CONSERVATION OF THE GREAT WHITE PELICAN *(PELECANUS ONOCROTALUS)* AND THE PINK-BACKED PELICAN *(P. RUFESCENS)* IN SOUTH EASTERN AFRICA

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ABSTRACT

Of the seven pelican species found world wide, only the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) are found in Africa. The KwaZulu-Natal province of South Africa supports only one breeding site for each of these species, and both sites represent the southern most breeding colonies for the two species in the eastern region of Africa. These nesting sites fall within the Greater St Lucia Wetland Park, and are afforded a degree of protection, but the same is not true for their foraging and dispersal ranges, and this is a cause for concern.

Considerable amounts of data have been collected relating to the status, distribution and breeding efforts of these two species in north eastern KwaZulu-Natal. These data have been collected in a variety of ways by a large number of people. Part of this work represents an attempt to collate and summarise these data to produce an estimation of the status, distribution and breeding success of these species, and to evaluate any trends in their demography. For this south eastern region of Africa I estimated the population for the Great White Pelican to range between 6000 and 9000 individuals, and the Pink-backed Pelican to range between 600 and 900 individuals.

Pelicans are highly mobile birds, and this allows them to move considerable distances when they forage, disperse or migrate. They are also long-lived birds with few natural predators. The two pelican species in south eastern Africa have been poorly studied and little is known about their movements, population dynamics and causes of mortality. Habitat change poses a potential threat to pelicans in north eastern KwaZulu-Natal, and habitat loss could drive these species out this region to areas north of South Africa. Much of this north eastern region of KwaZulu-Natal is under threat, mainly through the actions of man. Many areas are naturally unsuitable for pelican foraging, while others are vital to the survival of both species. This study

includes an attempt to assess the movements of these two species in south eastern Africa, and to assess the relative importance and condition of the potential pelican habitat in the north eastern KwaZulu-Natal region, focusing particularly on Lake St Lucia and the Pongolo River floodplain.

All this is necessary to produce a baseline from which long term predictions of potential pelican species survival can be made. In the absence of documented life tables and environmental variability data, a range of parameters was modelled to generate population viability analyses to simulate possible scenarios. These extinction models show the outcomes of both the deterministic and the stochastic processes. An attempt was also made to identify the factors that impact most severely on the persistence of these two species. The models were most sensitive to variation in survivorship in the first year of life and to the frequency of catastrophes. Changes in these parameters had the greatest effect on extinction risk.

In January 2004 Lake St Lucia was reduced to a fraction of its normal capacity as a result of a severe drought in this region of KwaZulu-Natal. After rains in the area the lake level rose and then fluctuated considerably over the next 24 months. During this time the mouth of the estuary into the sea was closed. Great White Pelican numbers and lake levels were monitored throughout this period. This part of the study relates the changes in population numbers to the lake conditions, and highlights the importance of the lake to this avian species. It uses lake levels as a proxy for the conditions of wetlands in the Lake St Lucia region. It also addresses the implications of these relationships to the management strategy of the lake and the conservation of some avifauna.

To identify conservation concerns for the Great White and Pink-backed Pelicans it was necessary to generate these baseline estimations. Although much of this

information is uncertain for these two species, an attempt has been made here to predict the persistence of these species in north eastern KwaZulu-Natal and to highlight the conservation issues related to their future.

PREFACE

This study was carried out in the School of Biological and Conservation Sciences, University of KwaZulu-Natal, Pietermaritzburg, from March 2004 to December 2005, under the supervision of Professor Colleen T. Downs and the guidance of Dr. Ricky H. Taylor.

This study represents original work by the author and has not been submitted in any form to another university. Where the work of others has been used they are duly acknowledged in the text.

Chapters 2-8 of this dissertation were written in the form of research or review papers, with the tables, figures and references at the end of each. This has resulted in the duplication of some information. To give the dissertation some degree of uniformity, the literature cited and the associated citations in these chapters have been formatted according to the manuscript requirements of the journal Conservation Biology. Other formatting is generic and consistent throughout these chapters.

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CHAPTER 1

General Introduction

Project Background and Motivation

Of the seven recognized species of pelicans found worldwide, only two occur in Africa, the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) (del Hoyo et al. 1992), and both are Red Data Book species in South Africa (Barnes 2000). The Great White Pelican is listed as 'Near-threatened', as defined in Barnes (2000), because of the vulnerability of the few breeding sites and the loss of wetlands (Crawford & Taylor 2000). The Pink-backed Pelican is listed as 'Vulnerable', as defined in Barnes (2000), due to its small population size, its single regular breeding site, and the loss and general decline of quality habitat (Taylor 2000). Both species are restricted in their southern African distribution but do occur in KwaZulu-Natal, and each has a single regular breeding site within the province (Williams & Borello, 1997a,b). The Great White Pelican has only one other breeding site in South Africa at Dassen Island in the Western Cape (Williams & Borello 1997a). The Great White Pelican is a colonial, ground nesting bird (Brown & Urban 1969) while the Pink-backed Pelican breeds in colonies in tall trees (Burke & Brown 1970). Both species are mainly piscivorous and while the Great White Pelican generally feeds socially the Pink-backed Pelican usually forages solitarily or in loose groups (Din & Eltringham 1974b).

Few studies have been done on the pelicans of KwaZulu-Natal, and so the status and future of these two species is uncertain. In this province, the Great White Pelican nests only on islands in Lake St Lucia while the Pink-backed Pelican nests only in the

trees on the banks of the Nsumo Pan in the Mkhuze Game Reserve (Williams & Borello, 1997a,b) (Fig. 1).

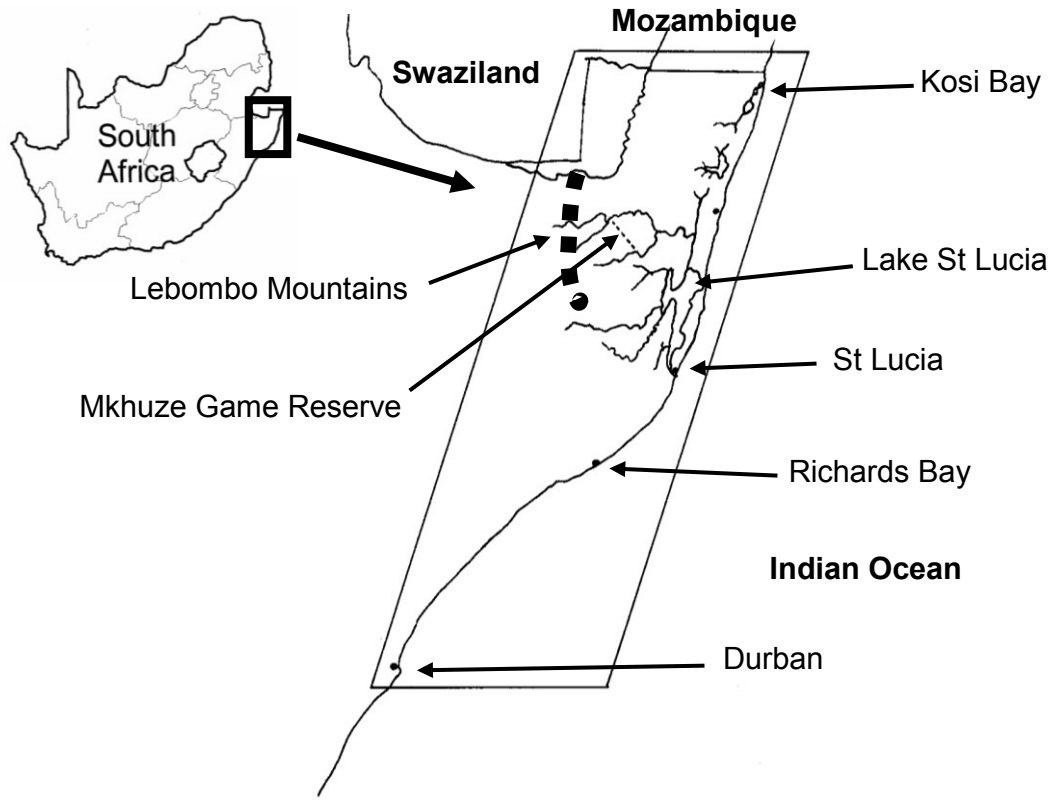

Fig 1. The study area in north eastern KwaZulu-Natal.

Both these sites fall within the boundaries of the Greater St Lucia Wetland Park (Fig. 2) and are therefore offered a degree of protection (Johnson et al. 1998).

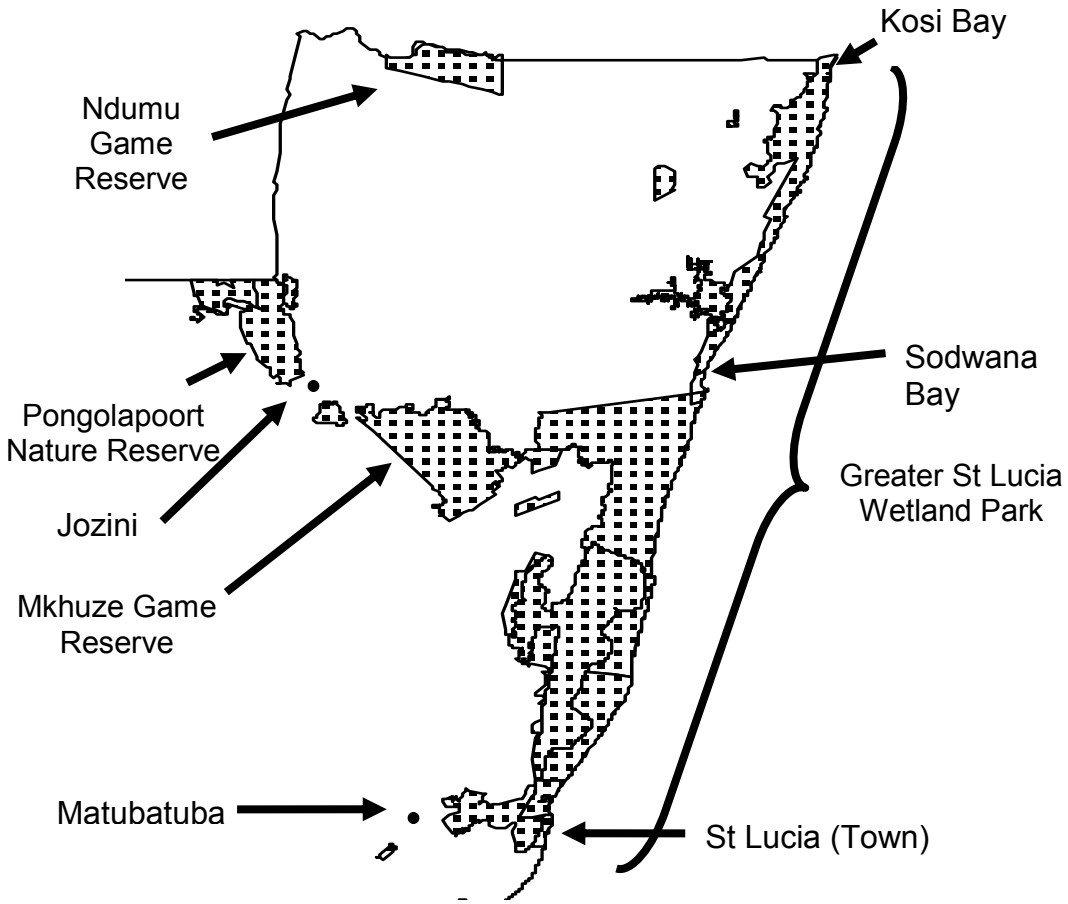

Fig 2. Ezemvelo KwaZulu-Natal Wildlife conserved areas in north eastern KwaZulu-Natal.

These birds however are extremely mobile and may cover several hundred kilometers each day when foraging (Berry et al. 1973). This takes the birds to feeding sites outside of the protected areas (Whitfield & Blaber 1979; Parker 1999), and this is a concern for the future of the KwaZulu-Natal pelicans.

The Great White Pelican and the Pink-backed Pelican could both be considered flagship species of north eastern KwaZulu-Natal as they could provide a symbol and focus for conservation awareness and action in this region, and yet their future may not be secure (R.Taylor, pers. comm.). Ecologists of Ezemvelo KwaZulu-Natal Wildlife are concerned that environmental changes, resulting particularly from

agricultural and other human activities in the region (Nanni 1982), are impacting on the pelican populations, and are keen to gather some base-line information on these birds (R.Taylor, pers. comm.). Pelicans are large, conspicuous birds that are easier to see and monitor than many of the other aquatic bird species. They are also predators in some very complex and unique systems (Whitfield & Blaber 1979; Johnson et al. 1998). These attributes could make these birds a valuable tool in the management of the area, and the principles that apply to their conservation might apply to other components or members of these ecosystems (Brooks et al. 2001). The position of the Great White Pelican as a major predator in Lake St Lucia makes this bird an indicator species of the biomass production of the lake (Chapter 7). Lake St Lucia supports over 350 bird species, and is the most important breeding area for waterbirds in South Africa, being the breeding ground for 48 waterbird species (Johnson et al. 1998), of which ten species are classified as species of conservation concern (Berruti 1980; Barnes 2000). Besides supporting the large colony of Great White Pelicans, the lake also supports large breeding colonies of Goliath Heron *(Ardea goliath)*, Great White Egret *(Egretta alba)*, Little Egret *(E. garzetta)*, African Spoonbill *(Platalea alba)*, African Fish Eagle *(Haliaetus vocifer)*, Grey-headed Gull *(Larus cirrocephalus)* and Caspian Tern *(Hydroprogne caspia)*, and is possibly the only breeding site in KwaZulu-Natal for at least ten waterbird species (Berruti 1980). At different stages in its salinity and water level cycles it also serves as the foraging area for a great variety of avifauna. After the Demoina floods of 1984, when the salinity levels of the lake dropped dramatically, ducks (*Anatidae*), rallids (*Rallidae*) and many other birds entered the system to forage (Ezemvelo KwaZulu-Natal Wildlife unpublished data; M.B., pers. obs.). The lake is listed as an Important Bird Area (Barnes 1998) and is probably the most important of these areas in KwaZulu-Natal (Johnson et al. 1998).

The Pongolo River floodplain also supports a variety of birdlife, of which at least ten species are included in the Red Data Book (Heeg & Breen 1982; Barnes 2000). It is advantageous for the managers of these extremely complex systems to have as many indicators of the health of these systems as possible, and the pelicans might offer them some of this insight as a potential indicator species.

An assessment of the long-term conservation needs is required for the survival of these two related species. The project will contribute significantly to the conservation of the Great White Pelican and Pink-backed Pelican, and the sustainable management of their breeding habitat and feeding areas in south eastern Africa and adjacent regions.

The Study Animals: Great White Pelican and Pink-backed Pelican

The Great White Pelican (*P. onocrotalus*)

The adult Great White Pelican is described as a large bird (mean adult male mass of 11.5 kg), generally white in the non-breeding season, but tinged pink when breeding (del Hoyo et al. 1992). The remiges are black, and this shows as a clear contrast with the white body, especially in flight (Crawford 2005). The immature birds are brownish, with some white on the back, rump and belly, but they progressively change into definitive adult plumage during the four years after hatching. The developing nestling is covered with black down (Johnsgard 1993). They are mainly piscivorous and are associated generally with large, shallow water bodies (Din & Eltringham 1974b). The Great White Pelican is normally gregarious and may form very large groups when loafing, breeding, roosting or foraging (Din 1979). They are ground nesters, breeding colonially in winter in south eastern Africa (Berruti 1980).

These birds soar effortlessly and are highly mobile, and this enables them to forage far from their nest site during breeding (Brown et al. 1982), and to disperse great distances during the non-breeding season (Urban & Jefford 1977; Crivelli et al. 1991).

The Pink-backed Pelican (*P. rufescens*)

The adult Pink-backed Pelican is also described as a large bird (mean adult male mass of 6 kg), generally grey in the non-breeding season, but with the back tinged pink when breeding (del Hoyo et al. 1992). There is a dark spot in front of the eye on the bare skin of the face. This can be used as a diagnostic feature when separating this species from the Great White Pelican (M.B., pers. obs.). The remiges are darker than the rest of the feathers, but not as dark as in the Great White Pelican, and do not show as a clear contrast with the grey body in flight (Ryan 2005). This is another feature that separates these two species in the field. The immature birds are brownish, with a white belly, rump and back and a greyish-white head and neck, while the developing nestling is covered with white down (Maclean 1985). The Pink-backed Pelican is generally solitary and can forage successfully on smaller water bodies (Din 1979). It is also piscivorous, generally feeding on smaller fish than the Great White Pelican (Din & Eltringham 1974b). These birds nest colonially in tall trees in summer, and during this time they exhibit a more social behaviour when loafing, roosting and flying, but still feed solitarily (Burke & Brown 1970). Pink-backed Pelicans are also extremely mobile, enabling them to feed large distances from their chosen breeding sites, and to disperse far from these areas in the non-breeding season (Brown et al. 1982).

More comprehensive and detailed accounts of the biology of Great White Pelican and the Pink-backed Pelican are given in Appendix A.

The Study Area

The study area extended from Durban in the south to the border between South Africa and Mozambique in the north, and from the Lebombo Mountains in the west to the Indian Ocean in the east (Fig. 1). It also included the Pongolo Dam which lies just to the west of the Lebombo Mountain range. This translated into a north-south distance of about 350 km, and a maximum east-west distance of approximately 100 km (Fig. 1). Of this area, the section from Richards Bay to the northern border was the most significant, and included the catchments of the Umfolozi, Mkhuze and Pongolo Rivers (Fig. 3).

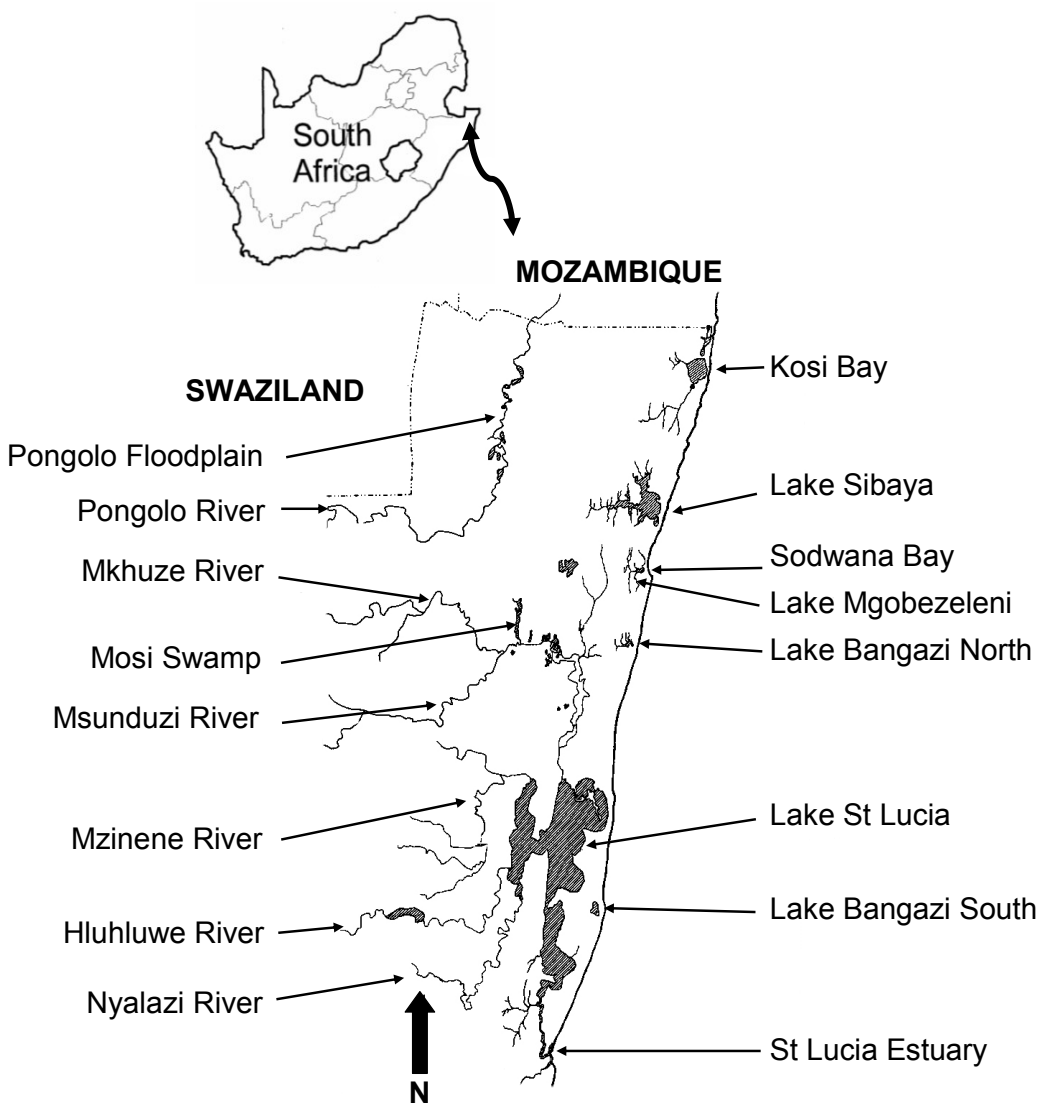

Fig. 3. Map of north eastern KwaZulu-Natal indicating the main catchments of the region.

The Mkhuze River has a series of sizeable pans along its floodplain, and is also the main supplier of fresh water to the Lake St Lucia system (Nanni 1982). The Pongolo River in the north has an even more extensive system of pans along its floodplain than does the Mkhuze River, and has long been regarded as a vital alternative foraging area to Lake St Lucia (Heeg & Breen 1982). The Pongolo River continues out of the study area into Mozambique as the Rio Maputo, eventually

reaching the sea near Maputo. Along this section of the river there are still more pans, several of them of far greater size and potential than the ones in South Africa (Parker 1999). There are also other large water-bodies along the coast line of KwaZulu-Natal including Lake Sibaya, Banghazi North and South and the Kosi lakes, as well as many smaller pans, dams and wetlands spread throughout the study area.

Although these rivers are an integral part of this area, it is Lake St Lucia that is really the most vital resource of this entire region for pelicans' survival (Chapter 2).

Previous Studies on the Great White Pelican and the Pink-backed Pelican

The Great White Pelican has been the subject of many studies, particularly in its northern range in Europe, where its numbers have been decreasing (Wetlands International 2002). It has also been studied in its most southern range in the Western Cape, South Africa, where its numbers have been increasing as a result of temporary but potentially dangerous artificial feeding sites associated with pig farming (Crawford et al. 1995), as well as in Namibia, both off the coast at Bird Rock platform (Crawford et al. 1981) and inland at Etosha Pan (Berry et al. 1973). The breeding and some aspects of the ecology of this species are probably most comprehensively described in the work done on the East African populations (Brown & Urban, 1969; Din & Eltringham, 1974a, 1977). Feely (1962) made some observations in KwaZulu-Natal of the breeding of Great White Pelicans at Lake St Lucia, while breeding has also been included in several studies of the lake (Chiazzari, 1952; Whitfield & Blaber, 1979; Berruti, 1980,1983).

The Pink-backed Pelican, which is endemic to Africa, has been studied far less than the Great White Pelican. Again, the most comprehensive work comes from East

Africa (Burke & Brown, 1970; Din & Eltringham, 1974 a,b), but little is known of the other African populations. In south eastern Africa reference is again made to this species in studies of Lake St Lucia (Berruti, 1980, 1983; Chiazzari, 1952; Whitfield & Blaber, 1979), but no study has been done on this population *per se*.

A full review of previous literature on the Great White Pelican and the Pink-backed Pelican is given separately in Appendix A.

Aim and Objectives of the Present Study

Among the aims of the South African provincial conservation organizations is the need to conserve the diversity of species and promote research on those species for which little is known (Barnes 1998). Both the Great White Pelican and Pink-backed Pelican in south eastern Africa are not well studied, and little is known of their conservation status despite their being highly conspicuous and visually appealing. Their conservation is dependent on the viable management of their KwaZulu-Natal breeding sites and eastern seaboard core ranges.

The aim of this study was to create a better understanding of the population status of the Great White Pelican and the Pink-backed Pelican, and to assess the factors that might be impacting on these populations and the extent of these impacts. From this a population viability analysis (PVA) was done for each species. However, before a PVA could be done, it was necessary to gather as much of the following information about the study animal as possible:

- an estimate of the population numbers, life-span, breeding age
- an estimate of the breeding success and mortality rate
- a risk assessment of likely catastrophes, including a habitat assessment

To identify conservation concerns using the results of the PVA, it was then necessary to have information about the birds'

- movement patterns and feeding range
- distribution of non-breeding population and post-breeding dispersal

The final outcome will be the production of guidelines for the conservation of these two species, to give the managers of the areas in which these birds breed and forage some insights into the needs of these birds and the dangers facing their long-term survival. This study should also provide baseline data for the ongoing monitoring, evaluation and revision of these strategies. Additionally, it is hoped that this study will also provide some insights as to how these large and conspicuous birds may give these managers an extra guideline with which to assess the condition of the systems they are managing by using pelicans as an indicator species.

The results are presented in chapters as manuscripts that follow the citation and cited literature conventions of the journal Conservation Biology. The formatting of the rest of the manuscript is generic and consistent throughout.

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CHAPTER 2

Population status and distribution of the Great White Pelican *(Pelecanus onocrotalus)* and the Pink-backed Pelican *(P. rufescens)* in north eastern KwaZulu-Natal

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Abstract

KwaZulu-Natal in South Africa is the most southerly area in Africa in which the Pink-backed Pelican *(Pelecanus rufescens)* breeds, and the most southerly area on the eastern seaboard of Africa in which the Great White Pelican (*P. onocrotalus*) breeds. Considerable amounts of data have been collected relating to the status and distribution of these two species in north eastern KwaZulu-Natal. These data have been collected in a variety of ways by a large number of people. This represents an attempt to collate and summarise these data to produce an estimation of the status and distribution of these species, and to evaluate any trends in their demography. We found no evidence of contraction or expansion in the distribution for these two species, and estimate their populations to number between 6000-9000 for the Great White Pelican, and 600-900 for the Pink-backed Pelican in south eastern Africa.

However, both species showed highly variable and unpredictable population size (both breeding and non-breeding) and various reasons may cause this.
Key words: KwaZulu-Natal, Great White Pelican, Pink-backed Pelican, population status, distribution, demography.

Introduction

The Great White Pelican (*P. onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) could both be regarded as flagship species of the north eastern regions of KwaZulu-Natal as they could provide a symbol and focus for conservation awareness and action (R.Taylor, pers. comm.). They are large, conspicuous, white birds easily seen and identified and their distributions are limited by their having to be near sizeable water-bodies (del Hoyo et al. 1992). It is therefore potentially possible to estimate the size of their population in an area with a fair degree of accuracy. This however is offset by their great mobility (Crivelli et al. 1991; Izhaki et al. 2002) and this must be factored into any population estimate.

Great White Pelicans are social birds and tend to roost socially at night, loaf socially in the middle of the day, and feed socially in the early morning and late afternoon (Johnsgard 1993). These loafing grounds are areas where birds rest and preen themselves between foraging sessions. These sites tend to be open, sandy areas near water, and certain sites are favoured as loafing grounds (Din & Eltringham 1974b). Because of this habit it is possible to count these birds at these sites over the period of the day when they are not very mobile, and so produce relatively accurate estimates. Even when they are feeding, they do so socially, and can be counted. Great White Pelicans are also colonial nesters and so counts can be done when they congregate to breed (Wetlands International 2002). Some of these loafing, foraging

and breeding sites in KwaZulu-Natal may be easily accessible at certain times of the year, and can be successfully counted from the ground or from a boat, while at other times they are inaccessible and can only be counted from the air.

The Pink-backed Pelican is a bird of sub-Saharan Africa, and a noteworthy species of the north eastern regions of KwaZulu-Natal, as this region is home to the only regular breeding colony of these pelicans in South Africa (Taylor 2000). Even though their distribution is limited by their having to be near water-bodies they are not as easy to census as the Great White Pelican as they are not as social (Johnsgard 1993), can be found on smaller water-bodies (M.B., pers. obs.), and are therefore more difficult to locate. They are also highly mobile (Williams & Borello 1997a), and this adds to the difficulty of estimating the size of their population in an area.

The Pink-backed Pelican is social while breeding (Burke & Brown 1970), and this is potentially the best time for estimating the size of their regional population (Wetlands International 2002). These estimations can be made when the birds are congregating at their colonial nesting site, or from estimates of breeding pairs once breeding has begun, as this is when populations are most stable in numbers and confined to a smaller area (Wetlands International 2002). These estimations however exclude immature birds that are not breeding and that have dispersed from their breeding grounds. It is not known whether senescent birds congregate at these sites, or what fraction of the total population this group represents. It is also not known how far the immature Pink-backed Pelicans disperse, but it is possible that they move north into Mozambique as juveniles (Williams & Borello 1997b), and therefore do not form part of the population of KwaZulu-Natal for the first two to three years of their lives.

Estimates have been made of the population status of some pelican species elsewhere in the world, where a population is regarded as all the birds that are

associated with the breeding sites in the area. These estimates refer to the total number of individuals in the population, including immature birds. Estimates of pelican populations are most easily derived from censuses made towards the end of the non-breeding season when the birds are congregating to select a colony site, or from estimates of breeding pairs once breeding has begun (Wetlands International 2002). However this automatically excludes the non-breeding individuals, juveniles and non-breeding adults, unless these are counted in the non-breeding areas (Urban & Jefford 1977). First year birds recruited into the population tend to suffer relatively high mortality, so the population will show a marked decrease in numbers over the course of the non-breeding season (Brown & Urban 1969). For the American White Pelican (*P. erythrorhynchos*), which is comparable to the Great White Pelican, there is an estimated 41 percent mortality rate between fledging and the end of the first year of life, and a 16 percent mortality for second year birds (Strait & Sloan 1974; Johnsgard 1993). This produces a population estimate that differs from the figure gained immediately after a successful breeding season. Wetlands International (2002) advocates that counting nests or the number of incubating birds is a reliable way of estimating the number of breeding pairs. One method advocated to estimate the total population size and to produce some level of consistency, is to multiply the number of breeding pairs by three, or the number of mature adults by a factor of 1.5, as this allows for the inclusion of the immature birds in the population estimates (Wetlands International 2002). However, if the immature birds have left this southerly region, this method will not provide accurate estimations of the population sizes of the Pink-backed or the Great White Pelicans in KwaZulu-Natal (Taylor 2000). It will however reflect the number of birds in these entire populations, assuming these populations to be discrete (Wetlands International 2002).

When the Great White and Pink-backed Pelicans of different ages are seen from close up, it is possible to distinguish different immature plumages (Appendix A - Tables 2 & 5), and thereby potentially estimate the age composition of these species (Brown & Urban 1969; Din & Eltringham 1974a). Unfortunately the sub-adults do not necessarily associate with the adults, and tend to disperse to different areas (Guillet & Crowe 1981). It is therefore not possible to get an accurate indication of the age composition of a population by sampling a single group and extrapolating this result for the entire population (Brown & Urban 1969). It is not known where the KwaZulu-Natal sub-adults spend their juvenile years, but it is assumed that they generally range north towards and into Mozambique, as far as the Zambezi River (Parker 1999; Barnes 2000).

The Great White Pelican and Pink-backed Pelican breeding areas are used only as breeding sites, and are abandoned for the rest of the year (Brown & Urban 1969; Din & Eltringham 1974a). As a result it should be possible to estimate the number of breeding birds in these pelican populations simply by subtracting the number of birds that visit the breeding colony from the overall count for the foraging area. This would give an estimate not only of the number of breeding birds, but also an indication of the number of non-breeders. However pelicans are highly mobile and can travel great distances from the breeding site to forage. It is therefore difficult to judge which of these birds are non-breeders, and which are breeders that are away from the colony foraging, but this can be done if the breeding plumage can be identified.

A large portion of the Great White and Pink-backed Pelicans' range lies within the area of Lake St Lucia (Williams & Borello 1997a, b), and over the years many observations of these birds have been made and recorded by the staff of the Natal Parks Board, now Ezemvelo KwaZulu-Natal Wildlife, and other interested parties.

These observations were not made regularly or systematically until the advent of the Coordinated Waterbird Counts (CWAC) in 1992 (Taylor et al. 1999).

For the long term conservation of these two species, it is important to have some baseline data on their past and present status. If any trends can be identified in the analysis of these data, then some explanation needs to be suggested for these trends, and necessary action can be taken to counter or reinforce these trends in the future. The aim was to attempt to collate and summarise the past and present data to produce an estimation of the population numbers, status and distribution of these species, and to evaluate any trends in their demography.

Materials and methods

Historical records from the files, rangers' reports and the photographic library of Ezemvelo KwaZulu-Natal Wildlife offices at St Lucia and the Mkhuze Game Reserve were accessed, and the relevant information on Great White and Pink-backed Pelicans, as well as lake conditions, was recorded, filtered and collated. This unpublished information and information from previous literature, was used to assess the distribution and population status of these two species. These distributions were compared to the normally accepted ranges for KwaZulu-Natal as illustrated in field guides (Maclean 1985; Newman 1992) and bird atlases (Cyrus & Robson 1980; Williams & Borello 1997a, b) (Fig. 1a,b; 2a,b).

Census data were also obtained from the Avian Demography Unit (ADU) at the University of Cape Town (UCT) in the form of CWAC figures. Most of the historical data on estimates of Great White Pelican and Pink-backed Pelican numbers pertain to Lake St Lucia or the Nsumo Pan in the Mkhuze Game Reserve (Fig. 3a), and most of those in turn focus on the numbers of adults and nestlings at the breeding sites

(Ezemvelo KwaZulu-Natal Wildlife unpublished data). The advent of the CWAC project in 1992 provided the first co-ordinated count for most of the areas or water bodies at which Great White Pelicans are found. These areas are counted twice a year, in summer and in winter, and the results are coordinated by the ADU who also dictate the counting methods used (Taylor et al. 1999).

