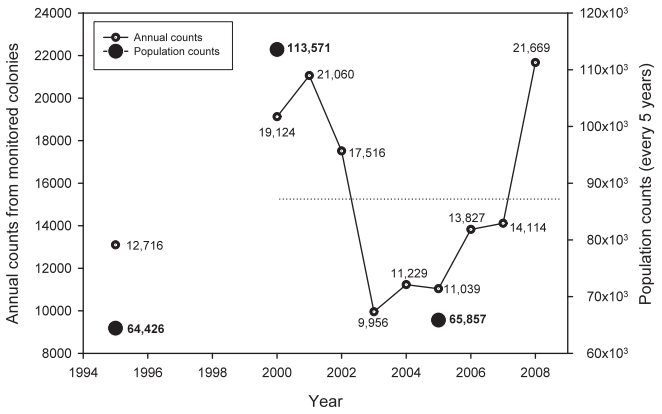

Fig. 2. Cumulative counts of breeding pairs of Gentoo Penguins from annually monitored sites and 5-yearly islands-wide counts.

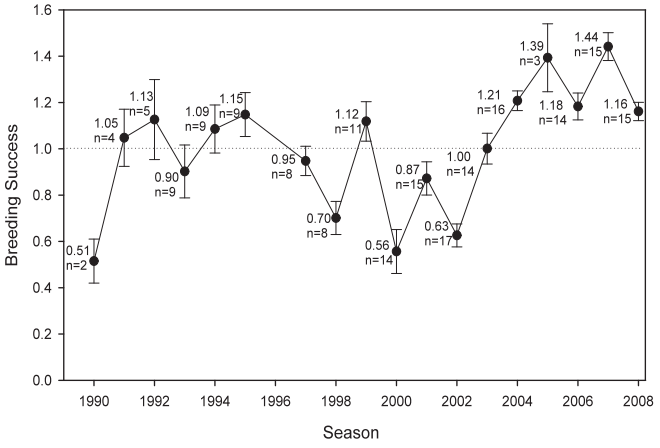

Fig. 3. Average annual breeding success (±SD) of Gentoo Penguins at the Falkland Islands.

the Falklands population during 2004-2008 is likely to contribute towards continued population growth in the near future, but only if moderate to high survival is sustained.

Complete breeding failure is not atypical for Gentoo Penguins, and generally occurs at sites where Antarctic Krill *Euphausia superba* makes up a large part of the diet (Croxall & Rothery 1995, Croxall *et al.* 1999, Crawford *et al.* 2003, Ashburner 2009). Complete failure has not been observed at the Falklands, perhaps because Gentoo Penguins there are more opportunistic in their foraging than elsewhere (Croxall *et al.* 1999, Pütz *et al.* 2001). At least some of their prey items around the Falkland Islands probably remain in sufficient quantities to help Gentoo Penguins evade breeding failure during any given year.

Gentoo Penguins are mainly inshore foragers (Adams & Wilson 1987, Croxall *et al.* 1988, Williams 1995, Boersma *et al.* 2002, Clausen & Pütz 2003), rarely observed more than several kilometres offshore (White *et al.* 2002). Due to their restricted foraging range, they are highly dependent on local resources during both the breeding and non-breeding periods (Williams *et al.* 1992a, 1992b). At the Falkland Islands, they take a mixture of cephalopods, crustaceans and fish (Pütz *et al.* 2001). At some localities in the Falklands the commercially fished Patagonian Squid, *Loligo gahi*, makes up over 50% of the diet in terms of mass, while Lobster Krill *Munida gregaria* has been found to be numerically the most abundant prey item (Pütz *et al.* 2001, Clausen & Pütz 2003). The commercial fishing fleet targeting *L. gahi* catches a mean of about 60,000 t per annum (Falkland Islands Government 2001), and potential competition between penguins and the fishing fleet has been suggested as a factor limiting population growth (Clausen & Pütz 2003). Competition also exists for Southern Blue Whiting *Micromesistius australis*. Although much smaller specimens are targeted by penguins, fisheries could potentially impact on recruitment within the target species (Clausen 2001, Pütz *et al.* 2001, Huin 2003).

Penguins are generally thought to be sensitive to climate change (Barbraud & Weimerskirch 2001, Jenouvrier *et al.* 2005, Trathan *et al.* 2006, Boersma 2008, Ainley *et al.* 2010), particularly when situated at the edge of their distributional range (Forcada & Trathan 2009). Although gradual ocean warming may result in a pole-ward shift in geographic distributions of penguins (Forcada *et al.* 2006), increases in inter-year variability associated with global warming (particularly an increase in frequency and intensity of inter-annual variation in Sea Surface Temperature (SST); IPCC 2001) is also likely to have an impact on penguin populations. The long-term effect of this on population dynamics will largely be governed by species-specific life-history traits, and the ability of populations to recover following mass mortality events. Gentoo Penguins, for example, are currently increasing their range as ice-free areas open up (Forcada *et al.* 2006, Lynch *et al.* 2008). They are, however, apparently intolerant of short periods of severe food shortage (Croxall & Davis 1999). As a result of their spatially restrictive foraging behaviour, localised SST anomalies that negatively impact on their food resources could result in high mortality events or reproductive failure. The potential for high reproductive output (as observed in this study) and an early onset of sexual maturity in Gentoo Penguins (mean age of three; Croxall & Rothery 1995, Croxall & Davis 1999) are adaptive traits in a fluctuating environment. This, in combination with the climate-driven increase in ice free areas suitable for colonization (Forcada *et al.* 2006), may offer Gentoo Penguins in the South Atlantic some resilience to climate change and associated environmental fluctuations.

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