In October 2004 the first concerted effort was made to obtain an accurate population estimate for both the Great White Pelican and the Pink-backed Pelican for all the areas of their normal distribution in KwaZulu-Natal. This exercise was repeated in January and July 2005. For the duration of this study period which ran from January 2004 till December 2005 the water levels of Lake St Lucia were unusually low and the lake was very shallow (Chapter 7). Consequently it was not possible to census these birds from the water or the land in most areas, and so aerial counts were done to establish the status of the Great White Pelican.

These population estimates were achieved by counting all potential pelican sites in KwaZulu-Natal on the same morning as a coordinated exercise using an aerial census where necessary, and backed up by ground support in the built up areas of Durban and Richards Bay (Fig 3a). The water bodies (Fig. 3b) were allocated as follows:

Counted from the ground using CWAC methods:

- BirdLife Zululand: the Richards Bay area
- BirdLife Port Natal: the Durban area

Counted from the air by aircraft belonging to members of the Bateleurs and Ezemvelo KwaZulu-Natal Wildlife:

- Estuaries north of Durban to St Lucia,
- Empangeni/Richards Bay region as far north as Lake Msingazi.
- Pans and Lakes on the Eteza and Umfolozi Rivers

- Mkhuze River floodplain and Pongolo River floodplain.
- Lake St Lucia and the eastern seaboard to Kosi Bay.

In a separate exercise, aerial counts were made from the Ezemvelo KwaZulu-Natal Wildlife Cessna 182 Skyline around the end of the third week of each month. The entire lake north of the Narrows was counted from a height of about 80 meters. The same aircraft, pilot and observer was used for each flight, and all flights were carried out between 09h00 and 11h00. The route flown was along the eastern shoreline of South Lake from the Narrows northwards past Fanies Island, along the eastern shoreline of North Lake as far as Lane Island, and then through Hell's Gates into the southern section of False Bay. The count then resumed at False Bay Park, and included the northern section of False Bay, the northern section of North Lake, Bird Island and the Selley's Lakes area (Fig. 4). From May 2004 the Muzi and Nsumo Pans were also included in these flights mainly to include the Pink-backed Pelicans into this programme. Visibility on all flights was good, and it was possible to see large groups from considerable distances as well as spot individual birds along the flight path.

A Garmin eTrex Legend™ Personal Navigator® was synchronized with a Fujifilm Finepix™ S5000® digital camera. The synchronization of the camera with the Garmin navigation aid (NAVAID) made it possible to pinpoint the exact location at which each picture was taken and to estimate the size of the groups at these points. All groups of pelicans were photographed for subsequent counting.

The aircraft's track recorded by the NAVAID and the digital images were downloaded to a desktop computer for analysis. Digital images were opened in Adobe PhotoDeluxe® Home Edition 4, and enlarged where necessary. For each picture a new transparent layer was created over the original image, and each individual was marked on this layer with a dot. For very large groups of birds the

image was divided into smaller areas and each area was dealt with separately. Finally the original image was removed, the dots were counted and the number of birds recorded. These estimates were then entered on a map using the location given by the NAVAID track.

Pelicans attract most attention when they are breeding, as they mass in impressive numbers. Most of the historical data collected by Ezemvelo KwaZulu-Natal Wildlife that was related to the Great White Pelican, centered around the population on Lake St Lucia, when the birds congregated there at their breeding colonies. Much of this information was recorded as "thousand of adults", "one to two thousand pairs" "500 chicks", 300 nesting adults", "two hundred sitting adults", and similar type entries. An attempt was made to interpret these comments in a consistent way so that these data could be used to identify any changes in the breeding effort on Lake St Lucia. Breeding success for the Great White Pelican has been estimated at about 0.8-0.9 nestlings per pair taken at the time fledging occurs (Brown & Urban 1969) and in this analysis a figure of 0.85 nestlings per breeding pair per annum was used. For the Pink-backed Pelican the estimate of nest success ranges between 0.40 and 0.95 fledglings per pair (Burke & Brown 1970; Din & Eltringham 1974a). The figure of 0.68 was used in the analysis and estimates of breeding effort. When estimating the number of adults associated with "500 nestlings" a figure of one nestling per breeding pair was used, as the age of the nestlings was seldom indicated and final mortality rates may not yet have been reached. Where the number of nests only has been recorded, then the estimate of numbers of breeding adults present has been taken as twice the number of nests.

Results

There was no evidence from the analysis of the unpublished data, from the literature and reports or from the observations during the study period that the distributions of the Great White Pelican and Pink-backed Pelican in north eastern KwaZulu-Natal were different from those already proposed (Cyrus & Robson 1980; Newman 1992; Williams & Borello 1997a, b). This implies that there was no contraction in their ranges as they were associated mainly with Lake St Lucia and the associated wetlands. The one recorded change was the presence of a second breeding colony for the Pink-backed Pelican in the trees in the Botanical Garden in Durban, consisting of fewer than five breeding pairs (M.B., pers. obs.).

There was however considerable variation in the presence or absence of these birds at foraging sites at different times. The CWAC sites indicated these variations well (Fig. 5a,b). Only Lake St Lucia had Great White Pelican and Pink-backed Pelican present for all counts, while at some CWAC sites in KwaZulu-Natal, including the Kosi lakes and Lake Sibaya, pelicans were never seen.

Estimates were made of the number of breeding Great White Pelicans at Lake St Lucia and breeding Pink-backed Pelicans at Nsumo Pan from 1950 to the present (2005) for the years in which breeding was attempted. Values for the Great White Pelican varied from 200 to 4400 (Fig. 6a) while for the Pink-backed Pelican they ranged from 14 to 420 (Fig. 6b). For those years where estimates were made, or when birds did attempt to breed, the average number of Great White Pelican breeders was 1969 ± 1128.61 (S.E.), (n = 40), and Pink-backed Pelican was 137 ± 71.54 (S.E.), (n = 35).

Populations varied considerably during the summer and winter CWAC seasons (Fig. 7a,b). The only year in which the summer count for the Great White Pelican exceeded the winter count of the same year was 1995. Estimates of numbers during summer counts for the Great White Pelican varied from 7 in 2001 to 3579 in 1995, with an average of 703 ± 1118.04 (S.E.), (n = 14). Estimates of numbers during winter ranged from 221 in 1995 to 5081 in 1992, with an average of 1944 ± 1571.76 (S.E.), (n = 14). For the Pink-backed Pelican estimates made during summer counts exceeded estimates made during winter counts in all years except 1998 and 1999. Summer estimates for the Pink-backed Pelican varied from 34 in 1999 to 250 in 2003, with an average of 122 ± 69.06 (S.E.), (n = 14). Winter estimates ranged from 46 in 2003 to 168 in 1998, with an average of 82 ± 39.96 (S.E.), (n = 14).

The average estimate of the total number of individuals was calculated only for those sites at which Great White Pelicans (Fig. 8a) and Pink-backed Pelican (Fig. 8b) were seen during the CWAC periods of summer 1992 through to winter 2005. For the Great White Pelican, Lake St Lucia with an average total of 817 far exceeded all other sites. For the Pink-backed Pelican, average totals of 40 at Lake St Lucia and 43 at Nsumo Pan were the highest.

Lake St Lucia accounted for most of the Great White Pelicans in north eastern KwaZulu-Natal in the counts done over the thirteen years of CWAC (Fig. 9). For the summer counts, the lake accounted for 71% of the Great White Pelicans recorded in KwaZulu-Natal, while the winter figure was 80%. CWAC counts showed that both the Nsumo Pan in summer (Fig. 10a) and Lake St Lucia in winter (Fig. 10b) had high numbers of Pink-backed Pelicans.

The three independent counts conducted on 16 October 2004, 29 January and 23 July 2005 of all the potential Great White Pelican and Pink-backed Pelican sites in KwaZulu-Natal (Table 1) produced totals of 2362, 2611, 3929, and 46, 628, 159 for

these two species respectively. The average number of Great White Pelican and Pink-backed Pelican for these three provincial counts were 2967 ± 223.93 (S.E.), (n = 3) and 278 ± 436.44 (S.E.), (n = 3) respectively.

Monthly aerial surveys of Lake St Lucia during 2004 and 2005 showed a variation from a minimum of 123 to a maximum of 6558 in the number of Great White Pelicans for this period (Fig. 11a). For Pink-backed Pelicans the surveys included Lake St Lucia and the Nsumo Pan, and their variation in numbers for this period ranged from a minimum of 0 to a maximum of 622 (Fig. 11b).

No estimations were made throughout the period of this study of the fraction of breeding birds in these populations, as with the low water levels it was not possible to access their loafing sites where an estimate of the fraction of birds in breeding plumage could have been made.

Discussion

The general distributions of the Great White Pelican and the Pink-backed Pelican have been well documented as a result of the bird atlas projects conducted for KwaZulu-Natal (Cyrus & Robson 1980; Williams & Borello 1997a, b), and surveys in the study area did not record any contraction or extension of these documented distributions. Although the distribution range of the Great White Pelican is well documented, it is clear that some areas are favoured above others, and that not all water bodies in north eastern KwaZulu-Natal are used by these birds. Noteworthy are the Kosi lakes and Lake Sibaya, both sizeable water bodies that are very seldom visited by Great White Pelicans (Taylor et al. 1999). There is not a single CWAC record of pelicans on any of these lakes (Taylor et al., 1999; CWAC unpublished

data). These water-bodies may be either too clear and sterile, or too deep, to be suitable for pelican foraging (R. Taylor, pers. comm., M.B., pers. obs.).

For the Great White Pelican which is found in Europe, Asia and Africa, the global population is estimated to be between 265 100 and 292 900. Approximately 210 000 birds of this species are found in western and eastern Africa. The area of Africa south of the Zambezi River accounts for an estimated 20 000 birds, and this population is increasing (Crawford et al. 1995; Wetlands International 2002). Although estimates have been made of the status of the Great White Pelican in north eastern KwaZulu-Natal these estimates vary considerably. Some of these estimates are based on the number of birds breeding, and may fail to take into account non-breeders. Between 1500 and 2000 pairs of Great White Pelicans were estimated to have nested at Lake St Lucia each year from 1974 to 1978 (Berruti 1980). In the 1980s the estimated number of breeding adults fell well below these levels, while in the 1990's their numbers increased again (Fig. 6a). In 1990 an estimated 4000–6000 birds were counted in the system, while in 1992 the estimate from an aerial count was 6000 breeding adults (Ezemvelo KwaZulu-Natal Wildlife unpublished data). Other estimates put the St Lucia numbers at about 2000 pairs (Crawford et al. 1981), and 3000 breeding pairs (Ezemvelo KwaZulu-Natal Wildlife unpublished data). Estimates of the number of breeding pelicans at Lake St Lucia vary markedly, and this can be related to lake conditions (Ezemvelo KwaZulu-Natal Wildlife unpublished data; Chapter 7). In 2005 no breeding was attempted as the lake level was low, and Bird Island and Lane Island were no longer islands and therefore offered potential nesters no protection from terrestrial predators. The Selley's Lake area was reduced to a large open sandy plain as the water level had receded and the protective beds of phragmites that died in the drought period of 2003 and 2004 had not regenerated (M.B., pers. obs.).

The average estimate of 2073 (Fig. 6a) breeding Great White Pelicans for Lake St Lucia does not really reflect the true situation. When conditions are ideal for breeding, the lake might attract more than 4000 breeding birds, but in other years there may be no breeding at all (Ezemvelo KwaZulu-Natal Wildlife unpublished data). The boom periods are probably driven by the availability of food (Kingsford et al. 1999), and nest site availability (Clauss 1972; Berry et al. 1973).

Many bird counts have been conducted at Lake St Lucia since 1950. Although these records give some indication of the number of birds in the lake system at various dates, they cannot be used to estimate the number of birds in the whole south eastern region of southern Africa, as there are many other water bodies throughout this region that are not counted. Most Great White Pelican population size estimates for the KwaZulu-Natal region are derived from or even equated to the estimates for the Lake St Lucia system. This is a close approximation at most times for the Great White Pelican (Fig. 8a, 9; Table 1). There may of course be occasions when large groups are away from the lake, as has been shown with CWAC records of 1000 birds at each of Lake Mfutululu and Hlonhlela Pan, each on a single occasion (Taylor et al. 1999). For the Pink-backed Pelican there are two sites that predominate, Lake St Lucia and the Nsumo Pan (Fig. 8b, 10a,b). These two sites account for most of the Pink-backed Pelicans, with Lake St Lucia predominating in winter as a foraging site, (Fig. 10b) and the Nsumo Pan in summer as their breeding site (Fig. 10a). Both Durban and Richards Bay attract small populations of these birds, and it is important that the foraging areas that these populations use are maintained. The birds recorded at the Botanical Gardens in Durban are resident and form a very small breeding colony that has been active since 2003 (M.B., pers. obs.).

The three separate counts done over the whole of north eastern KwaZulu-Natal showed that Lake St Lucia was by far the most important water-body in the region,

and always accounted for the highest percentage of the numbers of both pelican species. The Great White Pelican population ranged between 2362 and 3929, representing 97.0% and 98.6% of the KwaZulu-Natal population estimate respectively (Table 1). This falls well below the maximum estimate of 6000 breeding adults for the region. However the only breeding that took place in 2004 and 2005 was limited to a few hundred pairs (Ezemvelo KwaZulu-Natal Wildlife unpublished data; M.B., pers. obs.), and this combined with the great mobility of this species could have impacted negatively on the total number of individuals in the region. These counts were done at a time when the number of Great White Pelicans on Lake St Lucia was recovering after the Lake was reduced to a few small areas of water after the drought that ended in early 2004. By September 2005 birds had returned to the system, and the numbers had recovered to approximately 6500, which is probably about the maximum for the lake based on all estimates made since 1950 (Ezemvelo KwaZulu-Natal Wildlife unpublished data). The range for the Pink-backed Pelican for the same period of 2004 and 2005 was 46 to 628 individuals. The minimum value can probably also be ascribed to the dispersal of the population to more favourable foraging areas outside of north eastern KwaZulu-Natal, while the maximum value is higher than the 250 pairs (Williams & Borello 1997b) or 240-300 birds (Taylor 2000) suggested as the maximum. The minimum value may be an underestimate, as the birds move off and spread themselves over a greater range, making them more difficult to locate and count accurately. The April peak in the numbers of Pink-backed Pelicans may be the result of the first major wave of breeding, and may represent the size of the population with the 2004/2005 season's recruitment. This would imply that these nestlings had reached adult size and were about to fledge, and that as many as 200 fledglings were about to enter the system. The January peak may represent the major onset of breeding when both adults of each pair were present

during the courtship, nest-building and early incubation stages. The incubation period for the Pink-backed Pelican is about 30 days, and the time from hatching to fledging about 80 days (Din & Eltringham 1974a). This total of 110 days seems to concur with this suggested reason for the high peak in numbers.

The results of the monthly aerial counts of 2004 and 2005 confirmed that Pink-backed Pelican numbers in these areas increase during the summer breeding season, and that many of these birds leave these areas when not breeding (Fig. 11b). The Great White Pelican numbers increased steadily over this same period (Fig. 11a), initiated by the increase of the water levels in the lake after the rains in early 2004 and the improved foraging that accompanied this change (Chapter 7).

With the low lake levels, the great variations in numbers of birds experienced over the study period, and the failure of the Great White Pelicans to breed at all in 2005, it was not possible to estimate the proportion of breeding adults in the study area as planned.

These variations in population estimates of the Great White Pelican and the Pink-backed Pelicans could be ascribed to one or more factors.

- If the preferred census method is to count the adults at their colony sites, then some factor must be included to account for the non-breeding birds.
- The population might in fact vary to some degree over this period of time if the birds have several consecutive successful or unsuccessful breeding seasons. This is not uncommon for a species such as this to have annually variable breeding success (Brown & Urban 1969).
- The Great White Pelican is extremely mobile, and may leave the south eastern area of Africa if conditions there are not conducive to breeding, or if conditions for breeding are better at some other suitable but ephemeral wetland. These may even include areas in Botswana like Lake Ngami and the Sua Pans, where

this species is known to have bred in large numbers in unusually wet years (Williams & Borello 1997a).

- Counts may have been done during different months of the year when the distribution of the population was different. Counting in this region has been confined to certain areas, and other potentially productive sites such as the Pongolo River floodplain have been omitted. This floodplain was included in the three separate co-ordinated counts of the whole of KwaZulu-Natal.
- When food stocks in the area fail, these birds might move out of the local system completely, and fly to the wetlands of Mozambique or elsewhere. The numbers on Lake St Lucia can vary from only a few birds to several thousand
- There is potential for error when counting Great White and Pink-backed Pelicans, as they are not the only large white birds in the area. African Spoonbills (*Platalea alba*), Yellow-billed Storks (*Mycteria ibis*) Greater Flamingo (*Phoenicopterus rubber*), Lesser Flamingo (*Phoenicopterus minor*), Great White Egrets (*Egretta alba*), Yellow-billed Egrets (*Egretta intermedia*), Little Egrets (*Egretta garzetta*) and even Caspian Terns (*Hydropogne caspia*), can look similar to the Great White Pelican or the Pink-backed Pelican from aerial photographs. Some of these species also nest colonially on the ground or in trees, and spend time loafing socially, and can therefore be confused with pelicans.
- Pink-backed Pelicans tend to be more solitary while foraging. There are large areas of north eastern KwaZulu-Natal which are very difficult to access and single birds in an area of this size are easily overlooked during any survey. These birds also have the ability to roost in trees, and they may easily be missed

when perched. For an aerial census of an area like the Pongolo River and its associated pans this is a most important consideration

CWAC data are also not completely reliable for population estimates. These counts are also incomplete for KwaZulu-Natal as again there are many more water bodies that are not counted. These include the pans along the Pongolo River floodplain, and several areas along the Mkhuze River floodplain before it enters Lake St Lucia. It should also be noted that although these counts are coordinated by the ADU, and totals have been given for the summer and winter counts, on some occasions the counts did not take place at all sites on the same day, and in some cases were several weeks apart. With the ability that these birds have to disperse over great distances, the there is a possibility of either missing some birds in the count or of counting them more than once.

Analyses of these CWAC records indicated that the estimates of the Great White Pelican and Pink-backed Pelican populations in study area fluctuated considerably. They also indicated that there is no evidence that the distributions of the Great White Pelican and the Pink-backed Pelican are different from those already described and published.

It is difficult to estimate the population status of the Great White Pelican and the Pink-backed Pelican in north eastern KwaZulu-Natal, as it must be acknowledged that the birds in the study area do not represent a discrete group. There are times when the population of Great White Pelicans in KwaZulu-Natal may only number a few hundred, and other times when it may exceed 6000. Winter populations tend to be higher than those of summer, and this is probably as a result of birds immigrating into the region to breed at one of the traditional breeding sites in the Lake St Lucia system. The population estimates for the Pink-backed Pelican are also highly variable, with summer breeding season numbers generally being higher than winter numbers. At

non-breeding times the birds are free to leave the area and move to other foraging sites beyond the borders of the country.

An added difficulty in estimating the breeding population of these two species is that the birds breed asynchronously (Brown & Urban 1969; Burke & Brown 1970), and the breeding season may last for more than 6 months (Berruti 1980; M.B., pers. obs.). Lake St Lucia is very shallow, and the Great White Pelican breeding sites are in a wilderness area and are difficult to access. The colony can easily start their breeding season unnoticed, and even if they are monitored regularly, it is difficult to get accurate estimations of the number of birds that nest over the entire season. On average breeding colonies at Lake St Lucia exceed 2000 individuals, and this translates into a population size of over 3000 breeding and non-breeding individuals. These non-breeding birds may not be in KwaZulu-Natal during this breeding period, as juveniles tend to disperse further than the adults to avoid competing with the adults for food (Urban & Jefford 1977). Pink-backed Pelicans also breed asynchronously, and as a result it is difficult to document the progress and structure of their colony.

CWAC records suggest that on average there are about 700 Great White Pelicans in the study area in summer and about 1950 in winter. Of these 71% and 80% respectively are found at Lake St Lucia. For the Pink-backed Pelican the summer and winter averages are 133 and 97 respectively.

The independent KwaZulu-Natal count estimates the average population to be approximately 2970 and 280 for the Great White Pelican and Pink-backed Pelican respectively.

The monthly aerial surveys however show that the population for Lake St Lucia alone can exceed 6500 and can remain between 3000 and 5000 for an extended period provided that food is available.

Based on the data that have been collected from breeding congregations of Pink-backed Pelicans, the population status of this species seems quite favourable, and it appears as if the breeding population of north eastern KwaZulu-Natal may be growing in size (Fig. 6b). However prior to 2005 there had been little growth in the population, despite the move from the Hluhluwe River colony where they bred successfully until 1985 to the Nsumo Pan where they have been nesting since 1986.

Further study is needed on these populations to establish the extent of the normal, overall range of both pelican species and their relationship to the other populations of southern Africa. The present study area obviously represents only a portion of the distribution range of each species, as at some stages there are very few birds of either species in the entire KwaZulu-Natal. Parker (1999) reports that the number of Great White Pelicans in southern Mozambique may exceed 3000 at times and that they are common visitors to the larger water-bodies of the area. He also mentions that the Great White Pelican possibly breeds to the north in the Zambezi River delta. He describes the Pink-backed Pelican as an uncommon visitor, usually in small numbers but possibly exceeding 400 at times, and adds that more than 200 birds may have bred at Massingir in April 1995.

If there is a discrete population of Great White Pelicans in the KwaZulu-Natal and southern Mozambique region, then a population estimate of 6000 - 9000 individuals might be acceptable provided there is not another breeding site within the area. However, it appears that the population numbers in the St Lucia system are highly variable and unpredictable. For the Pink-backed Pelican with the same conditions applied, a population estimate of 600 - 900 is suggested. The great variation in population size (both breeding and non-breeding) of each species suggests that each population is not a closed one with movement in and out the area, as well as factors

that affect their recruitment and presence in the area. These will be explored in subsequent chapters

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Tables

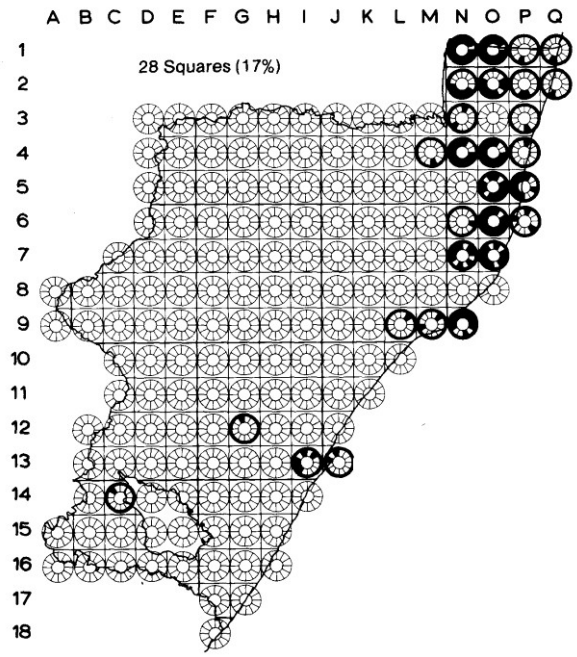
Table 1. Count data from the three coordinated Great White Pelican censuses of KwaZulu-Natal (Fig. 3).

DATE	Oct-04		Oct-04		Jan-05		Jan-05		Jul-05		Jul-05	
	GWP	%	PBP	%	GWP	%	PBP	%	GWP	%	PBP	%
AREA COUNTED												
Northern Treatment Works	0	0.0	0	0.0	0	0.0	0	0.0	13	0.3	0	0.0
Umgeni River Mouth	0	0.0	0	0.0	1	0.0	0	0.0	0	0.0	0	0.0
Botanical Gardens	0	0.0	4	8.7	0	0.0	14	2.2	0	0.0	15	9.4
Bay Head Heritage Site	0	0.0	3	6.5	1	0.0	0	0.0	0	0.0	12	7.5
Tugela Estuary	4	0.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Other estuaries north to St Lucia	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Sanctuary (Richards Bay)	45	1.9	0	0.0	10	0.4	5	0.8	0	0.0	2	1.3
All other water bodies around Richards Bay	0	0.0	0	0.0	0	0.0	0	0.0	11	0.3	0	0.0
Other water bodies on Umfolozi R. and surrounds	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Lake St Lucia	2291	97.0	24	52.2	2599	99.5	189	30.1	3875	98.6	25	15.7
Mkhuze floodplain	6	0.3	14	30.4	0	0.0	0	0.0	30	0.8	0	0.0
Nsumo Pan	6	0.3	1	2.2	0	0.0	407	64.8	0	0.0	10	6.3
Pongolo floodplain (including Pongola Dam & Ndumu)	10	0.4	0	0.0	0	0.0	13	2.1	0	0.0	95	59.7
Others: Sibaya, Kosi, Banghazi, etc	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
TOTALS	2362	100.0	46	100.0	2611	100.0	628	100.0	3929	100.0	159	100.0

GWP = Great White Pelican
PBP = Pink-backed Pelican
% = Percentage of the total for that count

Figures

a.



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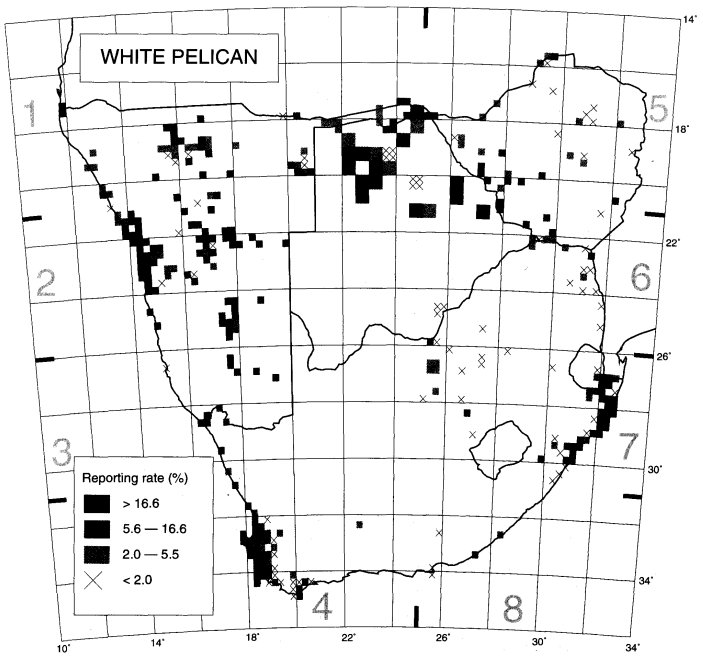
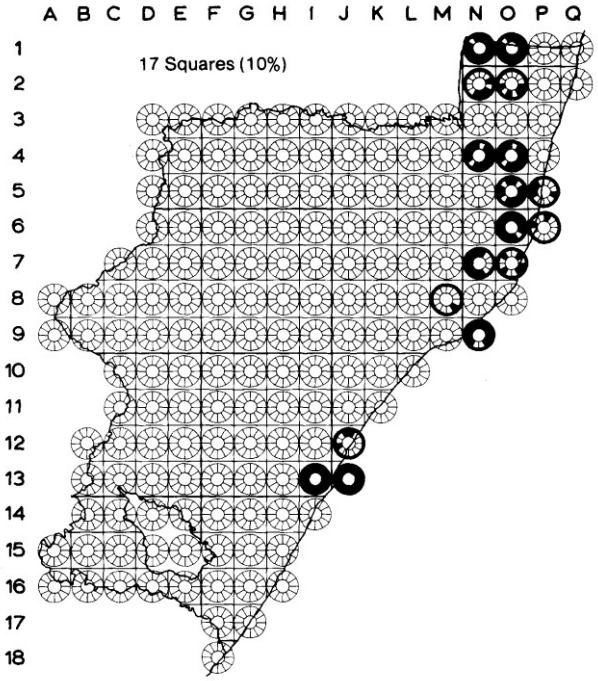


Fig. 1. Maps of the distribution of the Great White Pelican from a) Bird Atlas of Natal (Cyrus & Robson 1980) and b) The atlas of southern African birds (Williams & Borello 1997a).

a.



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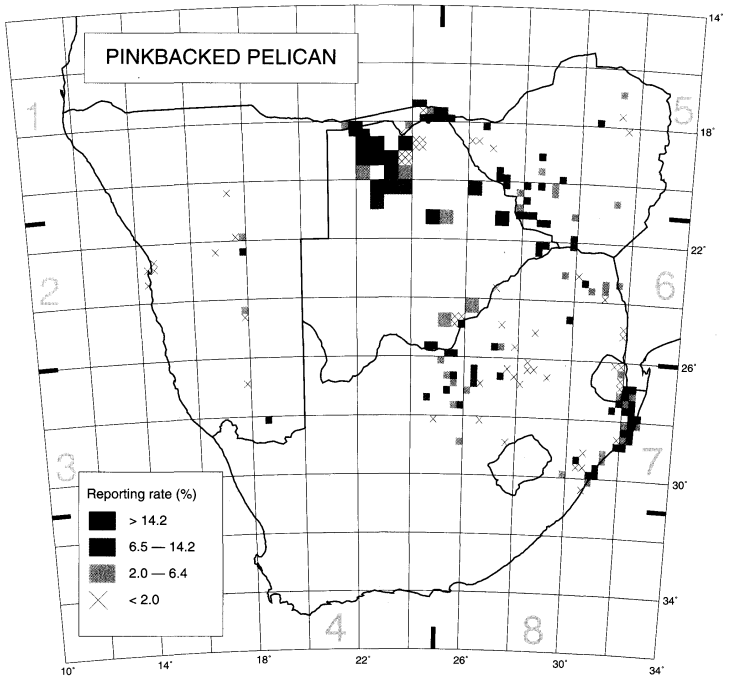
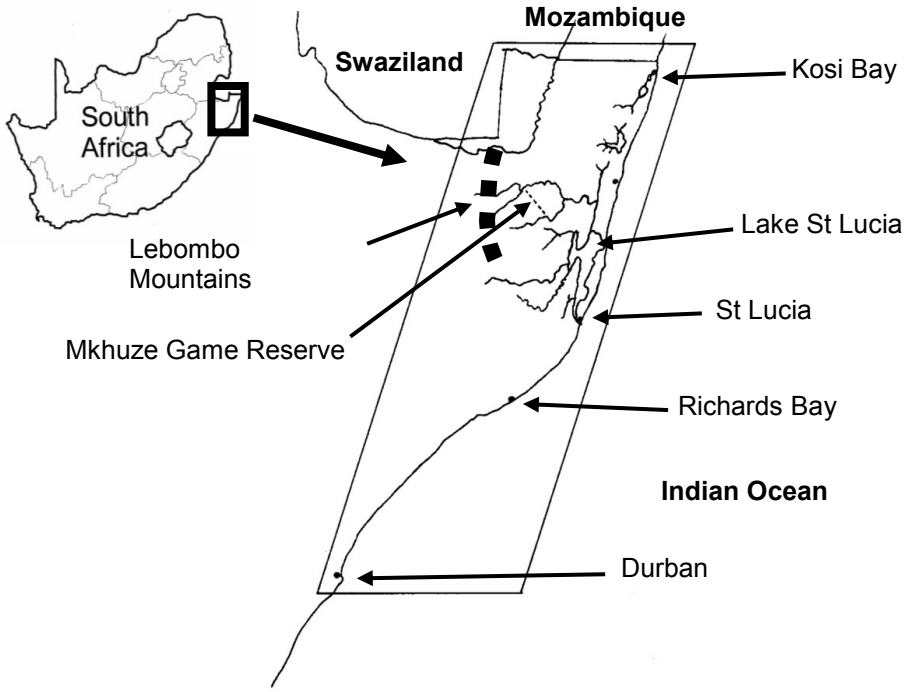


Fig. 2. Maps of the distribution of the Pink-backed Pelican from a) Bird Atlas of Natal (Cyrus & Robson 1980) and b) The atlas of southern African birds (Williams & Borello 1997b).

a.



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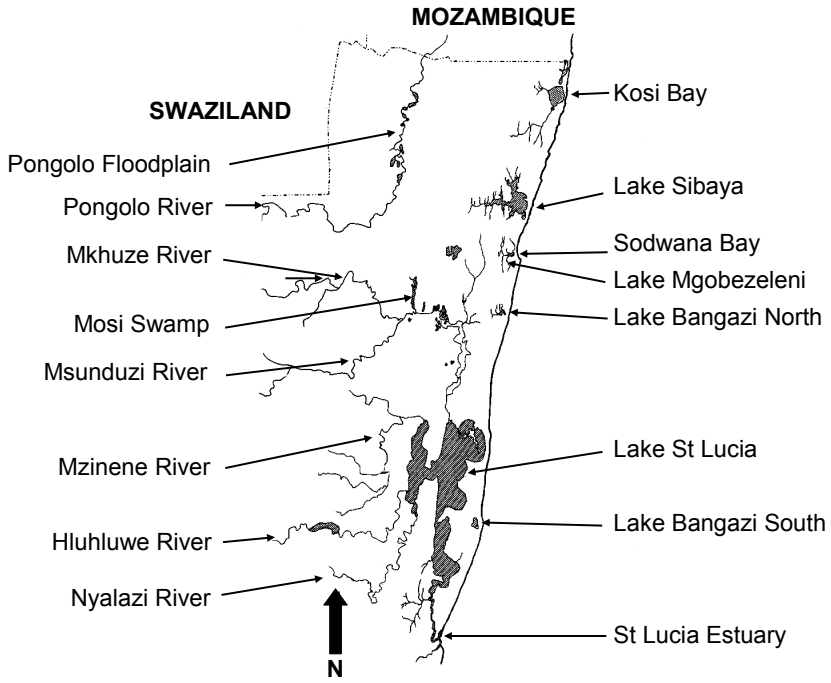


Fig. 3. Map of the study area in north eastern KwaZulu-Natal indicating a) the entire region and b) detail of the northern region.

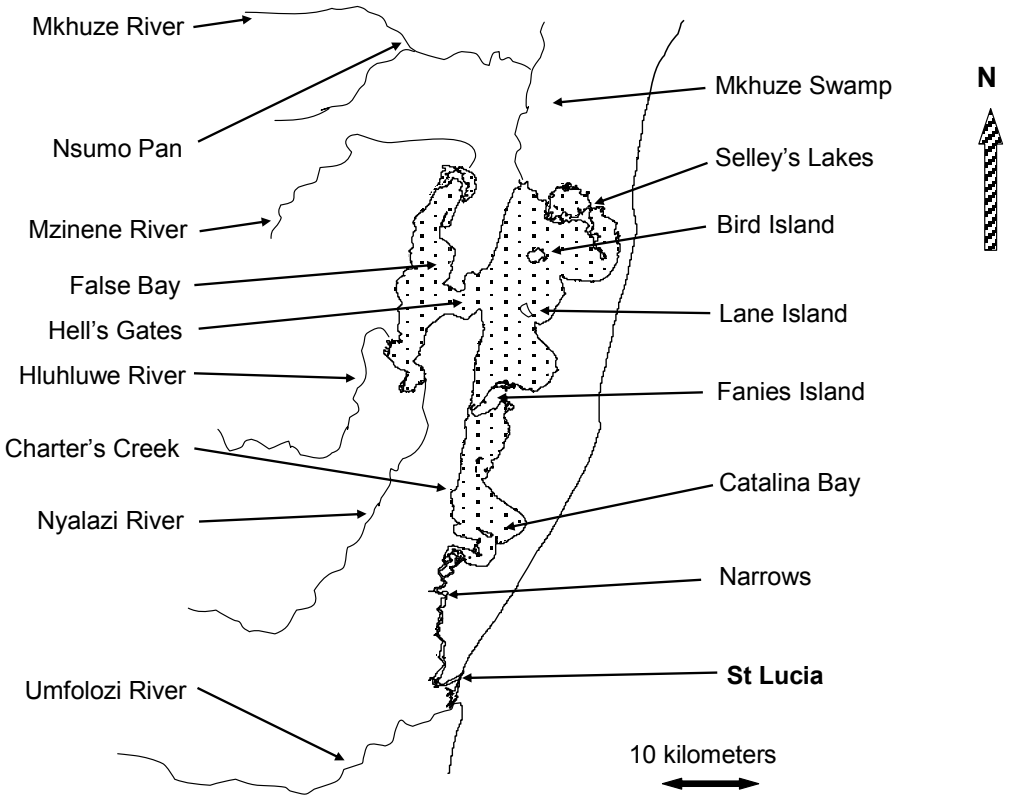
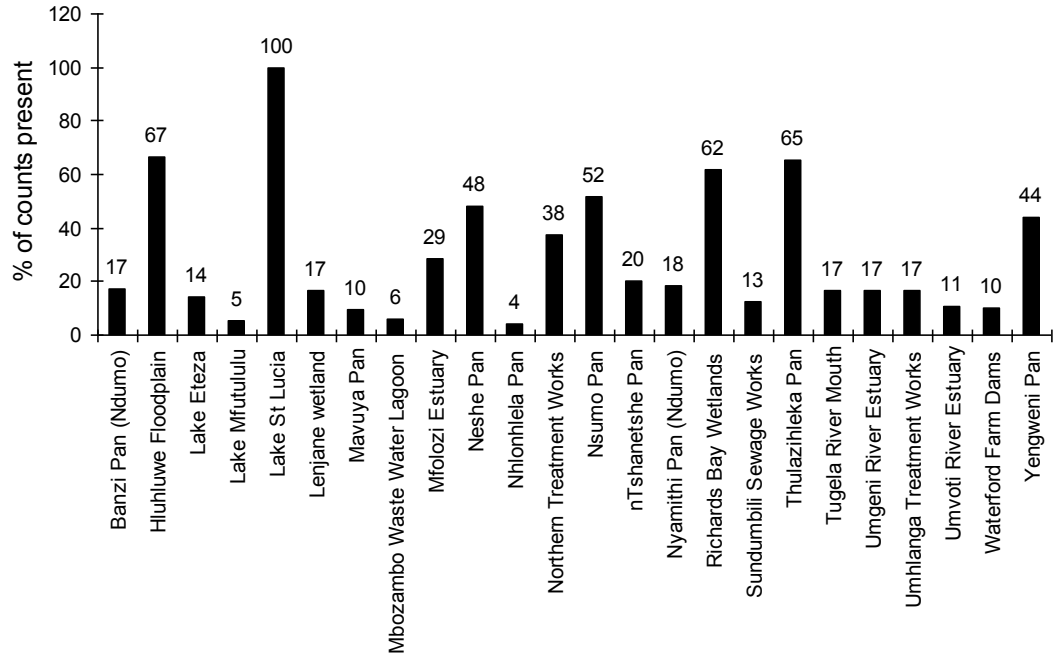


Fig. 4. Map of Lake St Lucia and the associated wetlands.

a.



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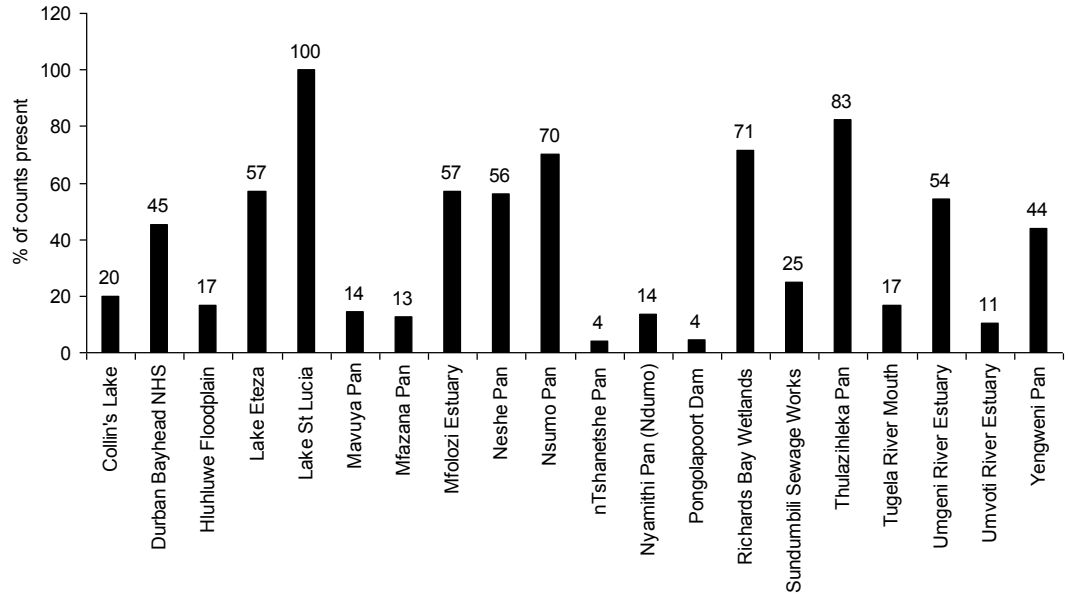
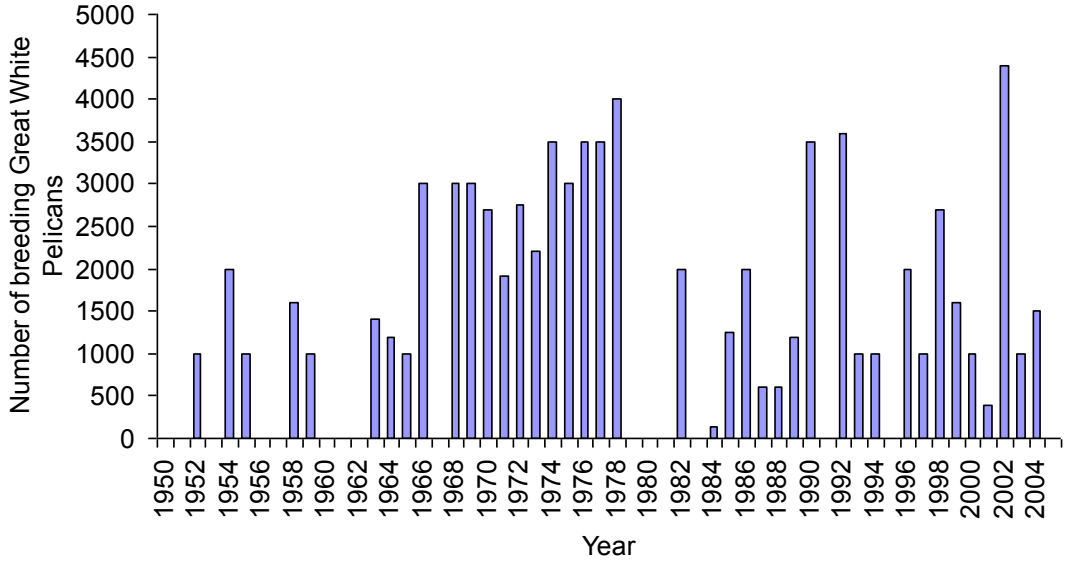


Fig. 5. The percentage of CWAC counts at which the a) Great White Pelican and b) Pink-backed Pelican were present at each site in north eastern KwaZulu-Natal between the years 1992-2005. Only sites counted five or more times have been included, and those sites at which pelicans have never been recorded have been omitted.

a.



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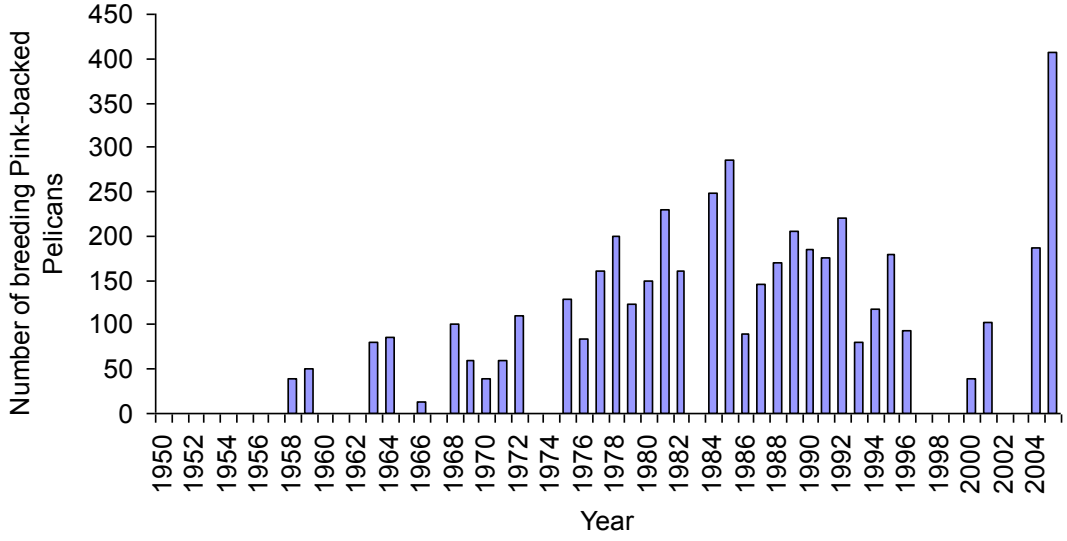
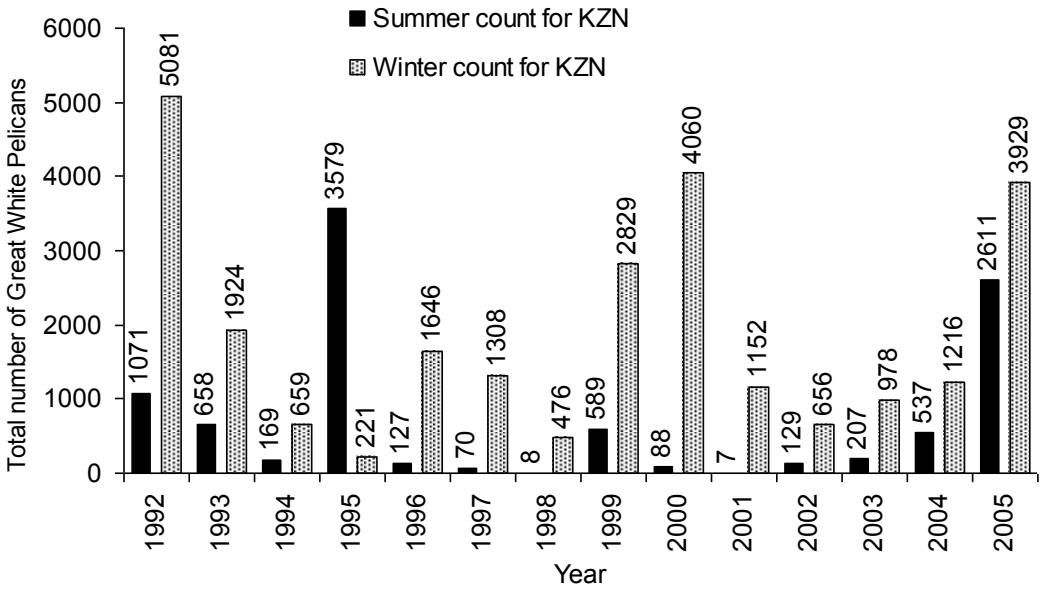


Fig. 6. Estimations of the numbers of breeding a) Great White Pelicans b) Pink-backed Pelicans present at nesting colonies in north eastern KwaZulu-Natal from 1950 till 2005.

a.



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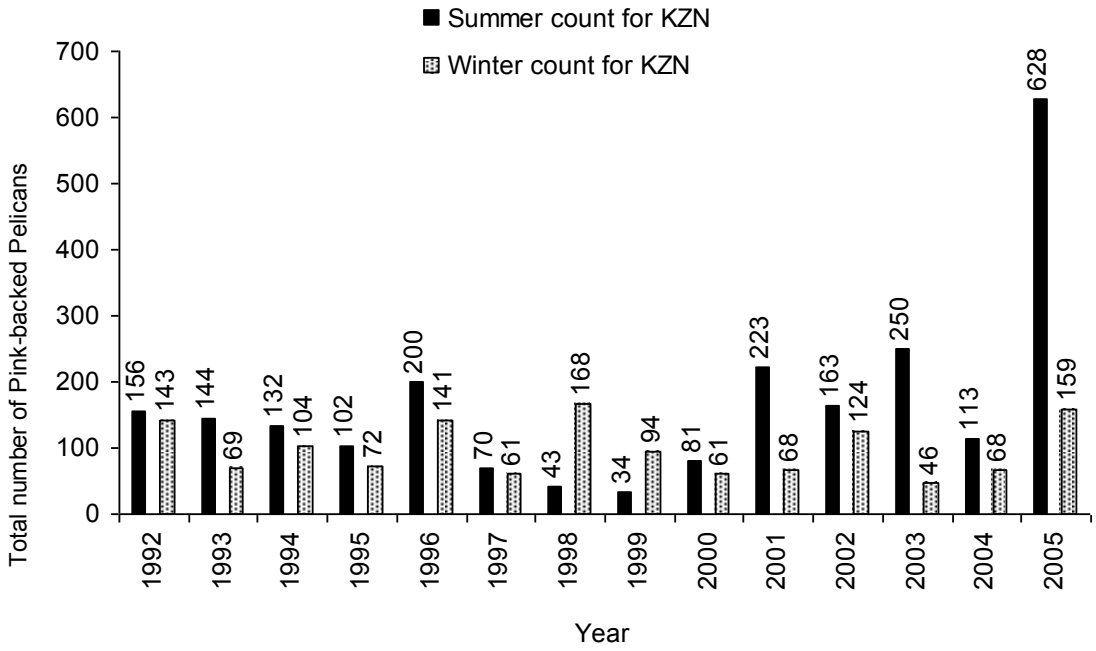
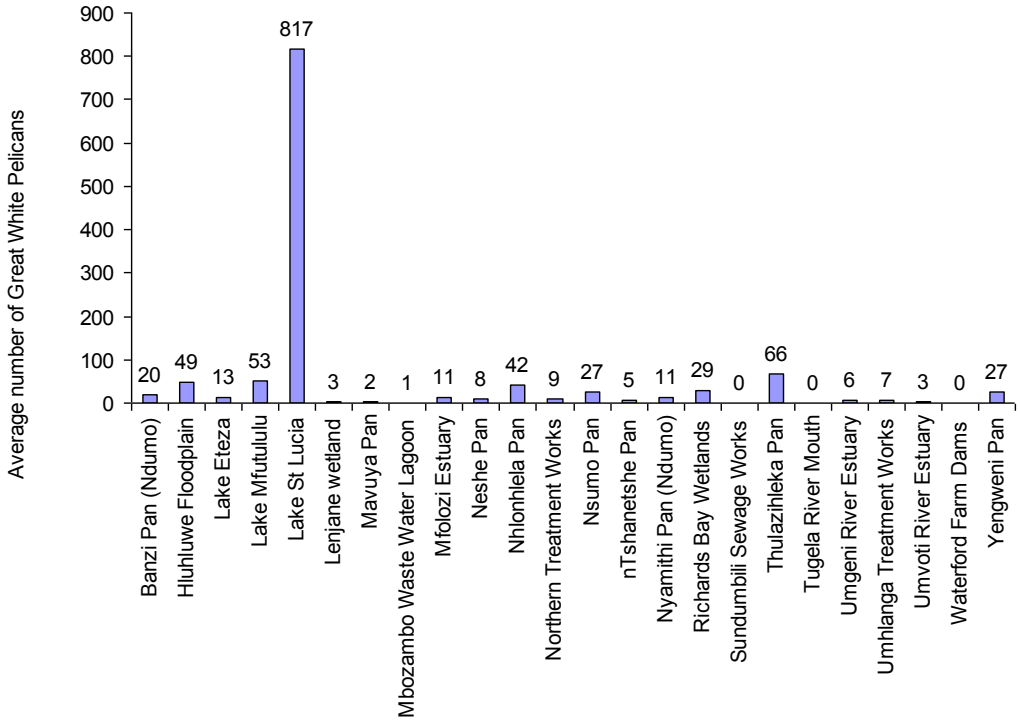


Fig. 7. Total number of a) Great White Pelicans and b) Pink-backed Pelicans at the north eastern KwaZulu-Natal CWAC sites during the summer and winter counts for each year from summer 1992 until winter 2005.

a.



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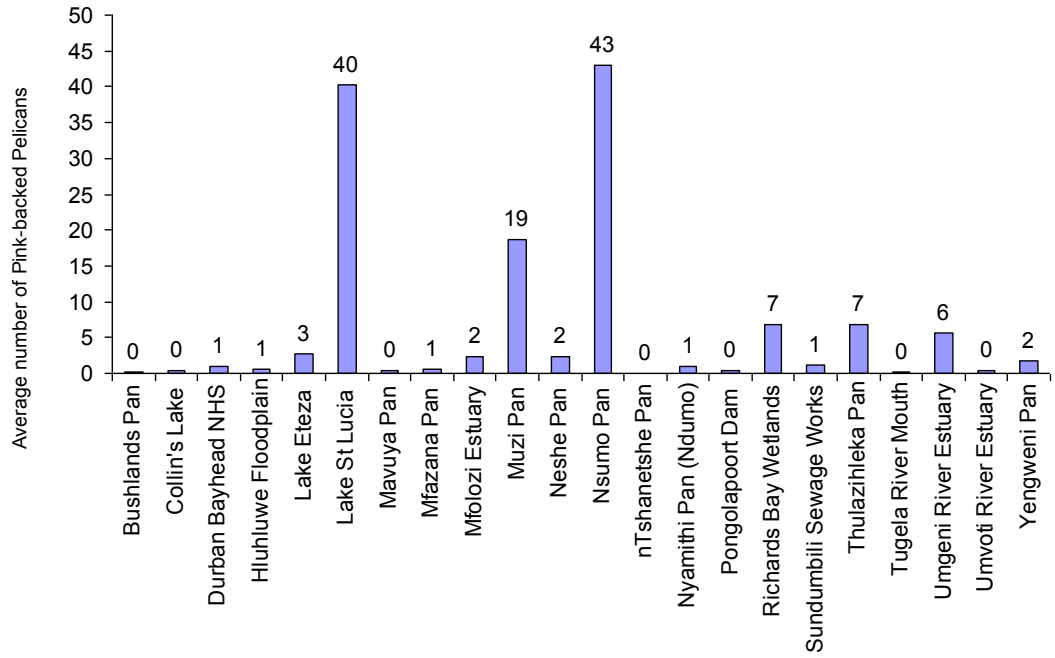


Fig 8. The average number of a) Great White Pelicans and b) Pink-backed Pelicans present at CWAC sites in north eastern KwaZulu-Natal during summer and winter counts for the period 1992-2005.

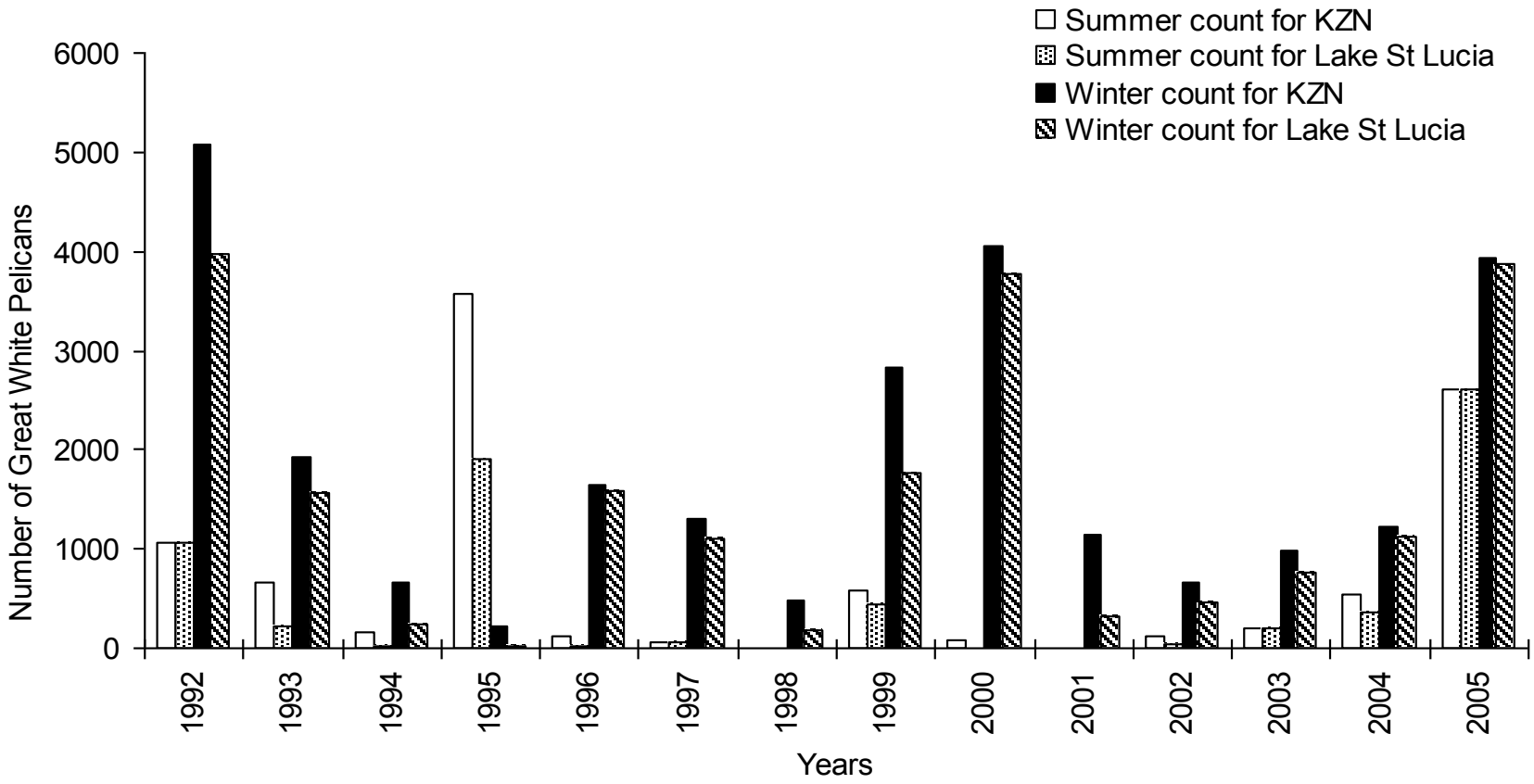
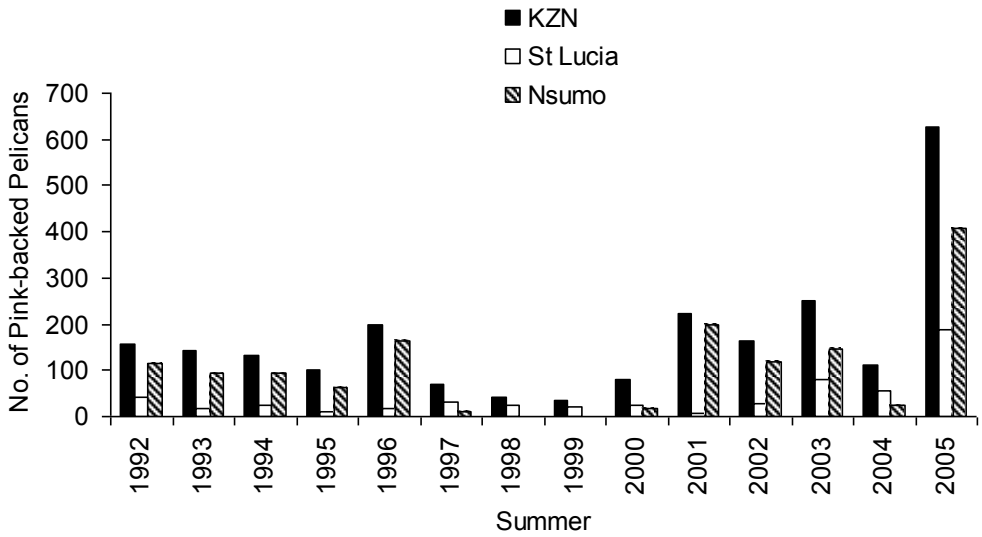


Fig. 9. The total number of Great White Pelicans counted at all north eastern KwaZulu-Natal CWAC sites (including Lake St Lucia) compared to the total number counted at Lake St Lucia, for summer and winter each year from 1992-2005.

a.



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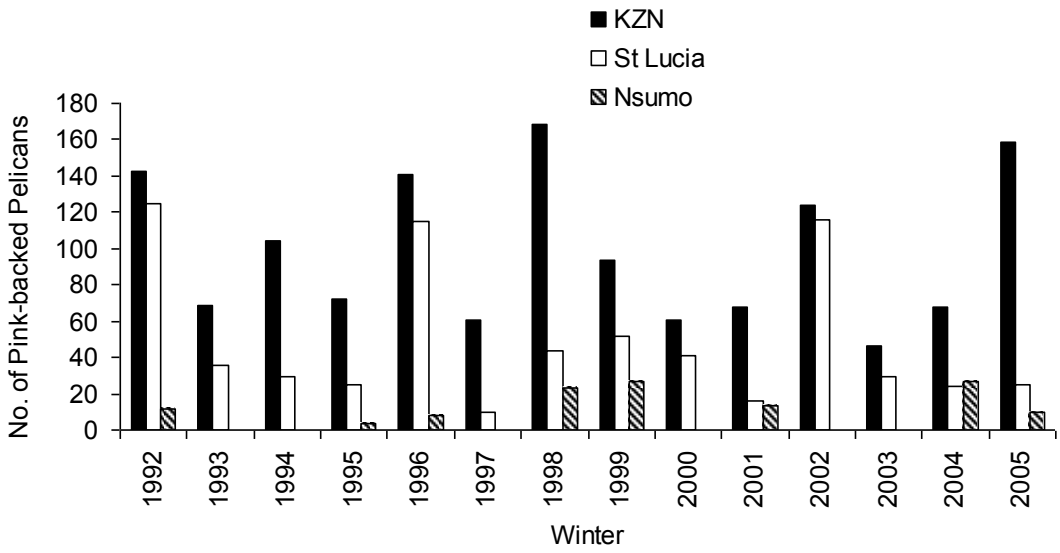
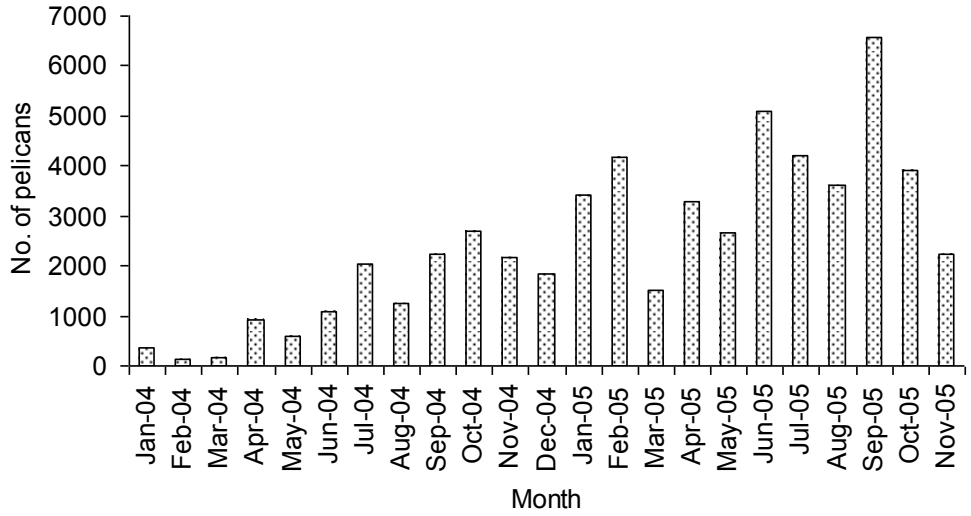


Fig. 10. The total number of Pink-backed Pelicans counted at all north eastern KwaZulu-Natal CWAC sites (including Lake St Lucia) compared to the total numbers counted at Lake St Lucia and the Nsumo Pan for summer and winter each year from 1992-2005.

a.



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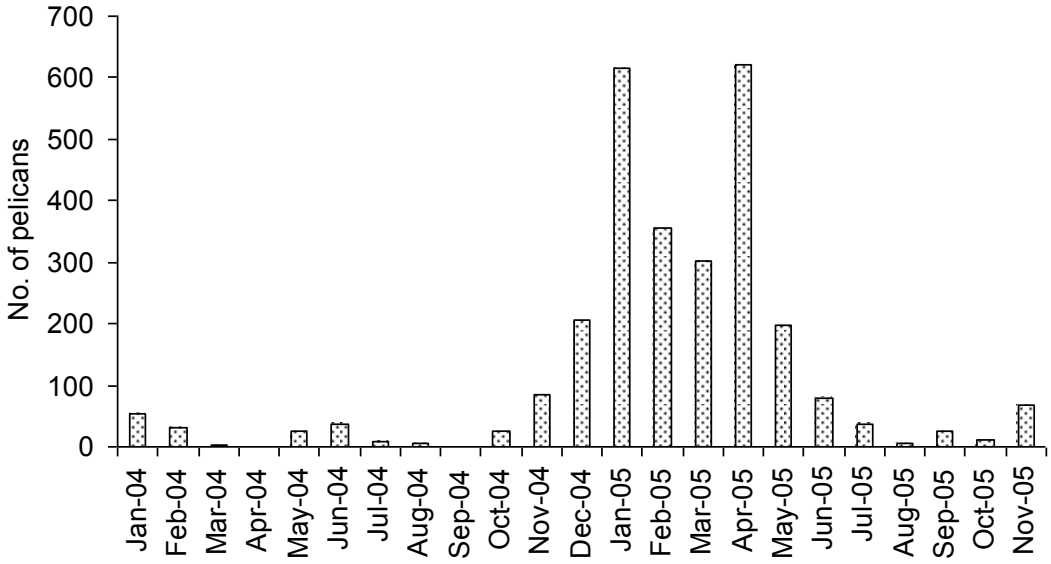

Fig. 11. The total number of a) Great White Pelicans on Lake St Lucia and b) Pink-backed Pelicans on Lake St Lucia, Nsumo Pan and Muzi Pan for the period Jan 2004 until Nov 2005.

CHAPTER 3

Breeding incidence of the Great White Pelican *(Pelecanus onocrotalus)* and the Pink-backed Pelican *(P. rufescens*) in south eastern Africa

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Abstract

The Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican *(P. rufescens)* are flagship species of north eastern KwaZulu-Natal. The traditional breeding sites for the Great White Pelican and the Pink-backed Pelican are confined to Lake St Lucia and Nsumo Pan respectively. Considerable amounts of data have been collected relating to the breeding efforts of these populations, and these have been collected in a variety of ways. This study represents an attempt to collate and summarise these data and to make some estimations of the breeding success of the two pelican species in south eastern Africa. The Great White Pelican showed erratic breeding attempts and success. Although less erratic only small numbers of the Pink-backed Pelican bred. This puts both species at risk.

Key words: Great White Pelican, Pink-backed Pelican, breeding sites, Lake St Lucia, Nsumo Pan, population

Introduction

Pelicans are generally popular and charismatic birds that could provide a symbol and focus for conservation awareness and action. This makes them an ideal flagship species for north eastern KwaZulu-Natal and a focus of attention for conservation. Any strategy proposed for the long term conservation of any species depends on input of many aspects of the biology and ecology of that species (Primack 1995). One of these aspects is breeding and so it is essential to gain some insight into the breeding efforts and success of the Great White and Pink-backed Pelicans before any pertinent conservation action can be formulated.

Lake St Lucia provides the only breeding area for the Great White Pelican (*P. onocrotalus*) in south eastern Africa (Williams & Borello 1997a). The earliest breeding record for Great White Pelicans in the region is from 1933 (Table 1), when a colony of Great White Pelicans was reported breeding on Bird Island in Lake St Lucia (Berruti 1980). The Pink-backed Pelican *(P. rufescens)* also has one major breeding site in south eastern Africa, and this is at the Nsumo Pan in the Mkhuze Game Reserve (Williams & Borello 1997b). When the first breeding of the Pink-backed Pelican was recorded in 1949, the nesting site was on the Hluhluwe River. In 1984 the colony moved to the present site, and they have used this site since then. Other minor sites have been used (Table 2) at various times, but never for more than two seasons. At present there is a small active colony of Pink-backed Pelicans in the Botanical Gardens in Durban (M.B., pers. obs.). Since these early dates the breeding colonies have attracted considerable interest and as a result there are many records of

observations made at these colonies. These records have been collected, and this study is an attempt to interpret and use these to produce an estimate of the breeding success in north eastern KwaZulu-Natal.

Like all the larger pelicans, Great White Pelicans are ground nesting birds that nest in large colonies (Maclean 1985). Normally this species favours islands for its nesting sites, but will nest on the mainland if the area is inaccessible to land predators (Brown & Urban 1969; Berry et al. 1973). Under abnormal circumstances nesting may take place in areas where they have nested in previous years even though the nest site may become exposed to predation (M.B., pers. obs.). Nesting sites are flat areas that may be covered with short vegetation or that may be bare. In the study area, Great White Pelicans have nested in the Lake St Lucia system (Fig. 1) on Bird Island and Lane Island, and more recently in the Selley's Lakes area in the northern region of the Lake (Feely 1962; Berruti 1980; Ezemvelo KwaZulu-Natal Wildlife, unpublished data).

The Pink-backed Pelican is one of only two species of tree-nesting pelicans in the world. Occasionally nests are placed in low bushes, reed beds and rarely even on the ground (Johnsgard, 1993). At the Nsumo Pan the Pink-backed Pelicans nest colonially, generally in the rainy season. They start congregating in December, and soon after that begin nesting in the *Acacia xanthophloea* trees that line the southern bank of the pan (Ezemvelo KwaZulu-Natal Wildlife unpublished data; M.B., pers. obs.).

The Great White Pelican is essentially a winter breeder in south eastern Africa. The breeding season however is highly variable, and the presence of a secure nesting site and an available food supply might be the initiating factors. It is not uncommon for there to be several waves of breeding within a single year, and these may coincide

with suitable foraging conditions and available fish stocks (Brown et al. 1982). Breeding at Lake St Lucia can start as early as April as in 1996, and can continue into March of the following year, as happened in the 1972/1973 breeding season (Table 1; Ezemvelo KwaZulu-Natal Wildlife unpublished data).

It is believed that Great White Pelicans breed initially at 3 to 4 years of age (Brown et al. 1982), while the smaller Pink-backed Pelicans reach sexual maturity a year earlier (Johnsgard 1993). Great White Pelicans start forming groups in which the individuals are closely spaced (Feely 1962). Brown and Urban (1969) describe how groups of males in full breeding condition form in the region of the breeding site, and gradually females are attracted. These groups become very closely packed and perform a wide range of group displays. Individual birds then leave the group to pair off, and then congregate at the breeding site. Normally two eggs are laid in a very simple nest, sometimes simply a scrape in the ground, and both birds incubate the eggs (Johnsgard 1993). Pelecaniform birds have two peculiar features related to their breeding strategy. Their eggs have a chalky texture, and the parent birds have no brood patch (del Hoyo et al. 1992). Incubation involves trapping the eggs between the feet and the belly to supply the necessary warmth (Johnsgard 1993). Incubation lasts for 37 – 41 days (Maclean 1985) and the nesting period is estimated to be about 65 to 70 days (Brown et al. 1982). The nestling is altricial, and is naked and red when it hatches. It then turns black before growing a cover of dark brown down (Brown & Urban 1969). The Great White Pelican is the only pelican whose nestling has dark brown down, all other pelican nestlings being white (Johnsgard 1993). In a large Ethiopian colony the breeding success at fledging was estimated to be 0.8 to 0.9 young per pair, or about 50% of the total number of eggs laid (Brown & Urban 1969).

The post-fledging dependence period is unknown as the birds can disperse far from their breeding grounds, and individuals are difficult to identify.

All pelican nestlings have a very short bill when they hatch. The bill grows steadily until the bird fledges, when it becomes the characteristic pouched bill of this family (del Hoyo et al. 1992).

For the Pink-backed Pelican, the nest is a relatively small structure, made up dried branches and twigs, with a small central depression in which the eggs are laid (Burke & Brown 1970). Din and Eltringham (1974) note that nest sites are chosen to include a "resting branch" near to the nest and these branches are used during preening, changeovers, nest building and while feeding the nestling when it is larger. They note also that the Pink-backed Pelican colony is not as closely packed as it is for the Great White Pelican, but that this is probably simply a result of there being limited nest sites available in a tree. The average clutch size is approximately two, and incubation starts immediately after the first egg is laid, lasting between 30 (Din & Eltringham 1974), and 33-34 days (Burke & Brown 1970). Hatching is asynchronous within each nest, with nestlings hatching in the same sequence as the eggs were laid. The average brood-size at hatching for 174 broods was 1.9 over three breeding seasons, with 64.9% of the nest producing two nestlings each (Din & Eltringham 1974). The nestling is helpless and blind when it hatches and takes a further 70 to 75 days before it is ready to leave the nest on its first practice flight (Burke & Brown 1970). The post-fledging dependence period for the Pink-backed Pelican is unknown as the birds can disperse far from their breeding grounds, and individuals are difficult to identify.

Although the breeding cycles of the Great White and Pink-backed Pelicans show similar patterns, their breeding strategies are quite different. Observations and records were collated and analysed in an attempt to identify any trends in breeding effort and

breeding success, or whether these were unpredictable. In particular, the aim was to determine the incidence and success of breeding in the Great White Pelican and Pink-backed Pelicans in north eastern KwaZulu-Natal. It was expected that breeding of the Great White and Pink-backed Pelicans in north eastern KwaZulu-Natal is irregular as a consequence of changing conditions at the traditional breeding colony sites and that this irregularity is exacerbated by their breeding strategies.

Methods

Data collected by Ezemvelo KwaZulu-Natal Wildlife, mainly from rangers' reports and bird counts were accessed. The photographic slide collection, lake condition reports and previous correspondence housed at the St Lucia Office of Ezemvelo KwaZulu-Natal Wildlife also yielded information on Great White Pelican and Pink-backed Pelican breeding. The Mkhuze Game Reserve research office provided breeding data for the Pink-backed Pelicans at the Nsumo Pan. Data were collected at the Nsumo Pan during the period 2004 and 2005. At Lake St Lucia, some data were collected during 2004, but not during 2005, as no breeding took place there during 2005.

The nesting sites of the Great White Pelicans on Lake St Lucia are often impossible to access by boat or from the ground, and so aerial surveys have been done. Aerial surveys have also been done of the Pink-backed Pelicans at Nsumo Pan where it is difficult to estimate the numbers of nests from below the trees (M.B., pers. obs.). It is also vital to keep the human disturbance in these areas to a minimum and aerial surveys cause fewer birds to temporarily leave their nests than entry into the colony area by land or boat (M.B., pers. obs.). However when counting the nests of the Pink-backed Pelicans using aerial estimates, there may be some danger of confusing the

pelicans with other white birds that nest in trees in the same location. These would include Yellow-billed Storks (*Mycteria ibis*), African Spoonbills (*Platalea alba*), and the white Egrets (*Egretta* sp) which have all nested at the Nsumo Pan with or near the pelican colonies. This potential error should not affect the counting of Great White Pelicans, as they nest on the ground, and do not seem to share their present breeding site in the Selley's Lakes area with other white birds. When the nesting took place on Bird Island, there was some sharing of the island with African Spoonbills (*Platalea alba*) and Caspian Terns (*Hydropogne caspia*), and this could happen again in the future (Ezemvelo KwaZulu-Natal Wildlife unpublished data).

Elsewhere the breeding success rate for Pink-backed Pelicans, defined as young fledged per breeding pair per annum, has been found to range between 0.55 (Burke & Brown 1970) and 0.7 (Din 1979), with an annual recruitment rate of about 18% of the total adult population (Burke & Brown 1970). For the Great White Pelican the breeding success has been found to be about 0.8 – 0.9 young per breeding pair per season or about 50% of the eggs laid (Brown & Urban 1969). For this exercise the average number of fledglings raised per Great White Pelican breeding pair has been taken as 0.85, or as 50% of the total number of eggs laid. For the Pink-backed Pelican the average of 0.63 fledglings per adult pair or per nest was used from documented values (Burke & Brown 1970, Din 1979) as no data for north eastern KwaZulu-Natal was available. This is necessary when nestling numbers are estimated from the numbers of breeding pairs, and vice versa.

For the Great White Pelican which is a winter breeder, the year given refers to the breeding season of that year. For the Pink-backed Pelican which breeds over the summer season, the year refers to the January that lies in that season. The date 1998

therefore applies to the breeding season that lasts from the end of 1997 to the beginning of 1998.

Results

During the period 1950-2005, equivalent to 56 potential breeding seasons, the Great White Pelican nesting sites at Lake St Lucia have failed or no breeding has been confirmed on 24 occasions (Table 1; Fig. 2a). During this same period the Pink-backed Pelican nesting sites have been noted to have failed, or not had any breeding attempts, on only six occasions (Table 2; Fig. 2b). This equates to a recorded rate of 43% and a 9% for the Great White and Pink-backed Pelicans respectively, for non successful breeding seasons.

Estimates made from the number of nestlings actually counted varied considerably (Fig 3a,b). This is to be expected if hatching is asynchronous and breeding effort can vary throughout the breeding period. Counting nestlings is also difficult if the parents are still with them as they may shield any view of the nests or nestlings. It is also at this stage that the nestlings are most vulnerable, and their numbers can decrease catastrophically with changes in weather or environmental changes. The average for the number of nestlings counted per successful breeding season was 1064 and 61 for the Great White Pelican and Pink-backed Pelican respectively (Table 3). Counting techniques included counts from aerial pictures, ground counts, but were not collected using standardised procedures.

Most estimates of breeding success for the Great White Pelican (Table 1) and the Pink-backed Pelican (Table 2) in this study were derived from adult breeding numbers or breeding pairs (Fig. 4a,b). These estimates produced averages of 1081 and 46

nestlings respectively per successful breeding season (Table 3). Few estimates were based on the number of birds that fledged, and these estimates gave averages of 451 and 15 nestlings per successful breeding season for the Great White and Pink-backed Pelicans respectively (Table 3, Fig 5a,b). For each year the estimations from these three methods were compared, and the maximum value for each year in which records were available was taken. These maxima were averaged to produce an estimate of the average maximum number of nestlings produced per year. For the Great White Pelican this produced a figure of 656 ± 236.95 (S.E.), (n = 3) nestlings per successful breeding season. The trends in the results were the same for both species for the three methods of estimation used, but all estimates of the number of nestlings produced per season for the Pink-backed Pelican were much lower. Their average for the maximum estimations reached only 46 ± 22.54 (S.E.), (n = 3) nestlings per successful season.

The estimates of the number of Great White Pelican nestlings produced each year showed no reliable trends over this period (R^2 = 0.0015) (Fig 6a). For the Pink-backed Pelican the number of nestlings produced per successful breeding season showed a positive trend over the 56 year period covered by this study (Fig. 6b), although this trend is not very robust (R^2 = 0.1774). For the Pink-backed Pelican this may be explained by their change from the Hluhluwe River nesting site at Lake St Lucia to the site at the Nsumo Pan in the Mkhuze Game Reserve. The new site provides the birds less human disturbance and a greater number of trees in which to nest (M.B., pers. obs.). They have moved from a site predominated by *Acacia robusta* to one predominated by *Acacia xanthophloea*. Although the birds are now a short distance from Lake St Lucia, they are still within easy access of both the lake as well as the pans of the Mkhuze and Pongolo River floodplains for foraging.

Discussion

Both the Great White Pelican and the Pink-backed Pelican nest colonially, and as a result any disturbance of their breeding effort can have a major negative impact on the outcome of that breeding season. Clutch size, hatching success, fledging success and overall reproductive success can be lowered by human and aerial disturbance (Carney & Sydeman 1999). Nesting sites on the islands in Lake St Lucia are also subjected to flooding by the influx of water into the lake during wet periods or by the effects of strong winds pushing the water into the northern areas of the lake (Taylor 1982). During times of drought the lake level drops rapidly and the breeding islands very soon become linked to the shoreline of the lake, as these areas are particularly shallow, and the islands then no longer provide safe nesting sites (M.B., pers. obs.). In the Selley's Lakes area the nesting sites of the Great White Pelicans are protected from the north by an extensive wetland and associated reed bed (Johnson et al. 1998), and so although the area is not a true island, it is still virtually inaccessible to land predators. When this vegetation dies back in years of drought, the area no longer provides a safe breeding site (M.B., pers. obs.). Great White Pelicans can therefore be forced to abandon their breeding effort for the season. In some years, as in 2005, they made no attempt at breeding, while in other years as in 1984, they made several attempts, but were forced to abandon them as conditions drove them away (Table 1; Ezemvelo KwaZulu-Natal Wildlife unpublished data). Colonial nesting also makes the group of birds susceptible to disease, and breeding can fail as a result. This is thought to have happened to the Selley's Lake colony in 1968 when only two birds

fledged naturally from a group of over 1000 nestlings (Table 1; Ezemvelo KwaZulu-Natal Wildlife unpublished data).

The tree nesting Pink-backed Pelican is not as susceptible to changing conditions as is the Great White Pelican. Although the trees in which they nest at the Nsumo Pan are along the shoreline of the pan, Pink-backed Pelicans still nested there in January 2004 when the pan was dry (M.B., pers. obs.). They also seem to be less susceptible to human disturbance (Burke & Brown 1970), as can be surmised from the small colony that has recently started in the Botanical Gardens in Durban (M.B., pers. obs.).

Weather conditions may therefore account for the frequent abandonment of nests and nest sites by the Great White Pelican (Table 1; Fig. 2a). Many of the nest site failures of the Great White Pelican on the islands in Lake St Lucia have been as a result of flooding (Table 1). Pink-backed Pelican nests and nest sites are abandoned less frequently, and this may be attributed partly to their elevation above the ground, where they cannot be flooded (Table 2; Fig. 2b).

The breeding records that have been accumulated since 1950 have been collected by many individuals, and there has been no consistency in the way observations have been made and recorded (Chapter 2). The nestlings of the Great White Pelican take about 70 days from hatching to fledging (Brown & Urban 1969) while the Pink-backed Pelican nestlings require about 80 days (Din & Eltringham 1974). During this phase mortality of the nestlings is particularly high. In the Great White Pelican this loss may be about 40% by the end of the first month after hatching (Brown & Urban 1969). Mortality among Pink-backed Pelican nestlings is also high, with 45% of the hatchlings dying within the first 60 days (Burke & Brown 1970). Therefore when the breeding records were analysed the phrase “1000 chicks” could reflect a range from 600 if they had been counted 1 month later, to about 1660 if hatched and counted 1

month earlier. To obtain a comparative figure, it is therefore necessary to know at what stage the counting was done.

This does not apply to the nestling stage only. Breeding in both species is asynchronous, even though the major effort is concentrated over an initial common period (Brown & Urban 1969; Din & Eltringham 1974). The number of adults at the breeding site can also vary significantly. If the birds are congregating at the nest site just prior to nest building or egg laying, then they are present in pairs, and their numbers will be at a maximum. Once incubation starts, half of the birds may be away foraging, and when they are feeding the nestling, both parents may be away simultaneously. In the Pink-backed Pelican the non-incubating bird may take up a position on a branch near the nest (Din & Eltringham 1974). All this makes the estimation of colony size, nestling productivity and breeding success less reliable. This again shows that it is important to know what stage the nesting cycle has reached when estimations are made.

Estimating the number of pelican nestlings that successfully fledge is the most difficult of all. While courtship and nest-building, incubation and the development of the nestling all take considerable periods of time, leaving the colony as a successfully fledged juvenile is a short process. Added to this is the possibility that they may return to or stay near the colony or may disperse to areas far from the breeding colony (Brown & Urban 1969). This is probably the reason that there have been so few estimates made of the annual number of fully fledged juveniles (Fig. 5a,b).

The maximum estimates for each of the three methods used were averaged. The result gave a value of 656 nestlings per successful breeding season for the Great White Pelican, which is well below both the estimations made from the extrapolation from adult numbers (1081), and the average number of nestlings counted (1064), but

is above the average for the number of birds fledged (451) (Table 3). The large discrepancy between the average number of birds that fledge and the estimates of the number of nestlings counted supports the findings of Burke and Brown (1970) and Brown and Urban (1969) that there is high mortality among the younger nestlings of the Great White Pelican. The same pattern emerges for the Pink-backed Pelican, with the nestling count of 61 higher than the overall average of 46, and the estimate from adult numbers (46) the same as the maximum estimate overall average (Table 3).

The Great White Pelican population for north eastern KwaZulu-Natal has been estimated to be between 2000 pairs (Crawford et al. 1981) and 3000 breeding pairs (Taylor 2000). In aerial surveys done in 1990 and 1992 an estimated 4000-6000 birds and 6000 breeding adults respectively were counted in Lake St Lucia (Ezemvelo KwaZulu-Natal Wildlife unpublished data). If an estimated 656 Great White Pelican nestlings were recruited into this population during each successful breeding season (Table 3), and 57% of breeding seasons were successful (Fig. 1) then this equates to an annual average recruitment of about 374 nestlings for the Lake St Lucia population. This then implies an annual mortality rate of approximately 6.2% if the population numbers were to remain constant at the maximum estimate of 6000 individuals. This is low compared with the mortality rates of about 20% proposed for the adults of the American White Pelican (*P. erythrorhynchos)*. This is a similar sized pelican with similar social and nesting habits, and the only pelican species for which a life table is available (Strait & Sloan 1974).

The estimated population in south eastern Africa for the Pink-backed Pelican is below 250 pairs (Williams & Borello 1997b). If an estimated 46 nestlings were recruited into the population during each successful breeding season, and if breeding seasons were 91% successful, then this means that an average of 44 Pink-backed

Pelican nestlings entered the population per year, and that the annual mortality rate was about 8% if the initial breeding population size was taken as 500 and was to remain at this level.

The explanation for the great annual variation in nestling production by the Great White Pelican is probably complex. There are no obvious patterns in the data of successful and unsuccessful breeding seasons. The South African Defence Force used this area for missile testing from about 1968 to 1990, and this may have impacted on the breeding success in some of those years. Breeding failure was more frequent from 1978 through to 1984 than it has been since (Figure 2a). Lake conditions are highly variable and there is more potential for catastrophic events on the ground at Lake St Lucia for the Great White Pelicans than there is for the Pink-backed Pelicans in the trees at the Nsumo Pan (Tables 1&2). Any trends may be an artifact of more regular and better quality data collection recently. Aerial counting has allowed access to areas that are suitable for foraging, but that may be inaccessible by foot, road, or boat, and this may have improved estimates of nestling and breeding adult numbers. The change in policy with respect to the opening of Lake St Lucia to the sea may have influenced the breeding in recent years. Closing the mouth from the sea results in greater fluctuations in lake levels, and this can influence both the food and the suitable nest site availability. It is too early to make a judgment on how this impacts on the pelicans in the region.

All these estimations are based on very coarse data that have been collected and recorded in an unsystematic way by many people over a long period of time. It does however allow some estimations to be made, and possible trends to be suggested. These possible coarse trends do not mean though that the Great White Pelican and the Pink-backed Pelican populations in north eastern KwaZulu-Natal are not at risk. The

Great White Pelican population may be fairly static for its entire range, but their numbers (Chapter 2) and breeding success north eastern KwaZulu-Natal imply that its presence in north eastern KwaZulu-Natal is erratic. For the Pink-backed Pelican the population trend seems to be a positive one for north eastern KwaZulu-Natal, but their numbers are still very low for what might be a discrete population. The erratic breeding of the Great White Pelican and small numbers for the Pink-backed Pelican put both these species at risk.

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Tables

Table 1. Summary of the breeding records for the Great White Pelican from the beginning of 1933 till the end of 2005

Year	Month	Site	Breeding Ad	Nests	Eggs	Chicks	Fledged	Remarks	Source of information
1933		Bird Island	2000						Berruti 1980
1949		Bird Island	250-500	60					Berruti 1980
1950		Bird Island	thousands					June: Nest building	Berruti 1980, NPB Files
1951		Bird Island			hundreds			Colony deserted in August	Berruti 1980
1952		Bird Island	thousands of adults			500		Flooded, unsuccessful	Berruti 1980
	June							Adults breeding (June)	Ranger's reports
1953	July	Bird Island						Breeding	Ranger's reports
	Nov	Bird & Lane Is						60 dead chicks found (Starved?)	Berruti 1980
1954		Bird Island	2000						Berruti 1980
1955		Bird Island	1000		800 - 1000			Flooded	Berruti 1980
	July	Bird Island						Eggs laid - 2nd attempt	Berruti 1980
1956		Bird Island						80% successful	Berruti 1980
1957		Lane Island			Incubated July		0	Flooded in Sept/Oct. Wiped out	Berruti 1980, Feeley 1962
1958	June	Lane Island	Approx 800 pairs		Incubated June			Aug - newly hatched chicks. Sept - Aprox 35 chicks. Oct - Young flying. Last young off island end of Nov.	Ranger's reports
	Aug	Lane Island	1500			300 - 500	300		Berruti 1980, Feeley 1962
1959		Bird Island			1000			Abandoned in April	Berruti 1980
		Lane Island					200 - 250	Eggs laid June - 2nd attempt. Sept - juveniles noted.	Berruti 1980
1960								Did not breed	Berruti 1980
1961								May have bred at Selley's Lakes	Berruti 1980
1962		Selley's Lakes							Berruti 1980
1963		Selley's Lakes	hundreds					500 chicks & 200 eggs lost in flood	Berruti 1980
1964		Selley's Lakes	hundreds			500 - 700			Berruti 1980
1965		Selley's Lakes	hundreds			Approx 500			Berruti 1980
1966		Selley's Lakes	1500 pairs						Berruti 1980
1967								Did not breed	Berruti 1980
1968		Selley's Lakes	1500 pairs (9 July)		2000 - 3000	1000	2 hand reared. 2 naturally	9 July: Half of Br Ad have laid. 18 Aug: hundreds of dead chicks; eggs still hatching; 50 chicks still alive. 2 Sep: 2 taken to be hand-reared. Fungoid microtoxicosis suspected for deaths. High salinities (42 - 47 ppt)	Forrest 1969 Notes, Berruti 1980
1969		Selley's Lakes	1000 - 1200 pairs			300		March: SADF fired rockets towards Bird Island. High salinities (42 - 49 ppt). Little birdlife	Berruti 1980 , NPB Files
1970		Selley's Lakes	1200 - 1500 pairs			1000 - 1500		R Taylor has blanks for this year	Berruti 1980 , NPB Files
1971		Selley's Lakes	1000 pairs			800			Berruti 1980
	June	Selley's Lakes	960 pairs	480	1440			Eggs present at hatching: 950 Eggs lost before hatching: 490. Discrepancy ad vs br pairs vs nests.	Forrest1971 notes
	Aug	Selley's Lakes		720		120 (nursery)			Forrest1971 notes

Year	Month	Site	Breeding Ad	Nests	Eggs	Chicks	Fledged	Remarks	Source of information
1972		Selley's Lakes	1500 - 2000			2000 - 3500		Breeding completed in March 1973	Berruti 1980, NPB Files
1973		Selley's Lakes	1100 pairs						Berruti 1980
		Bird Island				17 (June)		Colony "framed" (Taylor R)	NPB Files
1974	Oct	Selley's Lakes	1500 - 2000 pairs			Approx 700		SADF fired live warheads. Low flying helicopters	Berruti 1980 , NPB Files, Photo's
1975		Selley's Lakes	1500 pairs			Approx 250		May: Colony flooded. 10 June: breeding area abandoned	Feeley, Berruti 1980
	Oct	Selley's Lakes				212		147 Ad + fully fledged young	Aerial Photo
1976		Selley's Lakes	1500 - 2000 pairs			1500		Dec Last of chicks almost fully grown; starting to fly.	Berruti 1980, Lake Condition Report
1977		Selley's Lakes	1500 - 2000 pairs			1000 - 1500			Berruti 1980
1978		Selley's Lakes	1000 pairs			90		Most eggs and chicks deserted	Berruti 1980
	July		2000 pairs					SADF active mid-1978. Lane Island erection of tower & firing of missiles.	NPB Files
1979		Selley's Lakes			"thousands"	Approx 100		Thousands of eggs abandoned	Letter R Taylor to J Cooper July 1982
1980								No nesting recorded, but a few juveniles seen - nesting elsewhere? SADF active. Conditions ideal - but no breeding.	Letter R Taylor to J Cooper July 1982
1981		Selley's Lakes						No breeding	Letter R Taylor to J Cooper July 1982
		Lane Island		Approx 100				Unsuccessful - abandoned	Letter R Taylor to J Cooper July 1982
1982	July			1000		100		1 June: 1000 nests with birds on them; 100 chicks of 2/3 adult size. (Earlier nesting?)	NPB Files
	Aug		320			400 - 500		300-400 young; 96 nearing ad plumage	Lake Condition Report
	Nov					100 - 150		Dark juv, 3/4 ad size, starting to fly	Lake Condition Report
	Dec							Breeding finished. Colony 5 ad, 30 sub-ad.	Lake Condition Report
1983	Nov							It appears as if almost no young were produced this year	Lake Condition Report
1984			Approx 140				4		Lake Condition Report
1985	Aug	Selley's Lakes	1120			Approx 100		SADF firing G%. No NPB monitoring of SADF activities.	Bird count
	Oct	Selley's Lakes	1250			Approx 100			Bird count
1986							800*		R Taylor fax to D Johnson 2/9/91
1987		Selley's Lakes	610				0*	Flooded 28/9/87	R Taylor fax to D Johnson 2/9/91
1988		Selley's Lakes	300 nesting				0*		R Taylor fax to D Johnson 2/9/91
1989		Selley's Lakes	1200	1000			0*		R Taylor fax to D Johnson 2/9/91
	Aug	Selley's Lakes						Colony abandoned.gs partly incubated	Photo's C Fox
1990		Selley's Lakes	900 counted				1000*	Ad feeding away from Lake	R Taylor fax to D Johnson 2/9/91
	June	Selley's Lakes	1500-2000						Sept Bird Count, Photo's
1991		Lane Island			small no.			No breeding at Selley's Lakes. Water level 1,4m. Selley's and islands flooded. Eggs on Lane Is abandoned.	NPB Files, Photo's
1992	June	Selley's Lakes	Approx 1500 incubating			300 1/2 grown		2144 pelicans elsewhere on the Lake. Dry down conditions on Lake.	3 Monthly Research Monitoring Summary, Photo's
	Aerial								
	Sept	Selley's Lakes	224			1196	1000 - 1200	In 2 colonies. Approx 6000 br. Ad. Chicks almost ready to fly.	Aerial count - from slide (R Taylor). Notes from bird counts, Photo's
1993	Aug	Selley's Lakes	200 sitting			Approx 600		Ad sitting; chicks 1/2 grown	Aerial count, Photo's
1994	April	Selley's Lakes						2/3 of original colony was abandoned.	April Bird Count, Photo's
	July	Selley's Lakes	600					Large number have abandoned colony. 600 remain.	July Bird Count, Photo's

Year	Month	Site	Breeding Ad	Nests	Eggs	Chicks	Fledged	Remarks	Source of information
1995								No breeding. No pelicans. Islands flooded.	Aerial count
1996	April	Selley's Lakes	800 nesting			600 - 800			C Fox (Matubatuba BC newsletter).Confirmed G Forrest - aerial (oct). 3 Monthly Research Monitoring Summary
	June	Selley's Lakes	1500			300		All appeared to be on nests	Aerial count
	Sept	Selley's Lakes	224			1206			Aerial count
1997	13-Apr	Bird Island	972		Yard eggs found			Lake levels high. Selley's flooded.	C Fox. Bird count 13 April.
	05-Jun	Bird Island	Approx 1000	yes					RTaylor Aerial obs. 5 June, Photo's
	12-Jul	Bird Island	652			8 dark			July Bird Count
	15-Aug	Bird Island		489	Est 4000	262 dead	Some	Colony flooded by winter rains. Abandoned.	C Fox fax to Thinus, Photo's
	Oct	Lane Island			yes	5		Started in July?	October count
	Nov	Lane Island						Abandoned.	Photo's
1998	July	Selley's Lakes				1000		Hatched in May?	Matubatuba BC Newsletter (Aug), Photo's
	Jul-Dec	Selley's Lakes	741			2668		Aerial obs. In July	3 Monthly Research Monitoring Summary, Photo's
1999	July	Selley's Lakes	1600			1300 dark		Aerial photo. Lake too low for boat count.	3 Monthly Research Monitoring Summary
2000	Aug	Selley's Lakes	1000			700 - 1000			Aerial Photo S McLean
2001	16-Aug		400			150		Bred March till Dec	Aerial 16 Aug (R Taylor)
2002		Bird Island		2200		40		July CWAC. Abandoned. Illegal netters on Island.	Matubatuba BC Newsletter (July)
		Lane Island						July CWAC	Matubatuba BC Newsletter (July)
2003	Aug	Selley's Lakes	68 at colony			456 juveniles		456 Juv seen Aug.	Aerial count, Photo's
2004	June	Selley's Lakes	1500 at colony site					Not incubating	Photo's
	July	Selley's Lakes	700 incubating	700					Photo's
2005								No breeding. Water level low. Selley's area dry and no screening vegetation.	Monthly flights

Table 2. . Summary of the breeding records for the Pink-backed Pelican from July 1948 till the end of 2005

Period	Date	Site	Birds counted	Breeding Ad	Nests	Chicks	Fledged	Remarks	Sourceof information
JULY - JUNE									
1948 -1949		Hluhluwe 1			3			First discovered where Hluhluwe River enters Lake St. Lucia at False Bay	Berruti 1980
1949 -1950		Hluhluwe 1							Berruti 1980
1950 -1951		?						Breeding recorded	Berruti 1980
1951 -1952								No data	Berruti 1980
1952 -1953		Hluhluwe 1						"not in numbers of previous years"	Berruti 1980
1953 -1954		Hluhluwe 1							Berruti 1980
1954 -1955								No data	Berruti 1980
1955 -1956								No data	Berruti 1980
1956 -1957		Hluhluwe 1							Berruti 1980
1957 -1958		Hluhluwe 1		20 pairs				Jan-April 1958	Berruti 1980
1958 -1959		Catalina		40-50 birds			3	Jan: eggs laid. Feb: nesting. March: chicks: May: nestlings have left.	Berruti 1980, Forrest GW
1959 -1960		Hluhluwe 1or 2?							Berruti 1980 NPB Files
1960 -1961		Hluhluwe 1or 2?							Berruti 1980 NPB Files
1961 -1962		Hluhluwe 1or 2?							Berruti 1980 NPB Files
1962 -1963		Hluhluwe 2		80 adults				Change in nesting site	Berruti 1980
1963 -1964		Hluhluwe 2			43			Bred successfully	Berruti 1980
1964 -1965		Hluhluwe 2							Berruti 1980
1965 -1966		Hluhluwe 2			7 (2)?		None		Berruti 1980
1966 -1967		Hluhluwe 2						Did not breed	Berruti 1980
1967 -1968		Hluhluwe 2				45-50			Berruti 1980
1968 -1969		Hluhluwe 2		60			None		Berruti 1980
1969 -1970		Hluhluwe 2				20			Berruti 1980
1970 -1971		Hluhluwe 2			80		None	Entire colony abandoned in Jan 1971, with chicks present	Berruti 1980
1971 -1972		Hluhluwe 2			+/- 55 (43)			"good"	Berruti 1980 NPB Files
1972 -1973		Hluhluwe 2 Nkunduse						Colony partially abandoned	Berruti 1980
1973 -1974		Hluhluwe 2							Berruti 1980
1974 -1975		Hluhluwe 2			64		60		Berruti 1980
1975 -1976		Hluhluwe 2			42				Berruti 1980
		Jozini Dam						Bred	McLean S (unpub), SABAP
		Richard's Bay						Bred	SABAP
1976 -1977		Hluhluwe 2			80				Berruti 1980
1977 -1978		Hluhluwe 2			100				Berruti 1980
1978 -1979		Hluhluwe 2		124				Bred succesfully	McLean S
1979 -1980		Hluhluwe 2		149				Bred succesfully	McLean S
1980 -1981		Hluhluwe 2		143	100 - 120			Bred succesfully	McLean S
1981 -1982		Hluhluwe 2			+/- 80			Bred succesfully	McLean S
1982 -1983		Hluhluwe 2						Adults at site in Nov, preparing to breed. 10/2/83 none present. No breeding. Eggs abandoned	Holland GJ, McLean S

Period	Date	Site	Birds counted	Breeding Ad	Nests	Chicks	Fledged	Remarks	Sourceof information
								Successful. 15/4/84 Holland +/- 200 Ad; 84 young;72 nests.	
1983 -1984		Hluhluwe 2		248	91	117		Nov - July	McLean S
1984 -1985		Hluhluwe 2		286		112			McLean S
		Mkuze			2			No breeding	McLean S
1985 -1986	1/3/86	Mkuze	90	1?				In *A. xanthophloea.* 3 carrying nesting material. Breeding dress.	Goodman P (Mkuze records)
	2/4/86	Mkuze	20		8	yes		In A. xanthophloea. Adults seen feeding chicks.	Goodman P (Mkuze records)
		Hluhluwe 2						Entirely abandoned	McLean
1986 -1987		Hluhluwe 2						Abandoned	NPB Records
	9/1/87	Mkuze	40		0			Arrived 6/1/1987. Same tree as 1986.	Goodman P (Mkuze records)
	19/2/87	Mkuze	100	42 on nests	42 + 20 (?)			Nesting in 4 trees	Davies A.J.
		Jozini Dam	45		18			December	Tarboton W 1987
1987 -1988		Hluhluwe 2						No Attempt	NPB Records
	1/12/87	Mkuze	20					At nesting tree	Batchelor A.,Tarboton W.
	8/12/87	Mkuze						Nesting in 2 trees. Roosting in 3 other trees to the West	Goodman P.S.
	24/1/88	Mkuze	W=>60, E=>90		W=20, E=30			Roosting, nest building, possibly incubating	Goodman P.S.
	10/4/88	Mkuze				W=>20, E=>30		Size ranged from downy chicks to almost adult size. Feeding fledglings.	Goodman P.S.
	4/6/88	Mkuze		W=4, E=5				Birds still in nests	Bell A.G.
	19/6/88	Mkuze						Most fledgling have left E tree, except for 5. Tree taken over by yellowbilled storks.	Goodman P.S.
		Jozini Dam	20		7			November - breeding just started	Tarboton W 1987
1988 -1989	4/2/89	Mkuze			103	24 + "some"		Trees from West: 1=12 nests, 2=22 (some chicks), 3=9, 4=9, 5=4, 6=1, 7=4, 8=18, 9=24 with large chicks	Goodman P.S.
	27/3/89	Mkuze			11	69 + "lots"		Trees from West: 1=10n+4ch, 2=17-20ch, 3&4=15ch, 5&6=9ch, 7=1n, 8=20ch, 9=lots of chicks, nearly ad, ready to fly	Goodman P.S.
1989 -1990	10/2/90	Mkuze			92	some + +		Trees from West: 1=2n, 2=5n, 3=9n, 4=25n some ch, 5=9n, 6=6n(3+3aband.), 7=36n +ch. Adults sitting.	Goodman P.S.
					12	>17		In Bay around the corner: 1=2n 3ch, 2=2n 4ch, 3=2n 4ch, 4=6n all with large chicks	Goodman P.S.
	30/5/90	Mkuze		Not counted	21			1=10-20ad+3ch, 2=10n+10ch, 3=0, 4=9n+3ch, 5=1n, 6=1n+1ch	Goodman P.S., Johnson D.N.
1990 -1991	11/1/91	Mkuze	40						Goodman P.S.
	13/1/91	Mkuze	20					Starting to nest	Lewis F.
	17/2/91	Mkuze			88	large chicks	3	Some adults still sitting, and smal chicks present. Many chicks climbed out of nests	Goodman P.S.
	3/4/91	Mkuze			36	58			Goodman P.S.
	1/6/91	Mkuze	20 ad			10 to 15	others		Goodman P.S.
1991 -1992	11/1/92	Mkuze	220		112	present		Water levels low	Goodman P.S.

Period	Date	Site	Birds counted	Breeding Ad	Nests	Chicks	Fledged	Remarks	Sourceof information
	18/12/92	Mkuze			Approx 40			Counted from Picnic site	Goodman P.S.
	13/2/93	Mkuze	80 at nests only		40	29		Other ad on pan	Rushworth I., Scheepers T.
1994 -1995	12/1/95	Mkuze			90			Breding at 2 different sites, Pan and old Nsumo stream	Rushworth I.
	22/2/95	Mkuze			65	56		NB New site. See map and co-ordinates	Rushworth I., Hogan S.
1995 -1996	30/11/95	Mkuze	60		47			Nests under construction (Ndlovana Stream)	Blok R., Dlamini A.
	3/6/96	Mkuze	60		20	30		Ad carrying nesting material (Ndlovana Stream)	Goodman P.S.
1996 -1997								No records found	
1997 -1998								No records found	
1998 -1999								No records found	
1999 -2000	Jan	Mkuze			13			CWAC count	Johnson D.N.
	April	Mkuze			20			Grid ref 662/772. Aerial photos.	Mulqueeny C.
2000 -2001	July	Mkuze	38		20			Ndlovana Stream 27,684722S, 32.33889E	Johnson D.N., Mulqueeny C.
	7/4/2001	Mkuze	100		51	100		27.685833S, 32.321111E	Ostrosky E.W.
2001 -2002								No records found	
2002 -2003								No records found	
2003 -2004	14/01/2004	Mkuze	156		71			From photos from picnic site.	Bowker M., Bowker K.
	20/02/2004	Mkuze	65		43	9	1	From photos from picnic site.	Bowker M., Bowker K.
	13/03/2004	Mkuze	31		6	22	9	From photos from picnic site.	Bowker M., Bowker K.
	27/04/2004	Mkuze	48		6	6	3	From photos from picnic site.	Bowker M., Bowker K.
	19/05/2004	Mkuze	20					Aerial count from photographs. Breeding not confirmed, but likely.	Bowker M., Bowker K.
	21/06/2004	Mkuze	16		10			Aerial count from photographs.	Bowker M., Bowker K.
	17/07/2004	Mkuze	18		4	0		Aerial count from photographs.	Bowker M., Bowker K.
	20/08/2004	Mkuze	1		1			Aerial count from photographs.	Bowker M., Bowker K.
	20/09/2004	Mkuze	0					Aerial count from photographs.	Bowker M., Bowker K.
	16/10/2004	Mkuze	1					Aerial count from photographs.	Bowker M., Bowker K.
	14/12/2004	Mkuze	188					Aerial count from photographs.	Bowker M., Bowker K.
2004 -2005	21/01/2005	Mkuze	407		230			Aerial count from photographs.	Bowker M., Bowker K.
	22/02/2005	Mkuze	315		226			Aerial count from photographs.	Bowker M., Bowker K.
	22/03/2005	Mkuze	287					Aerial count from photographs.	Bowker M., Bowker K.
	22/04/2005	Mkuze	526					Aerial count from photographs.	Bowker M., Bowker K.
	20/05/2005	Mkuze	198					Aerial count from photographs.	Bowker M., Bowker K.
	20/06/2005	Mkuze	26					Aerial count from photographs.	Bowker M., Bowker K.

Table 3. Averages derived from different methods of estimating the number of pelican nestlings per breeding season

Average number of nestlings per breeding season from each method of estimation	Great White Pelican	Pink-backed Pelican
Estimation from breeding pairs	1081	46
From number of nestlings counted	1064	61
From number of nestlings that fledged	451	15
From the average of the maximum of these three estimates for each year	656	46

Figures

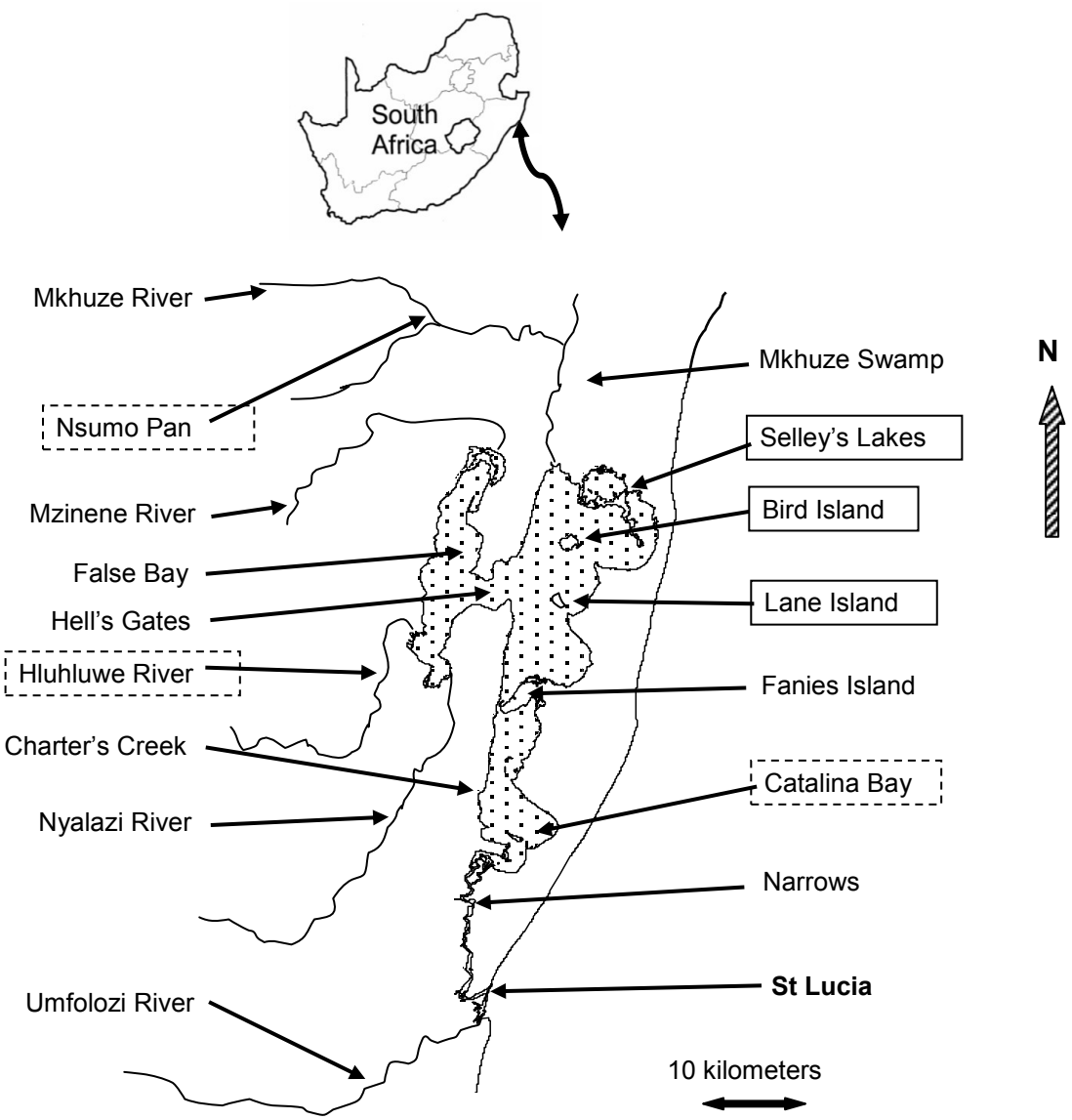
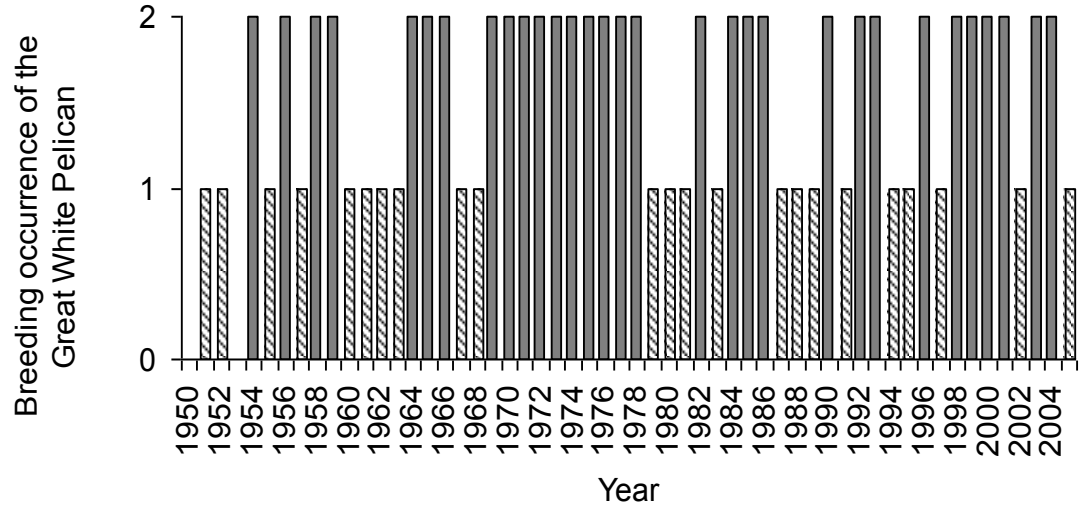


Fig. 1. Map of the Lake St Lucia and Mkhuze region of north eastern KwaZulu-Natal to show the main hydrological features, and the recorded breeding sites of the Great White Pelican (solid text box) and the Pink-backed Pelican (dashed text box).

a.



b.

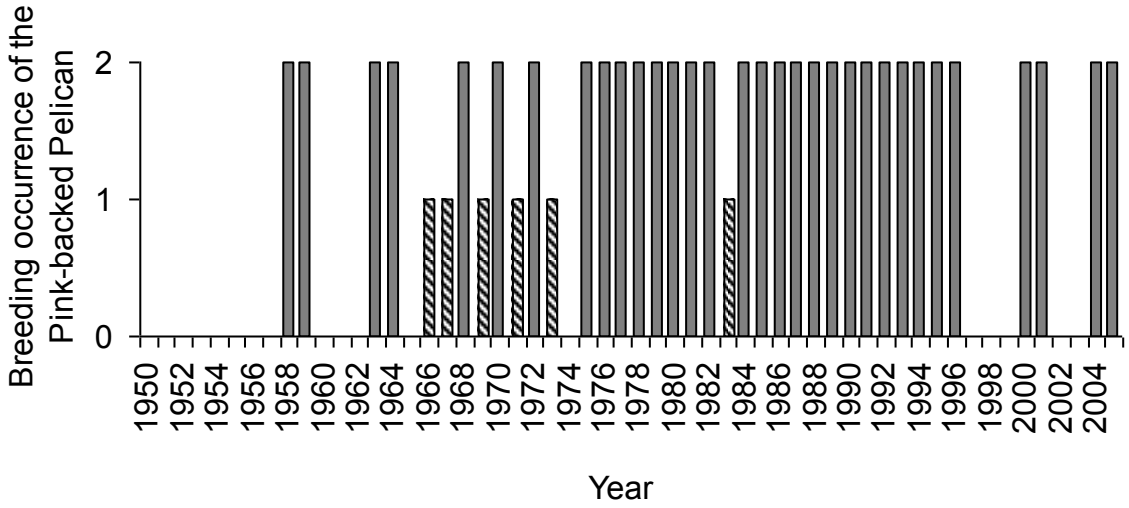
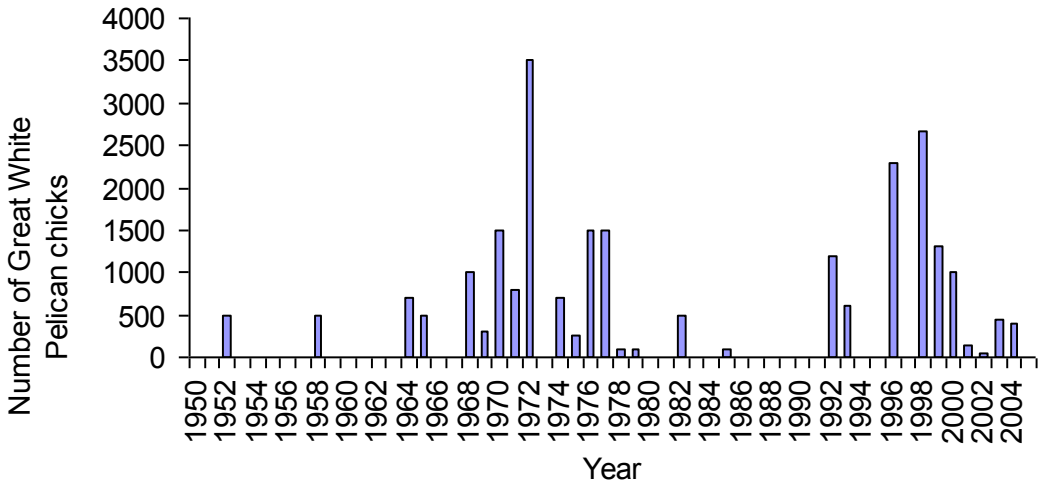


Fig. 2. Breeding occurrence of the a) Great White Pelican and b) Pink-backed Pelican for the period 1950-2005. (0 = no record found; 1 = failed, abandoned or no breeding attempted; 2 = some recorded breeding success) (See Tables 1 and 2 for sources of information).

a.



b.

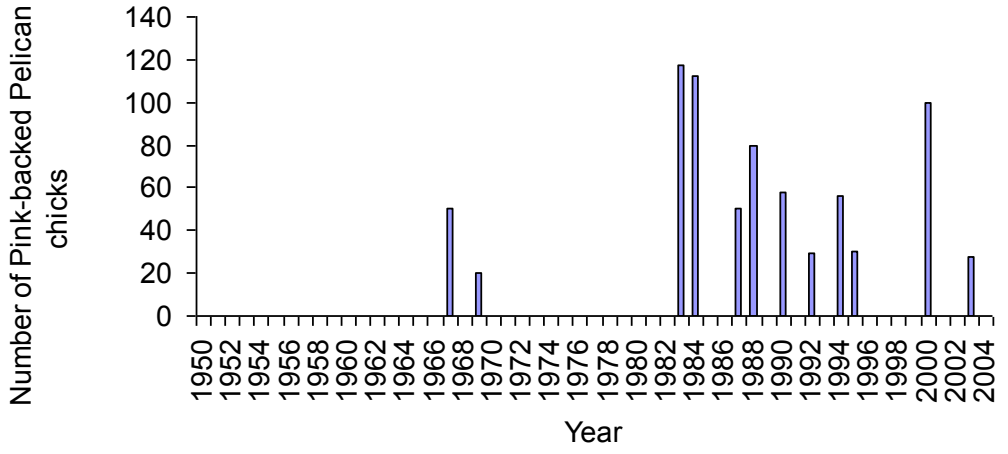
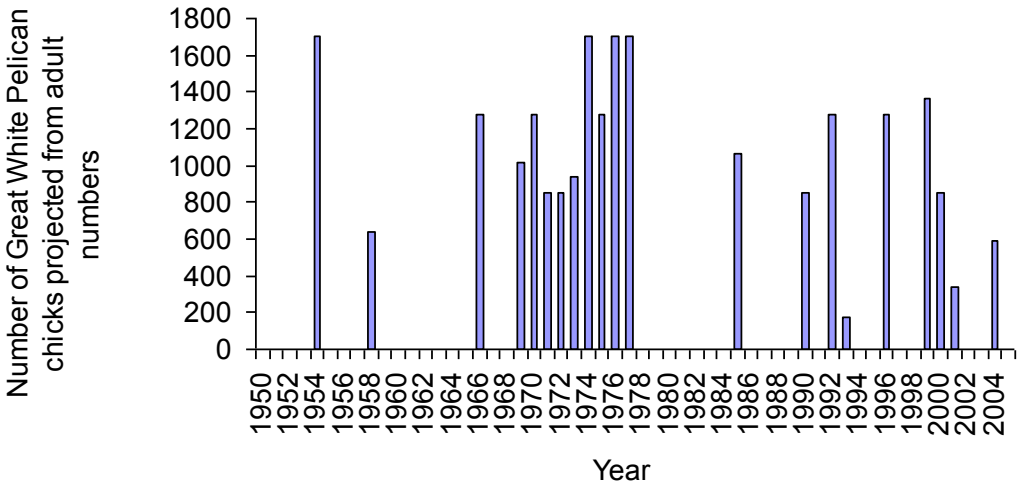


Fig. 3. Number of nestlings counted at the a) Great White Pelican and b) Pink-backed Pelican nesting colonies for the breeding period 1950-2005 (See Tables 1 and 2 for sources of information).

a.



b.

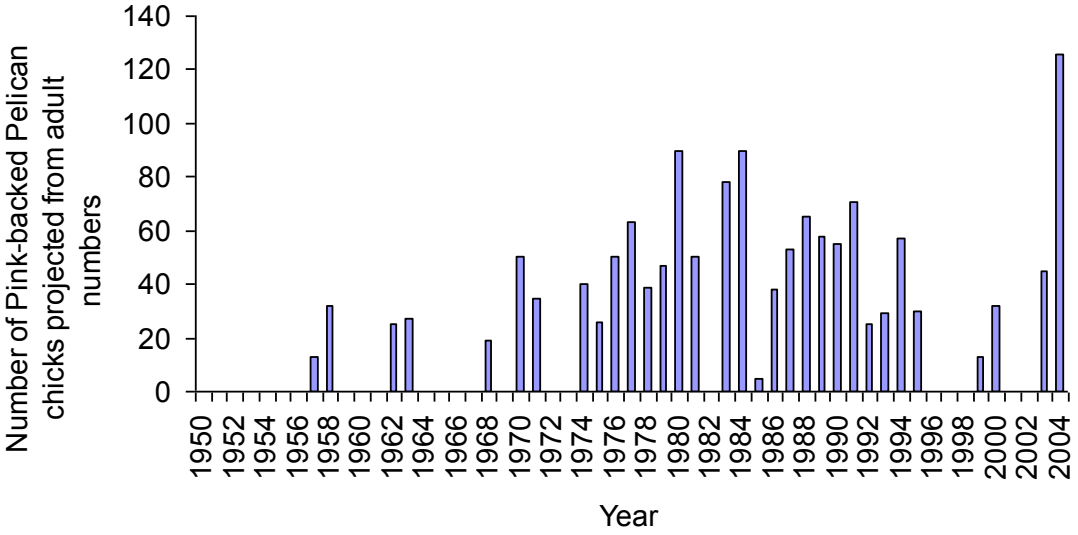
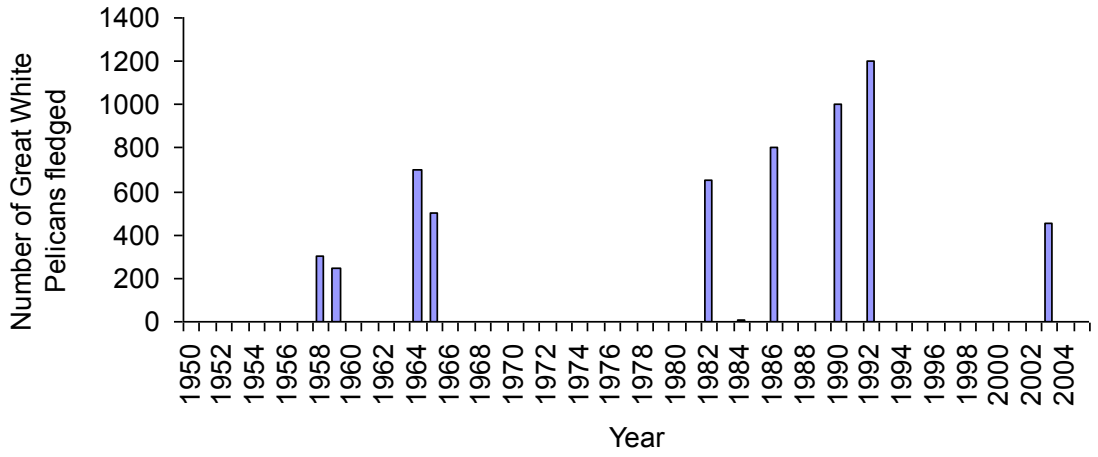


Fig. 4. Number of a) Great White Pelican and b) Pink-backed Pelican nestlings projected exclusively from adult numbers recorded for the breeding period 1950-2005. Estimates of 0.85 (Brown & Urban 1969) and 0.63 (Burke & Brown 1970; Din & Eltringham 1974) fledglings per breeding pair for the Great White Pelican and Pink-backed Pelican respectively have been used. (See Tables 1 and 2 for sources of information).

a.



b.

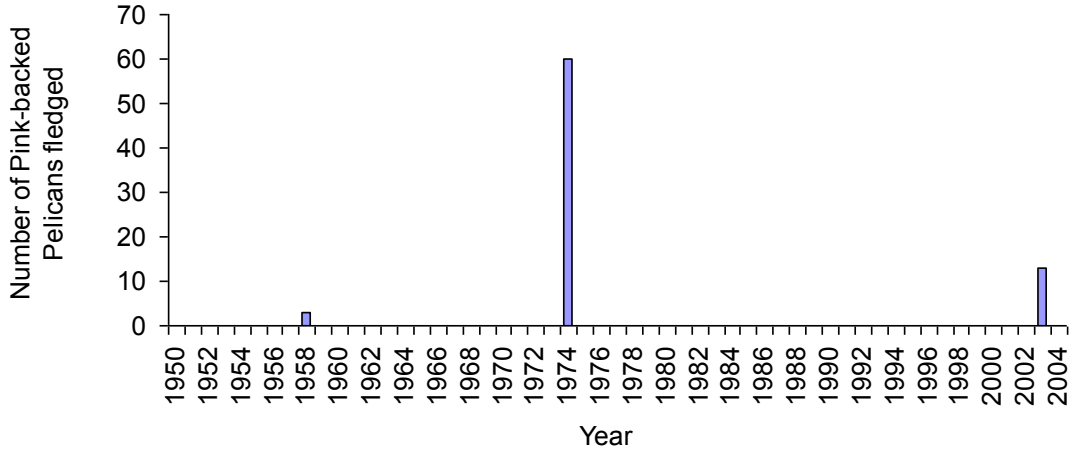
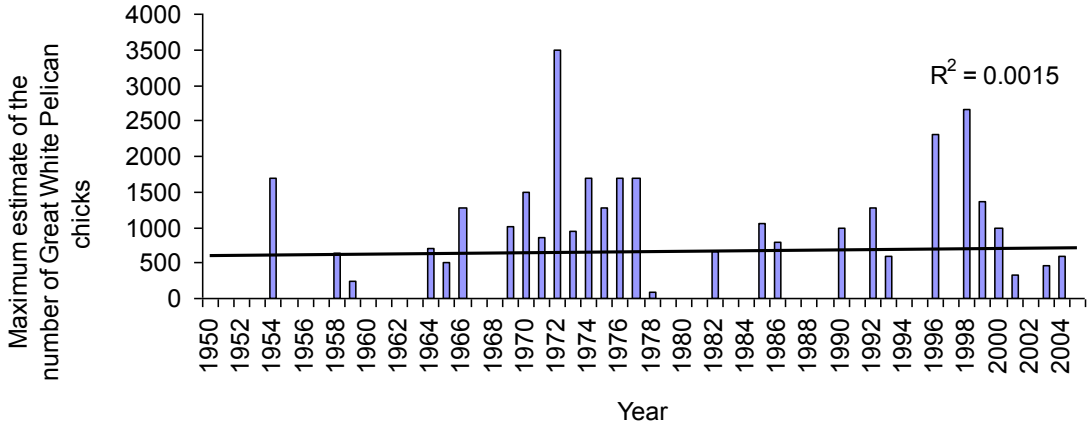


Fig. 5. Number of a) Great White Pelicans and b) Pink-backed Pelicans nestlings that were recorded as having successfully fledged, for the breeding period 1950-2005 (See Tables 1 and 2 for sources of information).

a.



b.

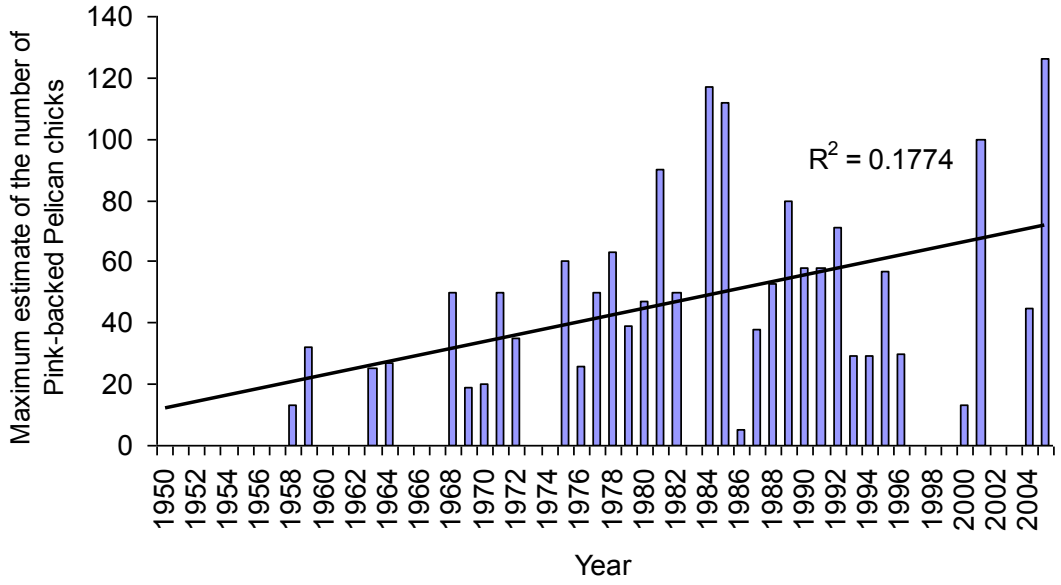


Fig. 6. Maximum estimate of number of Great White Pelican nestlings for each year in which an estimate was made, taken from the estimations of adult numbers, numbers of nestlings and number of fledglings for the breeding period 1950-2005 (See Tables 1 and 2 for sources of information).

CHAPTER 4

A review of the movements, population dynamics and causes of mortality of the Great White Pelican *(Pelecanus onocrotalus)* and the Pink-backed Pelican *(P. rufescens)* in south eastern Africa

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Abstract

Pelicans are highly mobile birds, and this allows them to move considerable distances when they forage, disperse or migrate. They are also long-lived birds with few natural predators. The two populations of pelicans in south eastern Africa, the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) have been poorly studied and little is known about their movements, population dynamics and causes of mortality. This is an attempt to assimilate what is known about these aspects of their biology throughout their range and to include this in any conservation action for the birds in this region.

Keywords: Great White Pelican, Pink-backed Pelican, movements, population dynamics, mortality.

Introduction

The Great White Pelican (*P. onocrotalus)* and the Pink-backed Pelican (*P. rufescens*) are long lived birds (Underhill et al. 1999; Urban & Ash 2001) that can move great distances (Izhaki et al. 2002). This makes them particularly difficult to study, as they can move out of the study site at different stages of their lives for varying lengths of time, (Parker 1999; Taylor 2000), and be subject to mortalities during these times. These birds reach adult plumage in about three to four years (Brown & Urban 1969; Johnsgard 1993), during which time it is possible to identify them as juveniles from subtle plumage differences. Once they have attained adult plumage it is no longer possible to age the birds visually, and so estimating the age structure of the population is not possible using plumage.

Some understanding of these aspects of their biology was needed before any conclusions could be reached about the birds' future survival. Attempts at studying these aspects failed as a result of unusual weather conditions in the region (Appendix 1). Consequently the aim of this study was to review literature to gain insight into the movements, population dynamics and causes of mortality in the Great White and Pink-backed Pelicans in south eastern Africa and to consider the impact that these have on the conservation of these two species.

Discussion

Movements

Pelicans undergo a variety of movements, ranging from short foraging trips to long migrations (Crivelli et al. 1991; Izhaki et al. 2002). During these trips they use the different thermal layers for soaring and gliding and this allows them to travel these

distances with the expenditure of comparatively little energy (Shannon et al. 2002). Although this type of flight is energy efficient, the Great White Pelicans that migrate from Europe to Africa stop over in Israel to rest and replenish their fuel reserves (Shmueli et al. 2000). Foraging trips of the Great White Pelican vary in length as the food reserves at the nesting sites are seldom sufficient to support the entire breeding colony and growing nestlings (del Hoyo et al. 1992). The south western Cape Great White Pelican population forage further when group size increases but seldom cover great distances (Guillet & Crowe 1981), while in north western Greece birds undertake a round trip of about 360 km on foraging trips while breeding (Hatzilacou 1996). Dispersal flights in Great White Pelicans can be substantial in length but are more erratic than the migrations. They can be initiated by competition between adults and newly fledged birds for food (Brown & Urban 1969; Urban & Jefford 1977), by drought (Catsadorakis et al. 1996), by the failure of an area as a food source or by disturbance (Carney & Sydeman 1999). Movements may also apply to whole colonies, as has been documented for the Great White Pelican colony off western South Africa (Crawford et al. 1994).

Little is known about the core ranges, foraging distances and dispersal patterns for either the Great White Pelican or the Pink-backed Pelican in southern Africa. A dispersal of up to 209 km for a Great White Pelican from a ringing site has been recorded by Underhill *et al* (1999). Birds have been seen at distances greater than this from the known breeding localities, like the Orange River mouth, Namibia (Crawford et al. 1995). Great White Pelicans have also bred in large numbers at Lake Ngami, Botswana (Clauss 1972), and then been absent from the area for many successive years when the lake has been dry (Williams & Borello 1997a). From south eastern Africa there is dispersal of fledged Great White Pelicans, probably to the north

(Berruti 1980). This is assumed to be true for the Pink-backed Pelican as well (Parker 1999).

It is not known whether the eastern and western populations of Great White Pelicans in southern Africa are discrete, and if so, what their northern limits may be. Cowan (1995) suggests that the populations of the Great White Pelican on the east and west coasts of southern Africa are largely discrete from one another, and that inland there is a nomadic group centered on permanent natural wetlands of Botswana and Zambia. He adds that these nomadic birds move freely between the natural and artificial wetlands of the northern provinces of South Africa, Zimbabwe, Botswana, Namibia and Zambia. The Pink-backed Pelican of southern Africa appears to have two core populations, one in the Okavango Delta in Botswana and the other in KwaZulu-Natal, South Africa (Williams & Borello 1997b), but again their northern limits are unknown.

The Pink-backed Pelican possibly has three populations in this southern region, based around the Chobe River in Botswana, the Kafue Flats in Zambia (Cowan 1995), and the Nsumo Pan in KwaZulu-Natal (Taylor 2000), and all movements centre around these colonies. No clear-cut migrations are known to occur for the Pink-backed Pelican, although in western Africa there are some north-south localised movements (Brown et al. 1982).

There is a need for a satellite or radio tracking study of these two pelican species to determine their ranges and movements. If it is thought that the pelicans of north eastern KwaZulu-Natal are of the same populations as those seen at the Zambezi delta or at Maputo (Parker 1999), distances of about 1200 and 240 km from Lake St Lucia respectively, then it is important to verify this for the conservation of these birds. A

study of this nature will also give insight into the likelihood of these populations being discrete.

With the anticipated use of cell phone technology in large bird telemetry it may soon be possible to discover more about the movements of these two species in the south eastern region of Africa, and to ascertain the range and boundaries of these populations. This technology has the advantage of being much cheaper than satellite telemetry, but will give much coarser data. It will only really be suitable for highly nomadic birds like pelicans when the cell phone coverage in neighbouring countries improves.

Population dynamics

If the numbers in a population are to remain stable, the species must balance its immature and adult mortality rates with its recruitment. Unfortunately the estimation of the numbers of fully fledged birds entering a pelican population is very difficult to assess as the breeding is generally asynchronous and in waves (Brown & Urban 1969; Berruti 1980; Chapter 3) and once the immatures have fledged and are free-flying they disperse into areas away from the colonies and the foraging areas of the breeding adults (Urban & Jefford 1977).

Population dynamics can be approached in two different ways. The easier approach is to estimate the percentages of different stages in a population and to build a life stage table based on this (Krebs 1978). Pelicans exhibit a range of immature plumages that allows individuals to be aged, but once they have reached adult plumage no further age determination is possible on appearance alone (Brown & Urban 1969; Burke & Brown 1970; Din & Eltringham 1974).

The other way of gaining an understanding of the population dynamics is by calculating the adult mortality rates (Krebs 1978). This requires long term banding studies and an adequate sample of band recoveries (Baillie 2001). The population dynamics of pelicans has been estimated for some species of pelicans from long term ringing studies (Strait & Sloan 1974), but much of this has contradicted estimations from other studies (Johnsgard 1993). Virtually no banding has been done on the KwaZulu-Natal populations of Great White and Pink-backed Pelicans. Two Pink-backed Pelicans were ringed in 1974, and one after rehabilitation in 1983 (Underhill et al. 1999). Of the 442 Great White Pelicans ringed in southern Africa with SAFRING rings from 1948-2001, only four were ringed in KwaZulu-Natal (Underhill et al. 1999).

Johnsgard (1993) suggests that pelicans exhibit relatively conservative reproduction strategies, and in this way are more like typical seabirds than terrestrially adapted waterfowl like geese. These strategies include producing small clutches, and having slow growth rates and deferred sexual maturities. These result in low rates of population increase and depend on relatively long life spans associated with low adult mortality. He adds that pelicans have low rates of population turnover and this strategy is aimed at keeping the population near the carrying capacity of the region.

The survival and mortality of the Great White and Pink-backed Pelican in south eastern Africa have not been well studied nor well documented. Because pelicans can range over these vast distances and disperse widely in their non-breeding season, it is difficult to make estimations of the survival or mortality of a population. Population estimates are normally best made when the birds congregate at their colonial nesting sites, and some projections can be made from these figures of the stage distribution of the population (Wetlands International 2002; Chapter 3). However these colonies can

vary in size depending on the environmental conditions during each breeding season and so this gives limited insight into the annual survival or mortality of the species, or of the various age categories (Chapter 3). Mortalities also presumably occur in the generally remote areas where these birds loaf, forage or breed, and so few deaths are recorded and few specimens are collected in these areas. This makes estimating mortality rates and determining causes of mortalities difficult.

Adult mortality rates have not been estimated for the Great White or Pink-backed Pelican populations in Africa. Strait and Sloan (1974) produced a life table for the American White Pelican (*P. erythrorhynchos*) from a long term ringing study that was later modified to compensate for estimated band loss by adults. Johnsgard (1993) has summarized what estimates have been made from various studies on different pelican species world wide and these estimates show a remarkable range in values. He quotes first year mortality rates (between fledging and the end of the first year of life) as varying between 33% for the American White Pelican and 70% for the Brown Pelican (*P. occidentalis*) and adult mortality rates of between 10% and 28% for two different populations of American White Pelicans. Generally though mortality figures of about 40% for first-year, 17% for second-year and 15% per annum for adult birds seem to correlate best with the estimates of the average number of young produced per nest per breeding cycle (del Hoyo et al. 1992; Johnsgard 1993), but they show great variation in their ranges. For the Great White Pelican and Pink-backed Pelican in East Africa, these nest productivity figures range between 0.8-0.9 (Brown & Urban 1969) and 0.57 (Burke & Brown 1970) young per pair per season respectively. Therefore even for these two species these general life table figures can only represent estimates. Burke and Brown (1970) estimated a 13% adult death rate and a mean life-span of about seven and a half years for a single population of Pink-backed Pelicans at

Rakewa in Kenya. Great White Pelicans have been shown to have a lifespan of over 30 years in Africa (Underhill et al. 1999), while ages for the American White Pelican of over 26 years and the Brown Pelican of 43 years have been documented (Urban & Ash 2001). The life expectancy of the American White Pelican appears to be in the region of 17 years (Strait & Sloan 1974).

Causes of mortality

Among the nestlings of several Pelican species, including both African species, there seems to be fatal sibling aggression (Din & Eltringham 1974; Cooper 1980; Cash & Evans 1986). The high mortality rate in the first ten days after the asynchronous hatching of the Great White Pelican may partly be explained by this. Of the eggs laid, 20% of the potential offspring fail to survive this initial period, and by the end of the first month the losses are about 40% (Brown & Urban 1969). For the Pink-backed Pelican the nestling losses were highest for the 11-30 day period when parental attention was reduced and when cold, wet, windy weather prevailed (Burke & Brown 1970). Some nestlings that fall from the nest die in the branches of the nesting tree while others fall to the ground and are ignored by the parents (Din & Eltringham 1974). Other causes of Great White Pelican nestling mortality are related to the position of their nesting sites. On Lake St Lucia the nest site is either on one of the islands in the lake or in the northern area where the site is protected from land predators by a barrier of wetland and *Cyperus papyrus* and *Phragmites australis* (Feely 1962; Berruti 1980; Underhill et al. 1999). Island sites are subject to flooding and interference by man (Ezemvelo KwaZulu-Natal Wildlife unpublished data; M.B., pers. obs.), and in dry years they may link with the mainland and be visited by land

predators (Berry et al. 1973). These events are common, cause mass mortalities, and account for most of the failed breeding efforts on Lake St Lucia.

In 1968 only two nestlings fledged naturally from a total of about 1 000 nestlings. It was believed that a fungoid microtoxicosis was responsible for the deaths (Forrest 1969). Breeding is asynchronous and in some years the last wave of Great White Pelican nestlings may be abandoned as either the food supply fails or as the adults disperse into areas away from the breeding site (Brown & Urban 1969; Chapter 3). When nesting birds are disturbed at their nest sites and temporarily leave their nests, their nestlings are sometimes subjected to attacks from other birds such as gulls (*Larus spp*.) (Carney & Sydeman 1999). In KwaZulu-Natal the Grey-headed Gull (*Larus cirrocephalus*) is the only gull present regularly, but it is not known to pose a threat to Great White Pelican nestlings or eggs.

Causes of adult mortality are less well known. Pelicans can carry heavy parasite loads in their digestive systems, can be affected by pesticide poisoning and may have to compete with man for food, all of which might lead to their deaths (Pyrovetsi & Papazahariadou 1995). Land and avian predators do not seem to pose a significant threat to Great White and Pink-backed Pelicans (Feely 1962; Burke & Brown 1970; Berry et al. 1973) but occasionally they may be preyed on by sharks (Player & Steele 1960) or crocodiles (Feely 1962). Annual mortalities world-wide due to collisions with electrical power lines and electrocutions from these lines are not well known (Bevanger 1998). In South Africa it is mainly juvenile Great White Pelicans in the Western Cape that seem at risk from collisions, and in some high risk areas markers have been placed on the lines to make the lines more visible (Crawford et al. 1995). In the Richards Bay area the Pink-backed Pelicans roost on the power lines (M.B., pers. obs.), but no reports of fatalities have been made. North of Richards Bay there

are fewer power lines and so this potential danger may not be significant in this region. In the Western Cape Great White Pelican deaths have been recorded from poisoning and avian cholera (*Pasteurella multocida*), both possibly related to the habit of these birds of eating dumped offal (Crawford et al. 1995). Great White Pelican eggs collected at the Etosha Pan in 1971 were found to contain DDT, BHC and dieldrin pesticides (Berry et al. 1973) while Pink-backed Pelican are susceptible to the accumulation of organochlorine and heavy metal toxins (Williams & Randall 1995).

No dead pelicans were seen during any of the aerial counts or during the field work in the area for the period 2004-2005. No references were found to the use of either pelican species in the muthi trade in KwaZulu-Natal and no evidence was found of the birds being used as a human food source, although poachers were seen near the Great White Pelican breeding colony in 2004 (M.B., pers. obs.).

A long term ringing study may give some insights into the mortality rates of the Great White and Pink-backed Pelicans (Baillie 2001). There is no major unnatural mortality factor that has be identified in south eastern Africa for these two species of pelicans, and they have no specific predators.

Conclusion

The movements, population dynamics and the causes of mortality of the Great White Pelican and Pink-backed Pelican populations in southern Africa have been poorly studied. There has been ringing of Great White Pelican nestlings in the Western Cape and Namibia (Underhill et al. 1999; SAFRING, unpublished data), but no project of this nature has been started in KwaZulu-Natal. Population modelling may give insights into the baseline levels of mortality that are acceptable and fecundity that is

necessary for the survival of these two species. These are all important aspects to consider when developing a conservation strategy for these two flagship species of KwaZulu-Natal.

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Appendix 1

Due to the low water levels of Lake St Lucia, (Chapter 7; Fig. 2&3) which is the primary foraging area for both the Great White and Pink-backed Pelican, it was not possible to collect data on age distributions from plumage differences and hence derive estimates of survival and mortality during 2004-2005. Attempts were made to catch Great White Pelicans at Lake St Lucia for satellite tracking to monitor movements. The trapping method chosen has been used successfully in other studies of pelicans (L.G. Underhill, pers. comm.), and involved the use of specially designed gin traps, that had weaker than normal springs, and rubber covered jaws. Traps were set at the loafing sites at the mouth of the Hluhluwe River, where the river enters False Bay. This was a favourite loafing site during the period of trapping as it had a large sand bank that extended well into the lake on either side of the river mouth (M.B., pers. obs.). These attempts were unsuccessful and consequently information and estimations of these aspects of their biology were derived mainly from previous literature.

There was limited breeding by the Great White Pelicans in 2004 but no attempt at breeding in 2005. Over the two year period of this study (2004-2005) the levels of Lake St Lucia remained very low and there was no boat access to the areas that the pelicans were using. As a result it was not possible to ascertain either the age composition of the populations or even whether the sub-adults of either species were present in the region. The Pink-backed Pelicans nested successfully in both seasons, but again their foraging areas on Lake St Lucia provided no data on the non-breeding population. This compounded the problem of estimating the age compositions and recruitments that might have been used to estimate survival or mortality rates.

Monthly flights over Lake St Lucia and Nsumo Pan showed that the number of birds present and their distribution in these areas changed, and that sometimes the birds were elsewhere. Results of flights are referred to in other chapters.

CHAPTER 5

A review of the condition and continued suitability of the habitat in north eastern KwaZulu-Natal that has historically been used by the Great White Pelican *(Pelecanus onocrotalus) a*nd the Pink-backed Pelican *(P. rufescens)*

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Abstract

Habitat change poses a potential threat to pelicans in north eastern KwaZulu-Natal, South Africa. This area represents the southern most distribution on the eastern seaboard of both African pelican species, the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican (*P. rufescens*). Habitat loss could drive these species out this region to areas north of South Africa. Much of this north eastern region of KwaZulu-Natal is under threat of habitat change, mainly through the actions of man. Many areas are naturally unsuitable for pelican foraging, while others are vital to the survival of both species. This study assesses the relative importance and condition of the potential pelican habitat in the north eastern KwaZulu-Natal region, focusing particularly on Lake St Lucia and the Pongolo River floodplain.

Key words: Great White Pelican, *P. onocrotalus*, Pink-backed Pelican, *P. rufescens*, habitat assessment, foraging, breeding site, Lake St Lucia, Pongolo River floodplain.

Introduction

The Great White Pelican (*P. onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) are both found in the north eastern region of KwaZulu-Natal (Fig. 1) from Durban in the south to the Mozambique border in the north, extending inland to the Mkhuze and Pongolo River floodplains (Williams and Borello, 1997a,b). Their distribution is limited to areas that have waterbodies (Fig. 2) that are suitable for their method of foraging and that have adequate food stocks (del Hoyo et al. 1992).

The Great White Pelican and Pink-backed Pelican may be considered flagship species for this part of KwaZulu-Natal because of their general appeal and restricted distribution throughout most of South Africa. Both species have their most southerly breeding sites on the eastern seaboard in this region and this area also represents the south-eastern limit of their distribution (Maclean 1985). It is essential that the future of these pelican populations is secure in the region as this region represents the south easternmost limit of their distribution. This can only be achieved if both the breeding sites and the feeding sites are conserved. It is therefore necessary to review the present conditions of these sites and to assess their continued suitability in the future.

Both pelican species of KwaZulu-Natal have well established, long-term breeding sites (Berruti 1980). The breeding of the Great White Pelican on the islands in Lake St Lucia was first documented in 1933 (Chapter 3), and although there has been limited local movement from island to island, they have remained faithful to the area (Ezemvelo KwaZulu-Natal Wildlife unpublished data). The Pink-backed Pelican

population has used two major sites. The birds moved from the original, established colony situated where the Hluhluwe River enters False Bay (Fig. 3), where they were first recorded in 1948, to the new site on the banks of the Nsumo Pan in the Mkhuze Game Reserve in about 1986. They are currently still using this latter site (Ezemvelo KwaZulu-Natal Wildlife unpublished data).

In the same way as there are traditional breeding sites, there are also favoured feeding sites (Crawford & Taylor 2000; Taylor 2000). This does not however exclude other waterbodies from being used when local conditions at these other sites are favourable (Taylor et al. 1999). Although these peripheral and ephemeral feeding sites are important, it is absolutely vital to focus attention on the major systems initially, as these are the sites that can maintain large numbers of pelicans for longer periods of time. In KwaZulu-Natal these areas are Lake St Lucia (Fig. 3) and the Pongolo River floodplain (Fig. 4) (Barnes, 1998; Chapter 2). Without these major sites the populations in this area would probably not survive.

When considering both species it is important to differentiate between the specific needs of each. Din and Eltringham (1974b) recorded that the Great White Pelican feeds socially as well as solitarily, mainly on large adult fish, while the Pink-backed Pelican feeds solitarily or in loose groups on fish fry or smaller adult fish. They note that the Great White Pelican also feeds further from the shore and in deeper water than the Pink-backed Pelican. There may also be some correlation between the method of foraging for the Great White Pelican and the turbidity of the water. Social foraging may be more common in clear water (Whitfield & Blaber 1979) when the birds are more visible to the prey, but high turbidities could be beneficial to foraging pelicans as the birds are more difficult to detect (Guillet & Crowe 1983). These different feeding habits are enough to separate these two pelican species ecologically

(Din & Eltringham 1974b). Both species nest socially, the Great White Pelican nesting on the ground and the Pink-backed Pelican nesting in trees (Brown & Urban 1969; Din & Eltringham 1974a; Maclean 1985).

It is also important to know what water conditions the Great White and Pink-backed Pelicans favour for management purposes. Both species are frequently seen feeding in areas that are drying out, where the prey is more concentrated and the demersal species are within reach (Feely 1962; Whitfield & Blaber 1979). Waterbodies like Lake Sibaya and the Kosi Lakes that may appear potential feeding sites are seldom visited by the birds, perhaps because of their greater depth and clarity, and low productivity (Berruti 1983; Chapter 2). When assessing the suitability of the habitat in the areas in north eastern KwaZulu-Natal that have traditionally been used by the Great White and Pink-backed Pelicans, it is therefore necessary to consider both their feeding and their breeding sites, as well as the conditions that best favour the foraging preferences of each species.

It was planned to assess both the condition of the habitat of the north eastern KwaZulu-Natal as well as its suitability to the feeding and breeding habits of the Great White and Pink-backed Pelicans in the area. Attempts at studying these aspects failed as a result of unusual weather conditions in the region (Appendix 1). Consequently the aim of this chapter was to review literature to gain insight into these aspects.

Discussion

In north eastern KwaZulu-Natal the breeding areas of these two species are well situated in terms of their position, as they both fall within the boundaries of the Greater St Lucia Wetland Park (Johnson et al. 1998; Crawford & Taylor 2000; Taylor

2000). Lake St Lucia is a declared World Heritage Site, a Global and a South African Important Bird Area (SA058) and a Ramsar site: the Mkhuze Game Reserve is a Global and South African Important Bird Area (SA057) and is fully protected by law (Barnes 1998). So provided the pelicans retain these as their breeding sites, these sites should be afforded a degree of protection against direct contact with man. However this status and position does not protect the breeding sites from the negative natural events that are evident in these areas, nor from the indirect negative effects that man has had on the region as a whole. The nesting sites of both species have failed at various times since records have been kept (Chapter 3). The Great White Pelican nesting sites have failed more often than those of the Pink-backed Pelican (Berruti 1980; Ezemvelo KwaZulu-Natal Wildlife unpublished data; Chapter 3). Reasons for failure of the Great White Pelican nesting sites at Lake St Lucia include flooding of the islands, drying out of the area so that islands link with the mainland, disease and disturbance (Berruti 1980; Feely 1962; Forrest 1969; Ezemvelo KwaZulu-Natal Wildlife unpubl data). Many of these failures can be attributed to the changing hydrological conditions on the lake and the prevailing weather. The lake which has a mean depth of less than one metre and a water surface area that varies under normal conditions of between 225-417 km^2 (Barnes 1998), can experience relatively large variations in depth and salinity (Taylor 1982). The prevailing winds have a major effect on the water levels and lake depths, and these may be enough to expose or cover islands in a relatively short time (Whitfield & Cyrus 1978). The apparent need for the Great White Pelican to nest on islands or in areas that are inaccessible to land predators (Brown & Urban 1969; Berry et al. 1973) limits their breeding site options in KwaZulu-Natal. It is therefore essential that the present sites remain suitable for future breeding. The sedimentation rate of Lake St Lucia is not well understood

(Taylor 1982). If sedimentation is causing the areas around Bird and Lane Islands (Fig. 3) to become shallower, and is linking the islands to the mainland, this will negatively influence the integrity of these islands that are used as breeding sites. The other site used by the Great White Pelicans is the northern area of the lake (Berruti 1980), where the birds nest on the shore, but are protected from land predators by an extensive wetland and beds of *Cyperus papyrus* and *Phragmites australis* (Ward 1982; Johnson et al. 1998). However if low water levels and hypersaline conditions prevail in this region, the *Phragmites* beds die, and the area becomes easily accessible from the north (Johnson et al. 1998). During an aerial count in August 2004 (Chapter 2) three poachers were seen in this area, in the vicinity of the Great White Pelican nesting site (M.B., pers. obs.). Any disturbance of or intrusion into this colony by man or small carnivores is likely to have negative effects on the breeding effort.

These breeding sites of the Great White Pelican have failed often since records have been kept (Chapter 3), but it would seem that they are still the most suitable sites in the region in spite of their record of failures. No other nesting sites in south eastern Africa have been reported, although there may be some unrecorded breeding on the Zambezi River delta (Parker 1999) The lake is by nature highly dynamic and the local climatic conditions impact on the water levels of the lake (Taylor 1982). Lake levels are lowered as a result of too much water abstraction in the catchments of the lake, and this impacts on the breeding success (Johnson et al. 1998). The management decision to keep the mouth of the estuary closed to the sea obviously also impacts on the lake levels, salinity and the integrity of the islands.

The Pink-backed Pelican nesting site (Chapter 3) seems to be robust and reliable and the number of nesting adults at the Nsumo Pan site in the Mkhuze Game Reserve seems to be on the increase (Ezemvelo KwaZulu-Natal Wildlife unpublished data).

There are many areas in this north eastern region of KwaZulu-Natal that have trees that seem suitable for nesting, and that are close enough to suitable foraging areas (M.B., pers. obs.). If the present site should fail because of the demise of the trees or the impact of some other negative factor, it seems more likely that the Pink-backed Pelicans could find an alternative site than it does for the Great White Pelican. Pink-backed Pelicans have nested on the wreckage of a crashed Catalina aeroplane in Lake St Lucia in the 1958-1959 breeding season (Berruti 1980), and in dead trees in the Pongolapoort Dam (Johnson et al. 1998). It may even be possible to attract this colony to an artificial nesting site within a protected area if this was ever thought to be necessary.

The foraging sites for the Great White and Pink-backed Pelicans are more numerous and widespread than their breeding sites, but unlike the breeding sites they are not all in protected areas (Williams and Borello, 1997a,b). However even those foraging sites within protected areas are subject to the impacts of agriculture, pollution and weather in their catchments (Johnson et al. 1998), and to the weather at the foraging sites. Lake St Lucia is the most important foraging site in KwaZulu-Natal for both the Great White and the Pink-backed Pelicans (Chapter 2) as it accounts for most of the birds in the province at all times of the year.

Nanni (1982) estimated the natural catchment areas of Lake St Lucia to total 8663 km^2. This includes the Mkhuze, Mzinene, Hluhluwe, Nyalazi River catchments, and the northern, western and eastern shores catchment areas (Fig. 3). He added that the Umfolosi River catchment area of 9416 km^2 does provide a small part of its runoff to the lake, and the Pongolo River which may be a source of water for the lake in the future has a catchment of 7725 km^2. In his summary on the state of the catchment area of Lake St Lucia, he stated that some of the most abused land in KwaZulu-Natal

lies in this area, and that the main changes that man has brought about in this region are the reduction of the freshwater supply to the lake and the increased silting in the Mkhuze-Mosi swamp. Alteration to the estuary and the Umfolozi River has also been significant. On a positive note he maintained that dams constructed in the river catchments, while reducing the inflow of fresh water, will reduce the silt load entering the system and he also stated that the principle of importing of water has been accepted.

The Pongolo River floodplain (Fig. 4) has been regarded as an important foraging area in KwaZulu-Natal for the Great White and Pink-backed Pelicans (Whitfield & Blaber 1979; Heeg & Breen 1982). There are two Ezemvelo KwaZulu-Natal Wildlife reserves along this river, the Ponglapoort Nature Reserve in the south and the Ndumu Game Reserve in the north. Both are classified as fully protected Global and South African Important Bird Areas (SA055 and SA052 respectively) and the Ndumu Game Reserve is also listed as a Ramsar Site of international significance (Johnson et al. 1998). The rest of the Pongolo River floodplain is under the control of various stakeholders, including the Department of Water Affairs and Forestry, the KwaZulu-Natal Department of Agriculture and Environmental Affairs, the KwaZulu-Natal Department of Health, Local Government and Ezemvelo KwaZulu-Natal Wildlife (Kotze 2002).

Heeg and Breen (1982) stated that following the completion of the Pongolapoort Dam in 1972 when the flow regime was brought under human control for the first time, the ecology of the Pongolo River floodplain was likely to be altered extensively. These changes could be manifested in many ways, mostly to the detriment of the sustainability of the system. They described the negative effects that this interference could have at all trophic levels of the ecosystem. They recommended that the volume

of the releases from the dam be sufficient not only to fill, but also to flush the pans, and warned of the implications of winter flooding. There are 35 resident fish species in this system and many are flood-dependent spawners, and it is not known what effect unnatural flooding regimes have had on these fish (Kok 1980).

CWAC counts done on the pans that fall inside the Ndumu Game Reserve show that these pans are also not visited regularly by pelicans. They are described as occasional visitors to the Ndumu Game Reserve (Johnson et al. 1998), but can occur in quite large number when present.

Whitfield and Blaber (1979) showed that the Pongolo River floodplain has played a major role in supporting the breeding effort of the Great White Pelican at Lake St Lucia. During September 1976 most of the food regurgitated by nestlings in the breeding colony at Selley's lakes came from freshwater systems north of the lake, and five fish species that do not occur south of the Pongolo River were identified in this food.

Pelicans are regarded as occasional visitors to Lake Sibaya and the Kosi lakes, (Johnson et al. 1998) and they have not been seen on either of these systems in all the Coordinated Waterbird Counts (CWAC) from 1992 to 2004 (Taylor et al. 1999; CWAC, unpublished data). The Great White Pelican population on Lake St Lucia grew substantially in 2005 when the level of the lake was falling (Chapter 2), and the Nsumo Pan was used in the late winter of 1957 when it was drying out (Feely 1962).

There are no other major foraging sites for the Great White Pelican (Chapter 2), although the Umhlatuzi lagoon in the Richards Bay Game Reserve was recorded as a foraging site for nesting adult Great White Pelicans previously (Feely 1962). This may be different now after the development of Richards Bay as a deep water harbour started in 1976, and the resultant loss of shallow areas in the bay. The Richards Bay

region does however feature regularly in the CWAC counts (Taylor et al., 1999; Ezemvelo KwaZulu-Natal Wildlife unpublished data). For the Great White Pelican it is the second most used area after Lake St Lucia and for the Pink-backed Pelican it rates third after Lake St Lucia and the Nsumo Pan. It must be noted that the Pongolo River floodplain is not included in the CWAC counts, and so this hierarchy of sites is not absolute. The Nsumo Pan's numbers for Pink-backed Pelicans are high because of their breeding rather than their foraging (Taylor 2000; M.B., pers. obs.).

Din and Eltringham (1974b) recorded that in Uganda the Great White Pelicans were often seen feeding solitarily or socially in groups that averaged 8.5 in number, but very seldom in groups greater than 50. They noted that the Pink-backed Pelican was always seen to be a solitary feeder although it did form loose clusters with as many as 30 other birds, but then did not display any form of co-operative feeding. This solitary habit may allow the Pink-backed Pelican to make use of the Pongolo River floodplain and other smaller ephemeral pans more effectively than the Great White Pelican.

Din and Eltringham (1974b) estimated that the Great White Pelican consumes 1201g and Pink-backed Pelican 776g of fish each day. Their study showed that *Tilapia* and *Haplochromis* (Cichlidae) were the most common adult fish found in the 65 Great White Pelican and 72 Pink-backed Pelican stomachs that they analysed. Fish fry were found in only 12% of the Great White Pelican stomachs compared to 70% of the Pink-backed Pelican stomachs, and the average weight of the *Tilapia* spp. was 503.2g for the Great White Pelican and 292.7g for the Pink-backed Pelican. Again this may allow these two species to forage in different areas and under different conditions, and may force these birds to fly long distances to forage.

The fish populations in Lake St Lucia vary considerably at different times of the year, especially if the lake is open to the sea (Blaber 1982). Migrating marine shoals of *Mugil cephalus* enter the Narrows and are preyed upon by Great White Pelicans as they move up into the lake. The pelicans follow this migration into the body of the lake (Feely 1962; Whitfield & Blaber 1979). This added food source may be the stimulus that is necessary to initiate breeding in the Great White Pelican population (Feely 1962). The management strategy now is to keep the mouth of the lake closed from the sea to keep the lake water as fresh as possible (R.Taylor, pers. comm.). This may impact negatively on this potential source of food for the pelicans as the migrations of fish and prawns into the estuary are not possible (Blaber & Cyrus 1982).

Whitfield and Blaber (1979) identified three phases in the feeding of the Lake St Lucia Great White Pelican. A pre-incubation period when the shoals of *Mugil cephalus* migrated, the incubation and post-incubation stages when the pelicans fed in the areas to the north of Lake St Lucia, and finally the post-fledging stage when the adults and the immatures fed in the lake. If this is a pattern they follow, then this needs to be factored in when assessing the habitat and conditions necessary for successful breeding.

For both species Lake St Lucia is the primary foraging site, and although no figures are available to substantiate it, the Pongolo River floodplain is probably the next most important. Man has impacted negatively on the hydrology of Lake St Lucia and the Pongolo River floodplain, and this is likely to continue and even intensify. If Lake St Lucia does not provide a sustainable and successful breeding site for the Great White Pelicans then their future in this region will be compromised. The other waterbodies in this northern region of KwaZulu-Natal are unlikely to be extensive enough to sustain the present population of Great White Pelican, and when the water

levels in Lake St Lucia are low it is likely that many of these smaller waterbodies may already be dry too. With its smaller population and smaller body size, the availability of alternative nest sites and its solitary feeding habit, the Pink-backed Pelican might have a greater chance of survival in the region than the more abundant, larger Great White Pelican, which has no apparent alternative breeding sites and few alternative feeding sites.

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We thank the following for their input into this study: The Avian Demography Unit for the CWAC data; Ezemvelo KwaZulu-Natal Wildlife for making their data available to us and for their assistance with the aerial surveys; Greg Nanni for his assistance on the aerial counts; Nora Kreher, Paul Dutton, Donovan Barton-Hobbs, Chris Rattray and James Hopcroft of the Bateleurs for their voluntary assistance with the three provincial pelican counts; BirdLife Zululand and BirdLife Port Natal for their help with pelican counts; The Greater St Lucia Wetland Park Authority for granting access to Lake St Lucia and to the Mkhuze Game Reserve; Ricky Taylor for guidance and assistance; Caroline Fox and Beka Nxele for access to relevant information, and to Vusi Gumbi for assistance on the Pongolo River floodplain. We also thank the National Research Fund for financial assistance.

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Figures

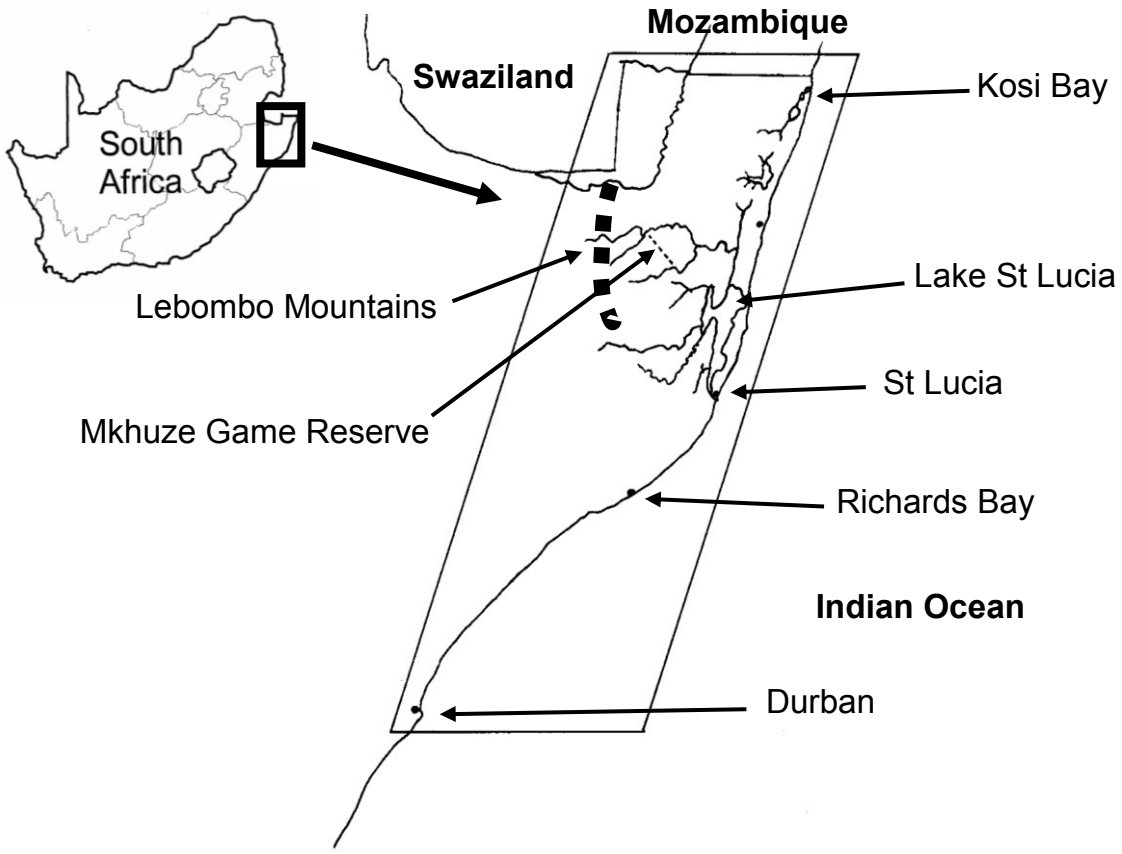

Fig. 1. Map of the study area in north eastern KwaZulu-Natal extending from Durban in the south to the Mozambique border in the north.

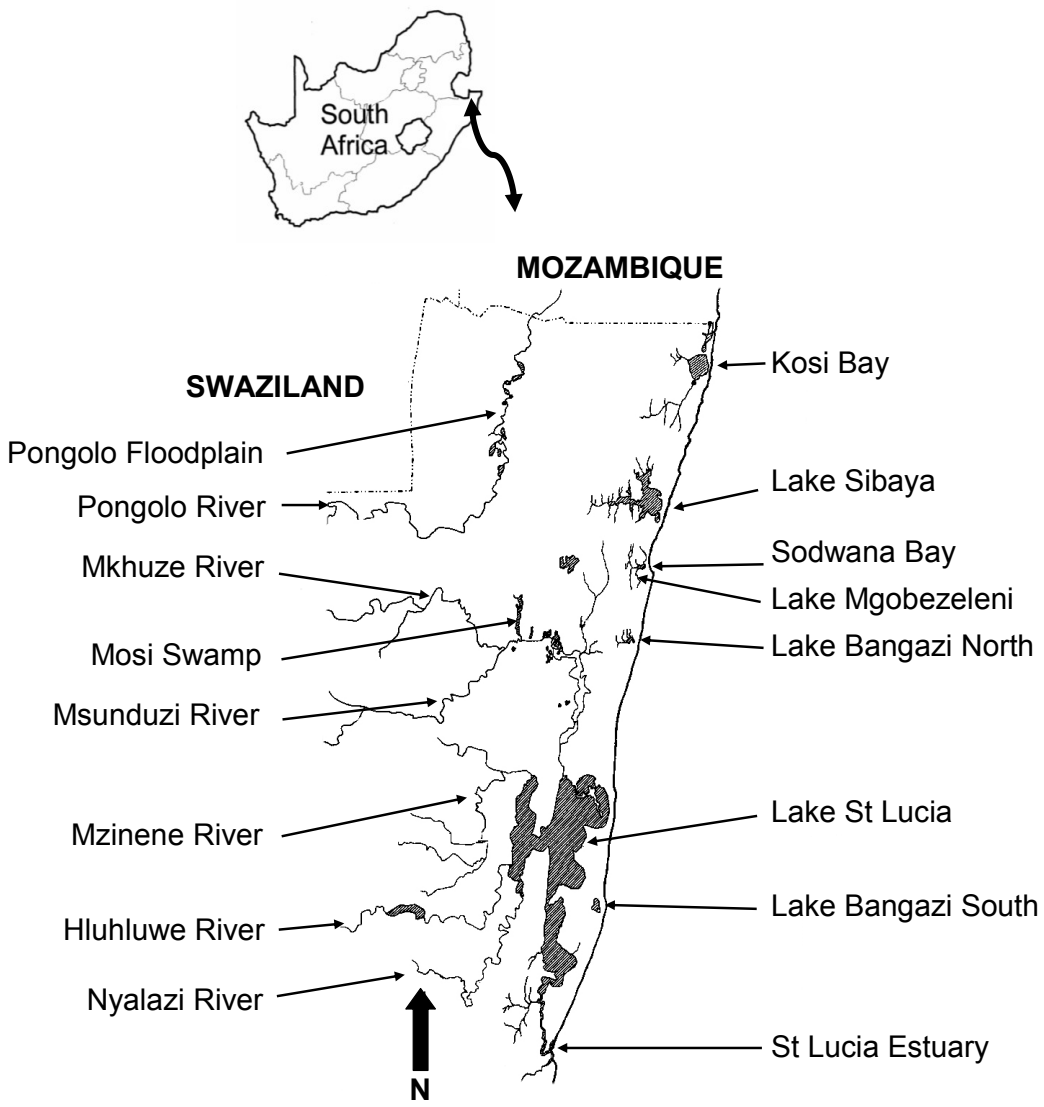

Fig 2. Map of the north eastern KwaZulu-Natal indicating areas of potential Great White and Pink-backed Pelican feeding habitat.

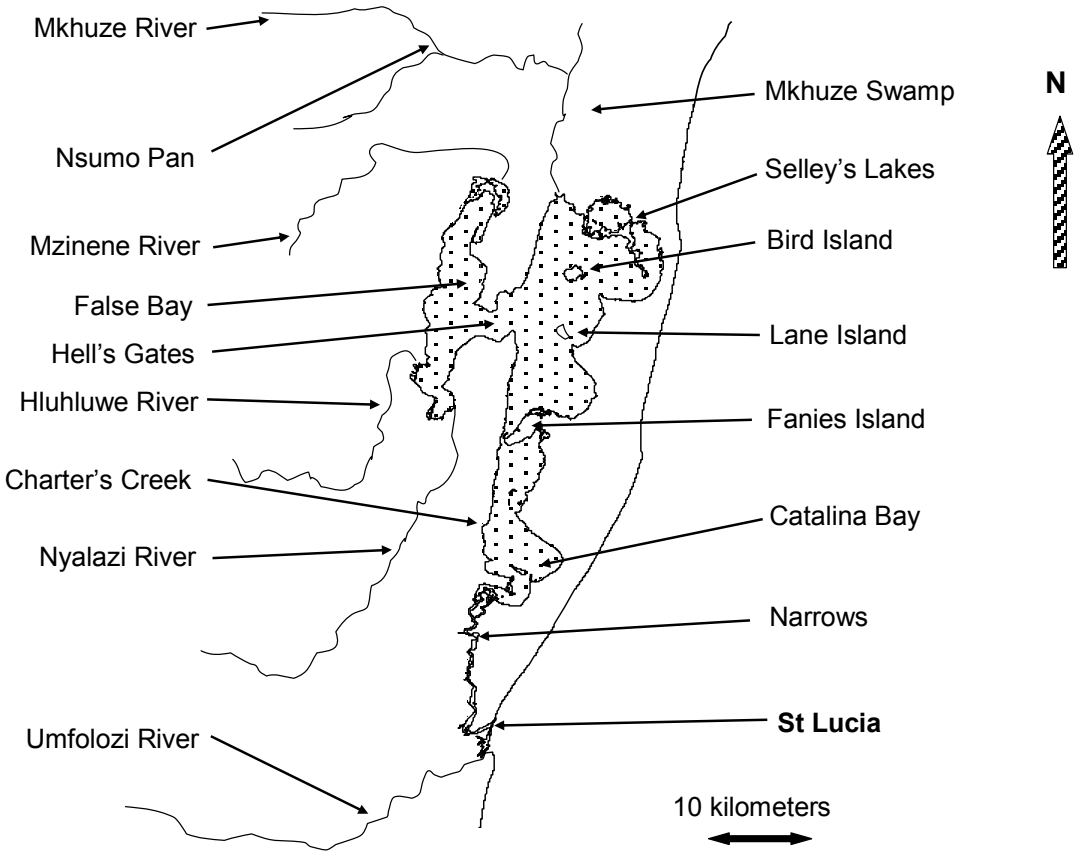

Fig. 3. Map of Lake St Lucia and the associated catchments.

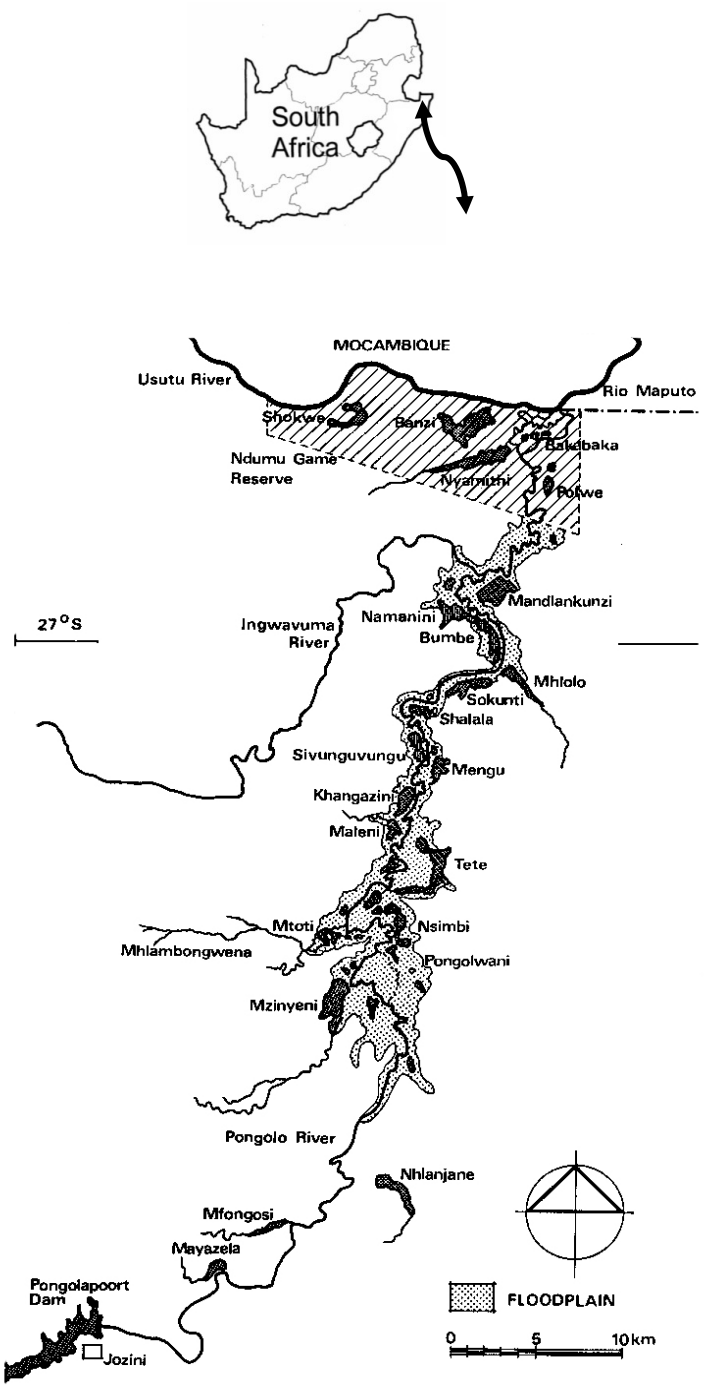

Fig 4. Map of the main water bodies of western Maputaland, showing the Pongolo River and the floodplain pans, the Pongolapoort Dam and the Ingwavuma and Usutu Rivers (Bruton & Cooper 1980).

Appendix 1

In October 2004 the first concerted effort was made to obtain an accurate population estimate for both the Great White Pelican and the Pink-backed Pelican for the whole KwaZulu-Natal and to assess the condition of the pelican habitat in the region, especially that of the Pongolo River floodplain. This exercise was repeated in January and July 2005. This was achieved by flying over all potential pelican foraging sites in KwaZulu-Natal on the same day in a coordinated exercise, backed up by ground support in the built up areas of Durban and Richards Bay. These were low level flights made from fixed wing and microlight aircraft (Chapter 2).

The larger pans on the Pongolo River floodplain were also accessed by vehicle in July 2004 and observations were made of the state of the pans and the number of pelicans present. Pelican presence on the pans was used to evaluate the habitat suitability for pelicans. Notice was also taken of the effect of the flooding regime and the extent of agriculture into the pans.

Other pans in north eastern KwaZulu-Natal were also visited during the Coordinated Waterbird Counts (CWAC) and pelican number were recorded

From observations made during the three flights made over the Pongolo River floodplain as part of the KwaZulu-Natal pelican counts (Chapter 2), it was noticeable that some parts of the floodplain have been altered extensively for agricultural use, while others are apparently still quite natural (M.B., pers. obs.). Pelican numbers were low on all three counts (Table 1) but during the first count this may have been exaggerated as a result of recent flooding.

A land visit was also made in mid-July 2004 to the larger pans on the Pongolo River floodplain to assess the number of pelicans using these pans. The pans visited were Mayazela, Mfongozi, Nhlanjane, Mzinyeni, Ntunte, Shalala, Sokunti, Mhlolo, Namanini (4 Pink-backed Pelicans), Mandlankunzi (7 Great White Pelicans; 8 Pink-backed Pelicans), Nyamithi, Banzi and Shokwe (Fig. 4). This count which lasted over two days shows the pelicans to be uncommon on the floodplain pans, and that they might be best described as occasional visitors. During these visits gill nets were evident in all the pans, and on the Namanini Pan it was estimated that 1 200 metres of gill nets had been deployed. On the Mandlankunzi Pan it was noted that two moulting White-faced Ducks (*Dendrocygna viduata*) had been caught and killed by the fishermen.

Unfortunately as a result of the adverse weather conditions that were experienced over this entire area during the period of this study, no useful data were collected as the conditions were abnormal.

CHAPTER 6

Demographic modelling for the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican *(P. rufescens)* in KwaZulu-Natal

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Abstract

To provide a basis for any conservation action for the Great White Pelican (*Pelecanus onocrotalus)* and the Pink-backed Pelican (*P. rufescens)* of north eastern KwaZulu-Natal, South Africa, it is necessary to produce a demographic baseline from which long term predictions of their survival can be made. In the absence of documented life tables and environmental variability data, a range of parameters has been modelled to simulate possible scenarios. The computer software program *VORTEX* has been used to generate this population viability analysis (PVA). The models show the outcomes of both the deterministic and the stochastic processes. An attempt was also made to identify the factors that impact most severely on the persistence of these two species. The models were most sensitive to variation in survivorship in the first year of life and to the frequency of catastrophes.

Keywords: Great White Pelican, Pink-backed Pelican, KwaZulu-Natal, population viability analysis, deterministic, stochastic, catastrophe.

Introduction

Before a conservation action for any species can be considered, it is desirable to evaluate the past and present demographics and the impact of the environmental variation for that species, in order to produce a baseline from which to work (Miller & Lacy 2005). Unfortunately for many species little is known about these aspects of their ecology (Wetlands International 2002), and the resulting recommendations are made on very scant information (Brook & Kikawa 1998).

In spite of being large, easily recognisable and appealing birds, the demographics of the Great White Pelican (*P. onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) have not been well documented. Little is known about the age structure of their populations, or the survivorships and fecundities of either species. What little has been published on age, clutch size, breeding success and mortality shows great variability in itself (Brown & Urban 1969; Burke & Brown 1970; Berry et al. 1973; Din & Eltringham 1974; Guillet & Crowe 1983). This variability is even evident between the populations in East Africa and those in South Africa (Crawford 2005; Ryan 2005).

Based purely on deterministic factors it is possible, given sufficient reliable information, to predict the long term trends in the survival of a species (Miller & Lacy 2005). Some of these deterministic factors may differ for the Great White and the Pink-backed Pelican, due to their dissimilar breeding and feeding habits. However, they share the same habitat and some habits, and this suggests that their populations are subjected to the similar primary causes of change (Chapter 1). Deterministic modelling produces only one exact outcome using these initial conditions. However population trends are subject to variations in these initial conditions over time, and

this stochasticity must be included to produce a biologically realistic model (Krebs 1978).

Stochastic processes affecting these two pelican populations will include demographic stochasticity, environmental variation and catastrophic events (Miller & Lacy 2005). Genetic drift has not been considered for these two populations as their numbers, 6000 – 9000 for the Great White Pelican and 600 – 900 for the Pink-backed Pelican, are above the level for which genetic drift is thought to have a potentially negative impact (Miller & Lacy 2005). Regular bottlenecking as is evident can result in genetic drift and decreased genetic variation.

As environmental conditions in the north eastern areas of KwaZulu-Natal, South Africa, change, it is thought that the Great White Pelican and the Pink-backed Pelican populations are likely to decline. These changes may include alterations to weather patterns, decreases in water runoff and availability, reduced food supply and general pressures exerted by the actions of man. Many scenarios are possible, but the development of some baseline model would be useful in identifying knowledge gaps that there are for these two species, and for making more meaningful predictions possible in the future.

There has only been one life table published for one pelican species, the American White Pelican (*P. erythrorhynchos*) (Strait & Sloan 1974). That study was based on a long term banding and recovery project. Many of the simulations run on the Great White Pelican and Pink-backed Pelican used this life table as a guide in the absence of life tables for the two study species.

The aim was to produce a demographic baseline from which long term predictions of the survival of the Great White Pelican (*Pelecanus onocrotalus)* and the Pink-backed Pelican (*P. rufescens)* of north eastern KwaZulu-Natal, South Africa can be

made. This could provide a basis for any conservation action for the two species. In the absence of documented life tables for the two local Pelican species and environmental variability data, a range of parameters has been modelled to simulate possible scenarios.

Methods

A population viability analysis (PVA) was run for each of several scenarios using the computer software package VORTEX Version 9.50 (Lacy et al. 2005).

Simulations were run for both the Great White Pelican and the Pink-backed Pelican. For these simulations the following assumptions were made or options selected, and these were then applied to all scenarios:

- each species was considered as having one discrete population
- each simulation was run for 200 years with 100 iterations
- environmental variation (EV) in reproduction and mortality was assumed to be concordant (EV effects each of these in the same way)
- mating was monogamous and long term
- 50% of the breeding pool were males
- the initial population size for the Great White Pelican and the Pink-backed Pelican were 6000 and 500 individuals respectively (Chapter 2)
- the population was considered extinct at 100 individuals for the Great White Pelican and 50 individuals for the Pink-backed Pelican
- there was no density dependence applied to reproduction
- mortality rates for females and males were made the same

Six scenarios were simulated for both the Great White Pelican and the Pink-backed Pelican. For each species, Scenarios 1-3 were partly based on the figures proposed by Strait and Sloan (1974), and Scenarios 4-6 were partly based on figures gathered from other literature (Brown & Urban 1969; Burke & Brown 1970; Berry et al. 1973; Din & Eltringham 1974; Crawford et al. 1981; del Hoyo et al. 1992; Johnsgard 1993; Crawford 2005; Ryan 2005). For the Great White Pelican and the Pink-backed Pelican Scenarios 1-3 were similar (Table 1 & 2). In each successive scenario for each species, one of the baseline criteria was altered to assess the influence of that change on the outcome of the model. These changes have been indicated in bold in the relevant tables.

Parameters set from Strait and Sloan (1974):

Scenario 1: Baseline

Scenario 2: With catastrophes

Scenario 3: With catastrophes and breeding age of four years

Parameters set from other literature:

For the Great White Pelican (Table 1):

Scenario 4: Baseline

Scenario 5: Decreased first year mortality

Scenario 6: Reduced catastrophes

For the Pink-backed Pelican (Table 2):

Scenario 4: Baseline

Scenario 5: Decreased first year mortality

Scenario 6: No change in carrying capacity

From the different simulations, tables of stable age distributions, deterministic projections, extinction probabilities, and figures of mean survivorship and population

numbers were extracted and analysed. Deterministic projections assumed no stochastic fluctuations, no inbreeding depression, no limitation of mates, no harvest, and no supplementation.

Results

Deterministic projections for the Great White Pelican and the Pink-backed Pelican using the figures from Strait and Sloan (1974) as outlined for both in Scenario 1 (Tables 1 & 2) indicated that the populations were sustainable at these values (Tables 3 & 4). This was indicated by the values of the geometric growth rate ($r = 0.032$), the annual instantaneous growth rate ($\lambda = 1.032$) and the net reproductive rate ($R_o = 1.213$) for both species (Tables 3 & 4). These rates ensured that the populations did not go extinct (Tables 5 & 6; Fig. 1a; Fig. 3a), and that at the end of the two hundred year period the population size for the Great White Pelican and Pink-backed Pelican were 4491 and 316 respectively (Tables 5 & 6). The populations did not remain at the figures of 6000 and 500 individuals originally used as the initial population of each species, but leveled off at a lower number as a result of the carrying capacity (K) set for each.

When reproductive catastrophes, such as failure to breed or reduced recruitment, were factored into the Scenario 2 model (Tables 1 & 2), then both species showed a reduction in values of r, λ and R_o (Tables 3 & 4). These values all still showed that deterministically the populations were either stable or had the potential to grow. Due to stochasticity however the mean probability of survival (Mean (P[survive])) decreased (Fig. 1a,b) and both populations tended toward extinction in the 200 year period (Tables 5 & 6; Fig. 2a,b). The parameters chosen for Scenario 2 included

catastrophes at the lowest likely limits of frequency and severity, and were factored into their breeding success but not their survival (Tables 1 & 2). Therefore this simulation represents the most favourable conditions likely for the KwaZulu-Natal populations using the Strait and Sloan (1974) figures.

In Scenario 3 the parameters were changed to have breeding starting at age four years (Tables 1 & 2). This figure was chosen as it represented the highest suggested possible first breeding age (Johnsgard 1993). At this value all deterministic growth rate figures dropped to levels that made extinction inevitable (Tables 5 & 6; Fig. 1a,b), and the mean population size (Mean (N[All])) for both species fell to zero in a very short period (Fig. 2a,b).

These results implied that the figures provided by Strait and Sloan (1974) were acceptable if these birds bred at the age of three years and if there were no catastrophes associated with their breeding. Based on these results, Scenarios 4-6 used three year old breeding as the probable baseline value, but imposed catastrophes, as these have been shown to be common at the breeding sites of these two pelican species (Chapter 3).

In Scenarios 4-6 the parameters chosen may more closely reflect the real values of reproductive ages, breeding successes, mortalities, carrying capacities, population sizes and the frequencies and severities of catastrophes for the Great White and Pink-backed Pelicans as resourced from the literature (Brown & Urban 1969; Burke & Brown 1970; Berry et al. 1973; Din & Eltringham 1974; Berruti 1980; Crawford et al. 1981; del Hoyo et al. 1992; Johnsgard 1993; Crawford 2005; Ryan 2005). For the populations of KwaZulu-Natal, estimations for these parameters have also been taken from Chapters 2, 3 and 7.

For Scenarios 4-6 the mortality rates for every age group were different from the Strait and Sloan (1974) figures, and the rates for the Great White Pelican differed from those of the Pink-backed Pelican (Table 1&2). The Pink-backed Pelican has a larger clutch size than the Great White Pelican, but has a lower breeding success per pair (Crawford 2005; Ryan 2005), and hence it was assigned a greater number of progeny and a higher mortality rate. The maximum breeding age or age at senescence was also increased to eighteen years on the evidence that the Great White Pelican can live to over 30 years of age (Underhill et al. 1999). For the Pink-backed Pelican the number of progeny was increased to a maximum of three on the evidence that the Pink-backed Pelicans in the sub-region produce larger clutches than the birds in east Africa (Ryan 2005). The Pink-backed Pelican also suffers fewer catastrophes than the Great White Pelican (Chapter 3) and this difference was factored into these scenarios. Introduced into the model for Scenarios 4-6 was a decrease in carrying capacity of the habitat of these two species. This was introduced at a 0.1% decrease per annum for the full 200 years to form some impression of the effect of a decrease in carrying capacity as might happen if the catchment degrades (Tables 1 & 2).

For both species, Scenarios 4-6 all showed favourable population growth rates (Tables 3 & 4), and the mean probability of survival remained high (Fig. 3a,b). For all scenarios the general trend was for the populations to remain extant (Fig. 4a,b), although in Scenarios 4 and 6 there were some extinctions in the 100 iterations (Tables 5 & 6).

Scenario 5 for both species showed that a decrease in 1st year mortality rate changed the population growth rates positively as would be expected, (Tables 3 & 4) and that the mean size of the population increased from 2124 to 3995 (Table 5) for the Great White Pelican and from 215 to 384 for the Pink-backed Pelican (Table 6) at

year 200. This is a significant increase and indicates the sensitivity of the model and pelican populations to first year mortality

Scenario 6 for the Great White Pelican showed that the model was sensitive to changes in the frequency of reproduction catastrophes, and that if these catastrophes could be reduced to half the present estimate (Table 1), then the change in the mean population numbers was significant (Fig. 4a; Table 5). This should be a major focus for the conservation of this species.

Discussion

Increasing populations typically have a predominance of young individuals, while stable or declining populations do not (Krebs 1978). The stable age distribution for Scenario 3 (Table 7) suggested that these populations would decline, while for the other scenarios the relatively high numbers of young birds implied potentially viable populations.

For both species there was a steady decline in scenarios 4-6 which included a decrease in the carrying capacity. This is predictable as it is a factor that must eventually drive the pelicans to extinction as the carrying capacity tends to zero. Scenario 6 for the Pink-backed Pelican shows that the removal of this limiting parameter in the model allows the population to survive at higher numbers and possibly be less likely to go extinction (Fig. 4b; Table 6).

Populations were considered as extinct at a level of 100 and 50 for the Great White Pelican and Pink-backed Pelican respectively. This estimation was made on the assumption that 67% of the population breed, of which half are females, and that as colonially nesting birds (Maclean 1985) there may be some density stimulus

needed to initiate breeding. This would translate into about 33 nests for the Great White Pelican and 17 for the Pink-backed Pelican.

There is much to be learned still about the pelican populations in KwaZulu-Natal. Knowledge gaps in survivorship and fecundity are factors that severely limit the formulation of more accurate models. Some fundamental assumptions made in this modelling need to be tested, the most basic of which being that for both species their populations are single and discrete. Others include the percentage of females breeding, age to senescence, carrying capacity and the effect of environmental variability on breeding and mortality.

In conclusion, although much of this analysis is based on parameters that are uncertain, the general trends in the output can give some guidance for predicting the conservation priorities for the Great White Pelican and the Pink-backed Pelican respectively.

The pelicans' chances of survival in the future could be improved considerably by reducing the negative influences on their reproduction. Flooding, drought or other disasters lead to catastrophic failure at the breeding site at Lake St Lucia especially and impact severely on the survival of these birds by increasing first year mortalities significantly. Loss of carrying capacity also impacts on the population size, which in turn impacts on the mean number of breeding adults. Conservation efforts should be directed initially at reducing catastrophic failures and consequently decreasing the mortality in first year offspring.

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Tables

Table 1. VORTEX input data for Scenarios 1-6 for the Great White Pelican. Changes in successive scenarios are indicated in bold text

Great White Pelican scenario*	**1**	**2**	**3**	**4**	**5**	**6**
Reproduction						
First age of reproduction for females	3	3	**4**	3	3	3
First age of reproduction for males	3	3	**4**	3	3	3
Maximum breeding age (senescence)	15	15	**12**	18	18	18
Maximum number of progeny	2	2	2	2	2	2
Sex ratio at birth	50	50	50	50	50	50
% adult females breeding	67	67	67	67	67	67
EV in % adult females breeding	15	15	15	15	15	15
Of the females producing progeny						
% producing 1 progeny in an average year	10	10	10	10	10	10
% producing 2 progeny in an average year	90	90	90	90	90	90
Mortality						
% mortality of females between ages 0-1	40	40	40	50	**40**	50
EV in % mortality: SD	10	10	10	10	10	10
% mortality of females between ages 1-2	16	16	16	20	20	20
EV in % mortality: SD	5	5	5	5	5	5
% mortality of females between ages 2-3	20	20	20	15	15	15
EV in % mortality: SD	5	5	5	5	5	5
% mortality of females between ages 3-4 or senescence	20	20	20	10	10	10
EV in % mortality: SD	2	2	5	5	5	5
% mortality of females between ages 4-senescence			**20**			
EV in % mortality: SD			**1**			
Catastrophe type 1: Flood/drought at breeding site						
Frequency (as a percent)		**20**	20	40	40	**20**
Multiplicative effect on reproduction		**0.2**	0.2	0.2	0.2	0.2
Multiplicative effect on survival		**1**	1	1	1	1
Catastrophe type 2: Disease at breeding site						

Frequency (as a percent)		**2**	2	2	2	2
Multiplicative effect on reproduction		**0.1**	0.1	0	0	0
Multiplicative effect on survival		**1**	1	1	1	1
Initial Population size	6000	6000	6000	6000	6000	6000
Carrying capacity	6000	6000	6000	6000	6000	6000
% decrease in carrying capacity for 200 years	0	0	0	0.1	0.1	0.1
EV in carrying capacity	11	11	11	11	11	11

*** Scenario**

1: Strait and Sloan (1974): baseline

2. Strait and Sloan (1974): with catastrophe

3. Strait and Sloan (1974): with catastrophe & breeding at age 4

4. Other literature: baseline

5. Other literature: decreased 1st year mortalities

6. Other literature: reduced catastrophes

Table 2. VORTEX input data for Scenarios 1-6 for the Pink-backed Pelican
Changes in successive scenarios are indicated in bold text

Pink-Backed Pelican scenario*	**1**	**2**	**3**	**4**	**5**	**6**
Reproduction						
First age of reproduction for females	3	3	**4**	3	3	3
First age of reproduction for males	3	3	**4**	3	3	3
Maximum breeding age (senescence)	15	15	**12**	18	18	18
Maximum number of progeny	2	2	2	3	3	3
Sex ratio at birth	50	50	50	50	50	50
% adult females breeding	67	67	67	67	67	67
EV in % adult females breeding	11	11	11	11	11	11
Of the females producing progeny						
% producing 1 progeny in an average year	10	10	10	10	10	10
% producing 2 progeny in an average year	90	90	90	50	50	50
% producing 3 progeny in an average year				40	40	40
Mortality						
% mortality of females between ages 0-1	40	40	40	70	**50**	70
EV in % mortality: SD	10	10	10	10	10	10
% mortality of females between ages 1-2	16	16	16	20	20	20
EV in % mortality: SD	5	5	5	5	5	5
% mortality of females between ages 2-3	20	20	20	15	15	15
EV in % mortality: SD	5	5	5	5	5	5
% mortality of females between ages 3-4 or senescence	20	20	20	10	10	10
EV in % mortality: SD	2	2	5	5	5	5
% mortality of females between ages 4-senescence			**20**			
EV in % mortality: SD			**1**			
Catastrophe type 1: Abandon breeding site						
Frequency (as a percent)		**10**	10	10	10	10
Multiplicative effect on reproduction		**0.2**	0.2	0.2	0.2	0.2
Multiplicative effect on survival		**1**	1	1	1	1
Initial Population size	50	50	50	50	50	50

	0	0	0	0	0	0
	50	50	50	50	50	50
Carrying capacity	0	0	0	0	0	0
% decrease in carrying capacity for 200 years	0	0	0	0.1	0.1	**0**
EV in carrying capacity	9	9	9	9	9	9

***Scenario**

1: Strait and Sloan (1974): baseline

2. Strait and Sloan (1974): with catastrophe

3. Strait and Sloan (1974): with catastrophe, & breeding at age 4

4. Other literature: baseline

5. Other literature: decreased 1st year mortalities

6. Other literature: no change in carrying capacity

Table 3. Deterministic projections for the Great White Pelican in north eastern KwaZulu-Natal for Scenarios 1-6

Scenario		**1**	**2**	**3**	**4**	**5**	**6**
Deterministic population growth rate:							
Geometric growth (finite rate of increase)	r	0.032	0	-0.046	0.02	0.043	0.047
Annual instantaneous growth rate	lambda (λ)	1.032	1	0.955	1.02	1.044	1.048
Net reproductive rate	Ro	1.213	1	0.733	1.175	1.41	1.451
Generation time for females and males	T bar	6.1	6.24	6.73	8.18	7.98	7.94

Deterministic projections assume no stochastic fluctuations, no inbreeding depression, no limitation of mates, no harvest, and no supplementation

Table 4. Deterministic projections for the Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 1-6

Scenario		**1**	**2**	**3**	**4**	**5**	**6**
Deterministic population growth rate:							
Geometric growth (finite rate of increase)	r	0.032	0.018	-0.03	0.02	0.089	0.02
Annual instantaneous growth rate	lambda (λ)	1.032	1.018	0.97	1.02	1.093	1.02
Net reproductive rate	Ro	1.213	1.116	0.818	1.178	1.964	1.178
Generation time for females and males	T bar	6.1	6.16	6.69	8.18	7.6	8.18

Deterministic projections assume no stochastic fluctuations, no inbreeding depression, no limitation of mates, no harvest, and no supplementation

Table 5. Extinction probability of the Great White Pelican in north eastern KwaZulu-Natal for Scenarios 1-6

Scenario at 200 years		**1**	**2**	**3**	**4**	**5**	**6**
	N[Extinct]	0	95	100	3	0	0
	P[E]	0	0.95	1	0.03	0	0
	N[Surviving]	100	5	0	97	100	100
	P[S]	1	0.05	0	0.97	1	1
	Mean size (all populations)	4491	24	0	2124	3995	4316
	SE	123	5		140	77	60
	SD	1235	53		1395	774	599
Means across extant populations only:	Population size	4491	207	0	2189	3995	4316
	SE	123	42		139	77	60
	SD	1235	95		1366	774	599
Number of simulations that went extinct at least once		0	96	100	5	0	0
Median time in years to first extinction			128	54			
Mean time in years to first extinction for those that went extinct			131	55	169		
Recolonisations			103	24	10		
Re-extinctions			102	24	8		
Mean growth rate across all years prior to carrying capacity truncation		0.006	-0.0285	-0.0735	0.0002	0.0217	0.0265

Table 6. Extinction probability of the Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 1-6

Scenario at 200 years		**1**	**2**	**3**	**4**	**5**	**6**
	N[Extinct]	9	77	100	15	0	13
	P[E]	0.09	0.77	1	0.15	0	0.13
	N[Surviving]	91	23	0	85	100	87
	P[S]	0.91	0.23	0	0.85	1	0.87
	Mean size (all populations)	290	37	0	215	384	246
	SE	16	7		13	3	16
	SD	157	71		127	26	156
Means across extant populations only:	Population size	316	142	0	249	384	280
	SE	14	18		11	3	15
	SD	138	88		105	26	137
Number of simulations that went extinct at least once		12	78	100	21	0	16
Median time in years to first extinction			125	38			
Mean time in years to first extinction for those that went extinct		161	112	38	131		132
Recolonisations		14	97	18	49		23
Re-extinctions		11	96	18	43		20
Mean growth rate across all years prior to carrying capacity truncation		0.0019	-0.0129	-0.0589	0.0029	0.0646	0.003

Table 7. Stable age distribution numbers for a) the Great White Pelican and b) the Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 1-6

a.

GREAT WHITE PELICAN Initial size of KwaZulu-Natal population: 6000

	Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Scenario 1	Females	664	541	419	325	251	195	152	117	91	70	55	42	33	25	20				3000
Scenario 2	Females	598	503	402	321	258	205	165	132	105	84	68	54	43	34	28				3000
Scenario 3	Females	531	467	392	328	274	231	192	162	135	113	95	80							3000
Scenario 4	Females	455	357	297	263	231	205	180	159	141	124	109	97	85	75	66	59	51	46	3000
Scenario 5	Females	511	392	319	275	237	204	176	152	131	113	97	84	72	63	53	47	40	34	3000
Scenario 6	Females	521	397	322	277	237	205	175	150	130	111	95	82	70	61	51	45	38	33	3000

b.

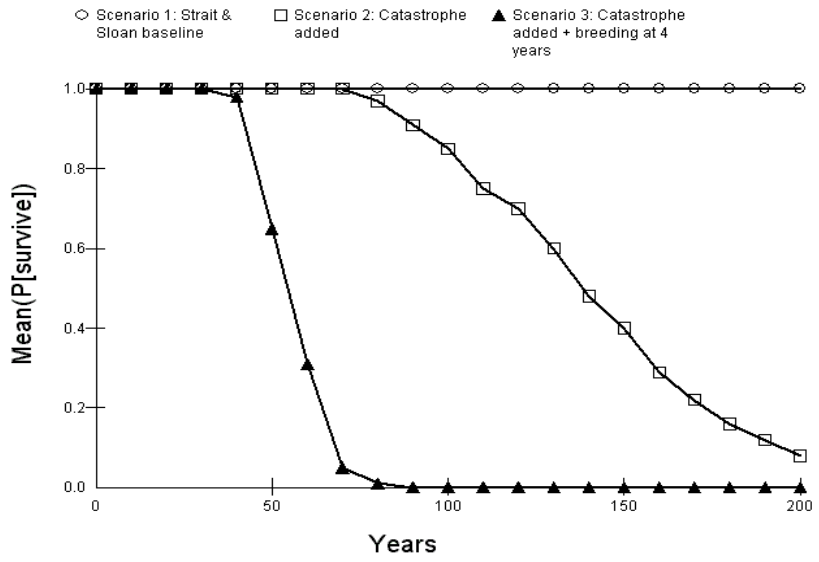
PINK-BACKED PELICAN Initial size of KwaZulu-Natal population: 500

	Age	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Scenario 1	Females	55	45	35	27	21	17	12	10	8	5	5	4	2	2	2				250
Scenario 2	Females	53	44	34	27	21	17	13	10	8	7	5	4	3	2	2				250
Scenario 3	Females	47	40	34	27	23	19	15	13	10	9	7	6							250
Scenario 4	Females	38	30	25	21	20	17	15	13	12	10	9	8	7	7	5	5	4	4	250
Scenario 5	Females	52	38	29	25	20	16	14	11	9	8	6	5	5	3	3	2	2	2	250
Scenario 6	Females	38	30	25	21	20	17	15	13	12	10	9	8	7	7	5	5	4	4	250

Note: Stable age distribution numbers equal for males and females.

Figures

a.



b.

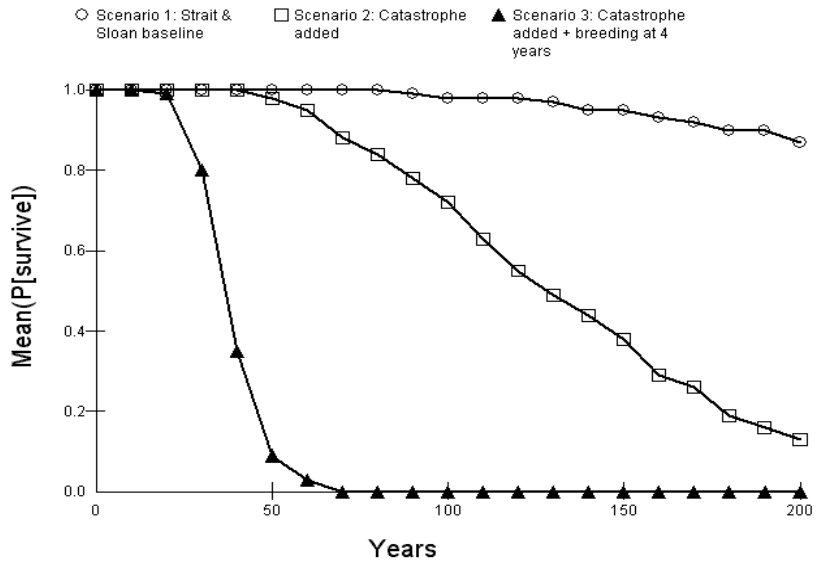
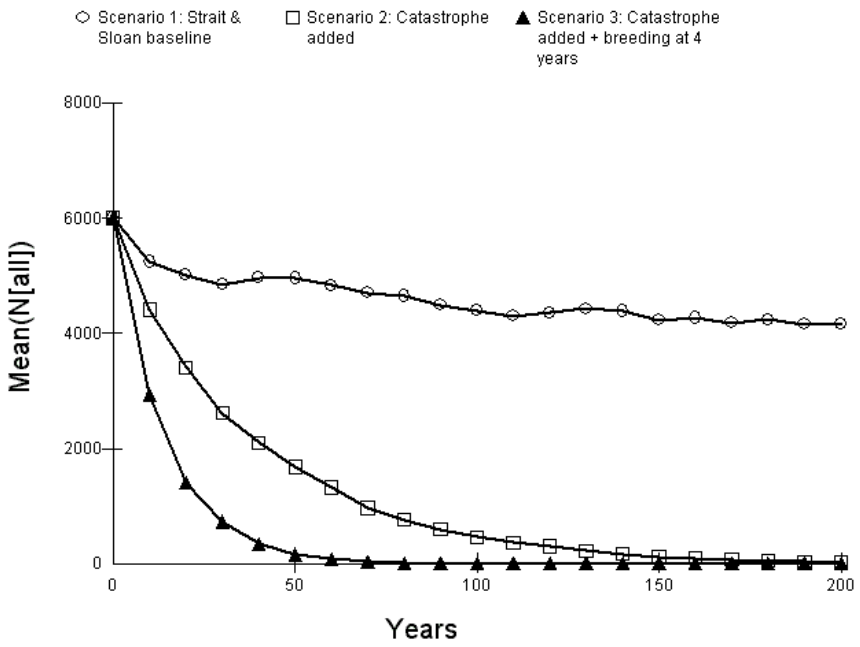


Fig. 1: Mean probability of survival of the a) Great White Pelican and b) Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 1-3.

a.



b.

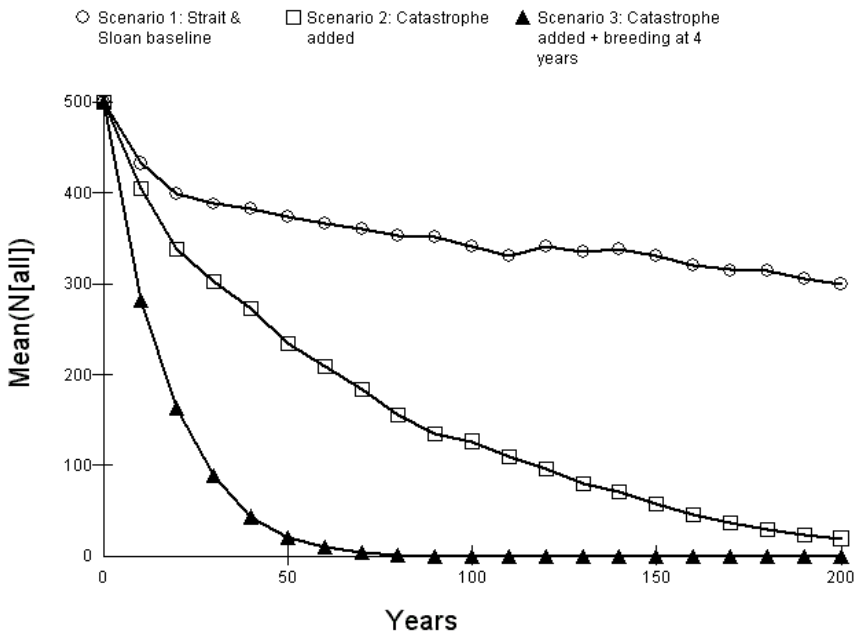
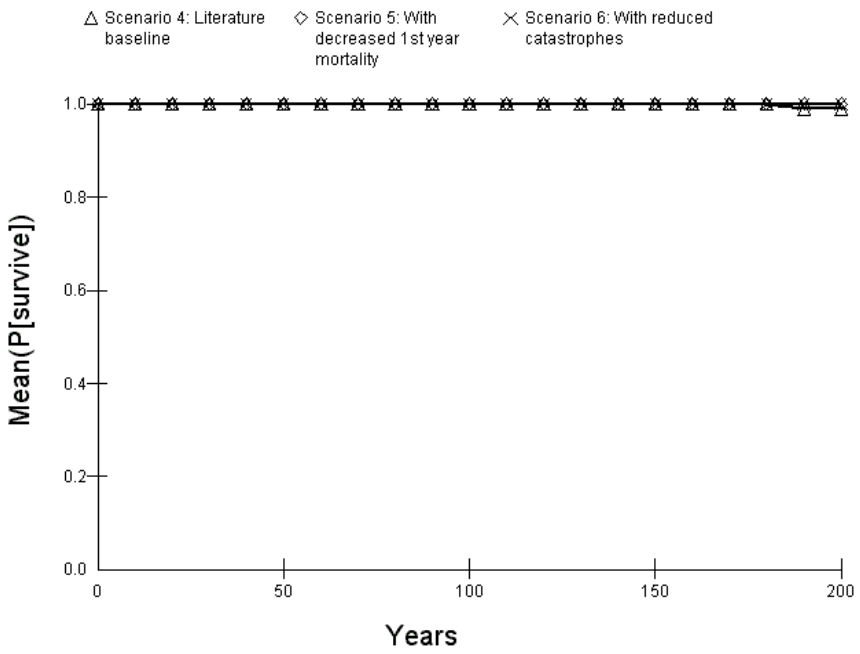


Fig. 2: Mean population numbers of the a) Great White Pelican and b) Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 1-3.

a.



b.

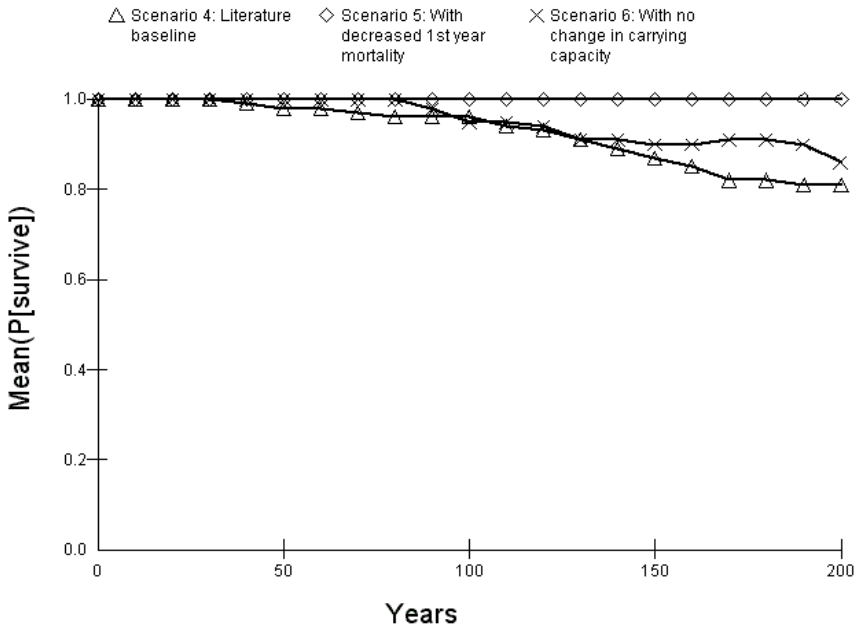
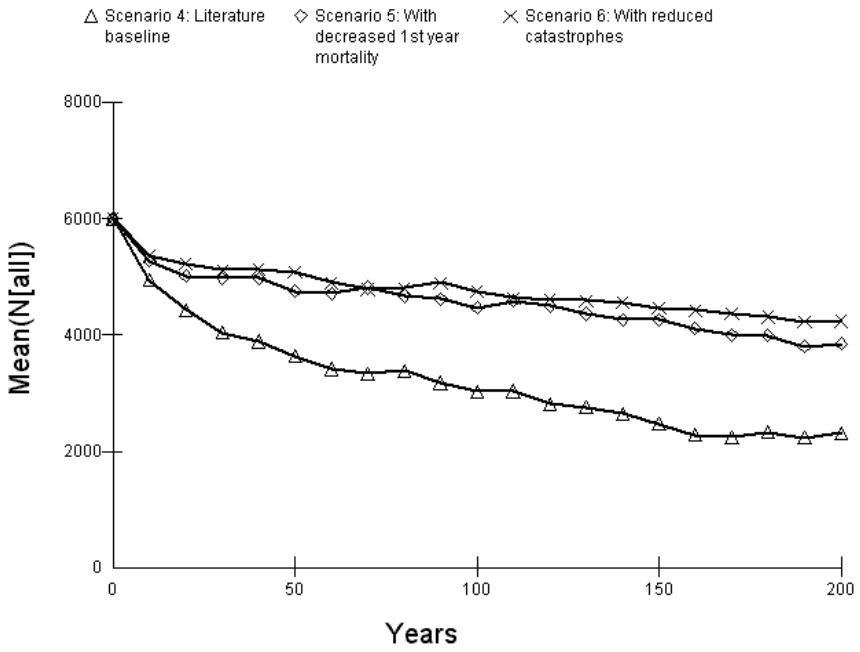


Fig. 3: Mean probability of survival of the a) Great White Pelican and b) Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 4-6.

a.



b.

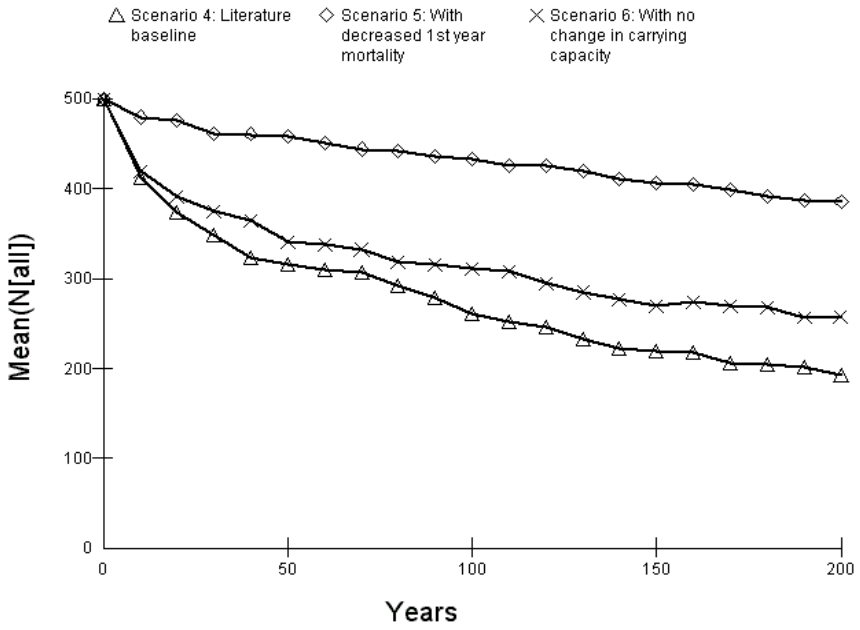


Fig. 4: Mean population numbers of the a) Great White Pelican and b) Pink-backed Pelican in north eastern KwaZulu-Natal for Scenarios 4-6.

CHAPTER 7

Fluctuations in the numbers of Great White Pelicans *(Pelecanus onocrotalus)* on Lake St Lucia in response to changing lake levels: implications for lake management strategy and conservation of pelicans

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Abstract

In January 2004 Lake St Lucia was reduced to a fraction of its normal capacity as a result of a severe drought in this region of KwaZulu-Natal, South Africa. After rains in the area the lake level rose and then fluctuated considerably over the next 24 months. During this entire time the mouth of the estuary into the sea was closed. Great White Pelican (*Pelecanus onocrotalus)* numbers and lake levels were monitored throughout this period. This study relates the changes in the pelican population numbers to the lake conditions, and highlights the importance of the lake to this bird. It also addresses the implications of these relationships to the management strategy of the lake and the conservation of the avifauna.

Key words: pelican, Lake St Lucia, population, management, conservation, avifauna.

Introduction

Lake St Lucia in KwaZulu-Natal (Fig. 1) is a highly dynamic water body. The lake is fed by several rivers and seepage zones, and also has the potential of being open to the sea (Taylor 1982). It is a large expanse of water being in excess of 70 km long and 18km wide, with a maximum surface area of about 417 km^2 (Johnson et al. 1998). The lake is shallow and experiences high evaporation rates. Salinities in the lake can vary enormously, ranging from 110 ppm in October 1970 to 0 ppm in August 1991 (Ezemvelo KwaZulu-Natal Wildlife unpublished data) and this in turn influences the natural resources that can develop in the system. Lake St Lucia can therefore provide a range of habitats for a variety of birds, and the lake levels and resulting salinities influence which species are able to use this resource (Whitfield & Cyrus 1978).

Pelicans are large, white, highly visible birds (Maclean 1985) that are reliant on healthy water bodies for their food and Lake St Lucia is one of these food sources (Whitfield & Blaber 1979). Because of their size and their total reliance on aquatic food, pelicans might qualify as an ideal indicator species for fish biomass in Lake St Lucia. Other highly visible birds such as flamingoes might fill the same role with respect to the biomass of micro-organisms in the lake. The Great White Pelican has been chosen for this study as it is largely piscivorous (Din & Eltringham 1974; Berruti 1983) and could be used as a measure of the lake's productivity as conditions in the lake vary.

Great White Pelicans *(P. onocrotalus)* are gregarious birds, and on Lake St Lucia form very large feeding groups numbering in excess of 3600 individuals (M.B., pers. obs.). There can be in excess of 6000 individuals of this species in the system at any one time, (Crawford & Taylor 2000; M.B., pers. obs.) and it is probable that all these

birds are utilizing the food stocks of the lake. Throughout the period of this study the lake was cut off from the sea as a management practice to stop the influx of sea water and thus limit the salinity of the lake (R.Taylor, pers. comm.). This impacted on the water level and resulting salinities within the system (Ezemvelo KwaZulu-Natal Wildlife unpublished data), and prevented the movement of potential prey species into and out of the lake. Fresh water enters the lake via the rivers that enter the system as well as through seepage mainly along the eastern shore (Johnson et al. 1998).

At the height of the drought at the beginning of 2004, the surface area of Lake St Lucia was reduced to a fraction of its maximum size, and the remaining area was extremely shallow (M.B., pers. obs.). The lake became unsuitable for many forms of life, and many birds left the system (M.B., pers. obs.). The Great White Pelican population was reduced dramatically as these highly mobile birds moved to more suitable foraging sites outside of KwaZulu-Natal (G.Nanni, pers. comm.). Subsequent rains over the lake and in the catchments raised the lake levels (Fig.2), and the system once more became progressively more suitable for pelicans. The conditions over the lake and in the catchments varied over the next two years, but generally over this time the lake levels were low, and dry conditions prevailed (Fig.3).

The levels of Lake St Lucia are not just an indication of the state of the lake, but also reflect the prevailing conditions in the catchments and therefore most other wetlands in north eastern KwaZulu-Natal. Lake levels may be regarded as proxy for all these factors and their effects (M.B., pers. obs.). Lake St Lucia may represent the last sizeable body of water that remains in the area during a severe drought and consequently the last source of food for pelicans.

During the period January 2004 to December 2005, the Great White Pelican numbers and lake levels were monitored. This study aimed to determine the effects of

changing water levels on pelican numbers over this two year period, and highlight the importance of the St Lucia system to this flagship species of KwaZulu-Natal both as a food source and as an indicator of the conditions in the region. It was expected that lake levels would influence the Great White Pelican population on Lake St Lucia.

Materials and methods

For the duration of this study period which ran from January 2004 till December 2005 the water levels of Lake St Lucia (Fig. 2) were unusually low and the lake very shallow. Consequently it was not possible to census these birds from the water or the land and so aerial counts were done to establish the status of the Great White Pelican.

Aerial counts were made from the Ezemvelo KwaZulu-Natal Wildlife Cessna 182 Skylane around the end of the third week of each month. The entire lake north of the Narrows was censused from a height of about 80 metres. The same aircraft, pilot and observer was used for each flight, and all flights were carried out between 09h00 and 11h00. The route flown was along the eastern shoreline of South Lake from the Narrows northwards past Fanies Island, along the eastern shoreline of North Lake as far as Lane Island, and then through Hell's Gates into the southern section of False Bay. The count then resumed at False Bay Park, and included the northern section of False Bay, the northern section of North Lake, Bird Island and the Selley's Lakes area. Visibility on all flights was good, and it was possible to see large groups from considerable distances as well as spot individual birds along the flight path.

A Garmin eTrex Legend™ Personal Navigator® was synchronized with a Fujifilm Finepix™ S5000® digital camera. The synchronization of the camera with the Garmin navigation aid (NAVAID) made it possible to pinpoint the exact location at

which each picture was taken and to estimate the size of the groups at these points. All groups of pelicans were photographed for subsequent counting.

The recorded track from the NAVAID and the digital images were downloaded to a desktop computer for analysis. The digital images were opened in Adobe ® PhotoDeluxe Home Edition 4, and enlarged where necessary. For each picture a new transparent layer was created over the original image on which each individual was marked with a dot. For very large groups of birds the image was divided into smaller areas and each area was dealt with separately. Finally the dots were counted and the number of birds recorded. These estimates were then entered on a map using the location given by the NAVAID track.

The levels of Lake St Lucia were recorded automatically by the Department of Water Affairs (DWAF) by a recorder (W3R002a04) at the bridge to St Lucia town in the Narrows area of the Lake, and by a recorder (W3R002a02) at Charter's Creek (Fig. 1). The monthly averages from these data were used when relating these levels to the number of Great White Pelicans in the lake.

Results

When the level of Lake St Lucia drops below a critical point, the lake separates into discrete bodies and these units respond differently to prolonged periods of drought (Fig. 3; M.B., pers. obs.). The Narrows which are deeper and have a small surface area are subject to less evaporation than the rest of the lake which is shallower and has a high surface area to volume ratio. When the lake levels are higher the recordings at the estuary and at Charter's Creek are quite similar and track each other, but as the levels drop, as they did in December 2003 till January 2004, these figures become

markedly different as the level at Charter's Creek drops more rapidly (Table 1; Fig. 3). The difference between the mean minimum daily levels was between 0.7m and 0.8m in December 2003 and January 2004 (Fig. 3).

On the 24th January 2004 the Umfolozi River overspilled and fresh water from this system entered Lake St Lucia (R.Taylor, pers. comm.). This raised the mean maximum water level in the estuary to just less than one meter, which is just below the mean sea level (Fig. 3). Consequently the mouth of the estuary was not breached, and the lake remained separated from the sea. The level at the recorder at the St Lucia bridge in the estuary then dropped quite rapidly as the water pushed up into the lake, topping over into the areas to the north, raising the level at the recorders at Charter's Creek.

Throughout the subsequent months till November 2004 the lake level fluctuated at levels well below mean sea level (Fig. 3), and the general trend was a steady decline in the lake levels (Fig. 2). The summer rains of the 2004-2005 season reversed this trend, and lake levels rose to approximately 0.60m. However by August 2005 the mean monthly water levels had again fallen to below 0.50m (Fig 2) and by September the lake surface was again divided into separate compartments (M.B., pers. obs.).

In the first half of January 2004, the lake was at its lowest level for this drought period (Fig. 3). At this time there were very few pelicans in the system and only 366 Great White Pelicans were recorded on the lake during the January count.

The number of Great White Pelicans dropped to 123 in February 2004 and then over the next 21 months the number showed a steady increase, rising to a maximum of 6558 in September 2005 (Table 1; Fig. 2).

Discussion

Pelicans are extremely mobile birds, and in Africa may cover great distances, presumably related to foraging or breeding (Brown et al. 1982). When the lake area and depth decreased to the low levels of January 2004, foraging opportunities decreased, and birds left the lake (Fig. 2).

In late January fresh water flowed into the lake, but only filled it to about half its maximum depth. This was enough however to encourage the birds to start returning, and by July 2004 the count reached 2028. Pelican food stocks had obviously recovered as well, as these birds remained in the system and were joined by others, swelling their numbers to a peak of 6558 pelicans in September 2005. The increase in pelican numbers was not a direct result of the rise in lake levels, but rather the result of the change that this rise manifested in the system. A newly filled water-body does not provide suitable foraging for pelicans immediately, but when the level starts dropping after a period of being high, then conditions become ideal for feeding, as prey is within reach and more concentrated. Lake levels are not the causative factor, but rather the stimulus for the production of food, not only in the lake system, but also in the wetlands of the whole of north eastern KwaZulu-Natal.

Whether the fish stocks needed this period of time to recover from their low levels of 2003 or whether the birds that had left the system had found suitable foraging sites elsewhere and were not under pressure to leave these new foraging grounds is not known. What is noteworthy however is the productivity of Lake St Lucia.

Assuming that one pelican feeding from the lake for one day is equivalent to 1 'pelican-day', then the period January 2004 till September 2005 represents approximately 1 350 000 pelican-days for Lake St Lucia. It is estimated that the Great White Pelican consumes about 1.2 kg of food per day (Din & Eltringham 1974), or

about 10% of its body mass (average 11.5 kg) (Brown & Urban 1969). This translated into a mass of approximately 1.62 million kg of food removed by this species alone. The period June to October 2005 was equivalent to approximately 705 000 pelican-days, representing 846 000 kg of food taken in 150 days or an estimated 5640 kg of food removed per day.

Throughout this period the lake was cut off from the sea, so there could have been no replenishment of the food resources from the sea. The rivers supplying water for the system also dried up soon after the summer rains each year, and could not have acted as a reliable reserve from which to source food. This implies that this biomass was produced within the lake, and that this was possible even when the number of birds on the lake was steadily increasing and the removal of food reserves was continuous. This would give some support to the management practice of keeping the mouth of the estuary closed in terms of pelican and other piscivorous bird conservation. Whether a dynamic system such as an estuary or Lake St Lucia can sustain such high levels of biomass production if closed off from the sea is uncertain. However the conditions in the lake by November 2005 resembled those of January 2004, with the whole of False Bay being dry, and the Lake reduced to a few isolated areas of water (M.B., pers. obs.), and this was accompanied by a decrease in the numbers of pelicans (Fig. 2). Numbers fell from 6558 in September 2005 to 2233 in November 2005, and this may be indicative of the lake now failing as a feeding area for this many birds. Most fish species breed after rains, and this decrease in the pelican numbers may be linked to this, as the decrease coincides with the end of the dry winter months as carrying capacity is exceeded and competition increases.

It appears also that the behaviour of the Great White Pelican under these conditions may differ from observations made elsewhere. Many feeding groups have

been counted during these aerial surveys, and many of these have numbered in excess of 1000 actively feeding individuals, with a maximum of over 3000. This differs from the observations of these birds made by Din and Eltringham (1974), where the largest feeding group numbered 129, and the average size was 8.5 birds per flock.

Under conditions of severe drought as experienced in northern KwaZulu-Natal in 2003, the pelicans abandoned Lake St Lucia as a feeding site. However as the lake level rose the Great White Pelican returned and their numbers kept increasing until September 2005 when the dry cycle again started to impact on the population. It appears that the lake is an extremely rich and sustainable source of food, and that the conditions experienced in the lake over 2004 and 2005 were ideally suited to the foraging of the Great White Pelican. Newly filled pans and dry pans are of no benefit to foraging pelicans, as they supply no food, but water bodies that are drying out provide the best feeding conditions as the prey is concentrated. The shallow water may also have provided ideal fishing conditions as the concentrated prey fish could not escape the birds by diving out of reach of the pelicans' long bill and neck. Unfortunately, these low water levels that favour foraging, discourage nesting. There are no large islands or areas protected by swamp and vegetation to offer the Great White Pelican a suitable area for breeding. So although the adults might be in breeding condition, no breeding takes place.

Water level does have an influence on the suitability of Lake St Lucia for the Great White Pelican, but it appears that this is a secondary effect. The production and availability of prey species under these changing water levels appears to be the primary parameter. Furthermore, water level is related to area and depth of the lake in a dynamic way. Consequently it is suggested that water level is not the causative factor, but an indicator of the suitability of Lake St Lucia and the surrounding

wetlands for the Great White Pelican population. It is this that could make the Great White Pelican an ideal and useful indicator species for Lake St Lucia.

Acknowledgements

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Tables

Table 1. Number of Great White Pelicans on Lake St Lucia and the lake depth at the Narrows and Charter's Creek for the period January 2004 till November 2005

Date	Great White Pelican numbers	Narrows Mean depth (m)	Charter's Creek Mean depth (m)
Jan-04	366	0.311	-0.253
Feb-04	123	0.572	0.106
Mar-04	150	0.585	0.216
Apr-04	909	0.454	0.28
May-04	602	0.517	0.436
Jun-04	1072	0.41	0.274
Jul-04	2028	0.421	0.255
Aug-04	1244	0.457	0.368
Sep-04	2233	0.452	0.376
Oct-04	2693	0.3	0.264
Nov-04	2176	0.262	0.186
Dec-04	1834	0.34	0.189
Jan-05	3431	0.516	0.146
Feb-05	4160	0.53	0.17
Mar-05	1528	0.639	0.258
Apr-05	3271	0.548	Not available
May-05	2673	0.534	Not available
Jun-05	5092	0.536	Not available
Jul-05	4212	0.523	Not available
Aug-05	3613	0.498	Not available
Sep-05	6558	Not available	Not available
Oct-05	3901	Not available	Not available
Nov-05	2233	Not available	Not available

Figures

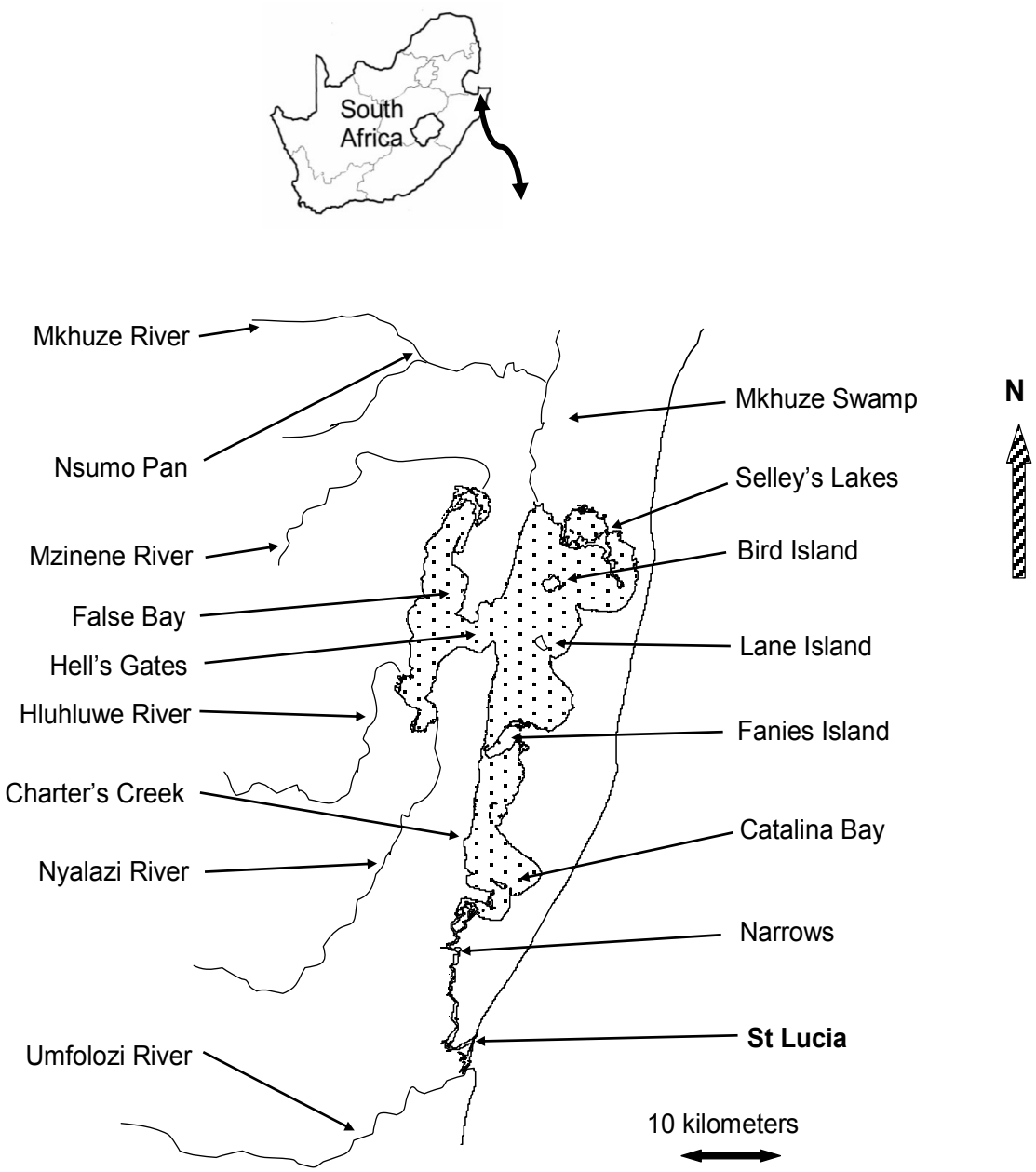

Fig. 1. Map of Lake St Lucia in north eastern KwaZulu-Natal and the catchments for the lake

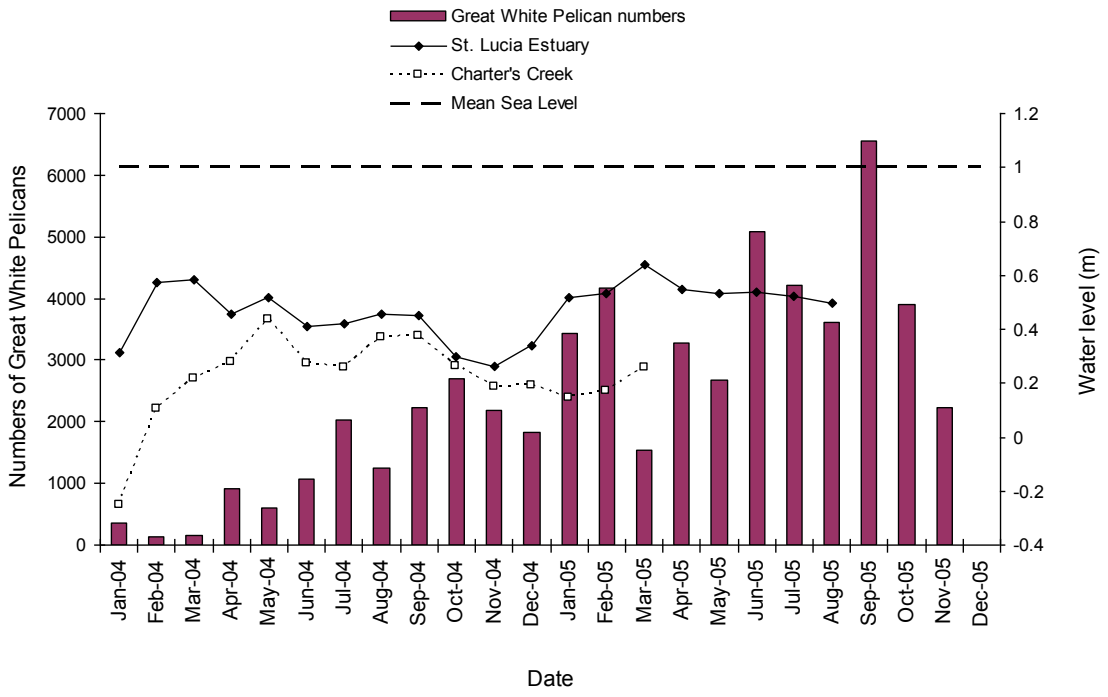

Fig. 2. The mean monthly water levels (m) at the St Lucia Estuary and at Charter's Creek and numbers of Great White Pelicans counted in the Lake St Lucia system from December 2003 to December 2005. Mean sea level is approximately 1m above the mean lake bottom level. Sea water would enter the lake if the mouth was not closed by a sand bar.

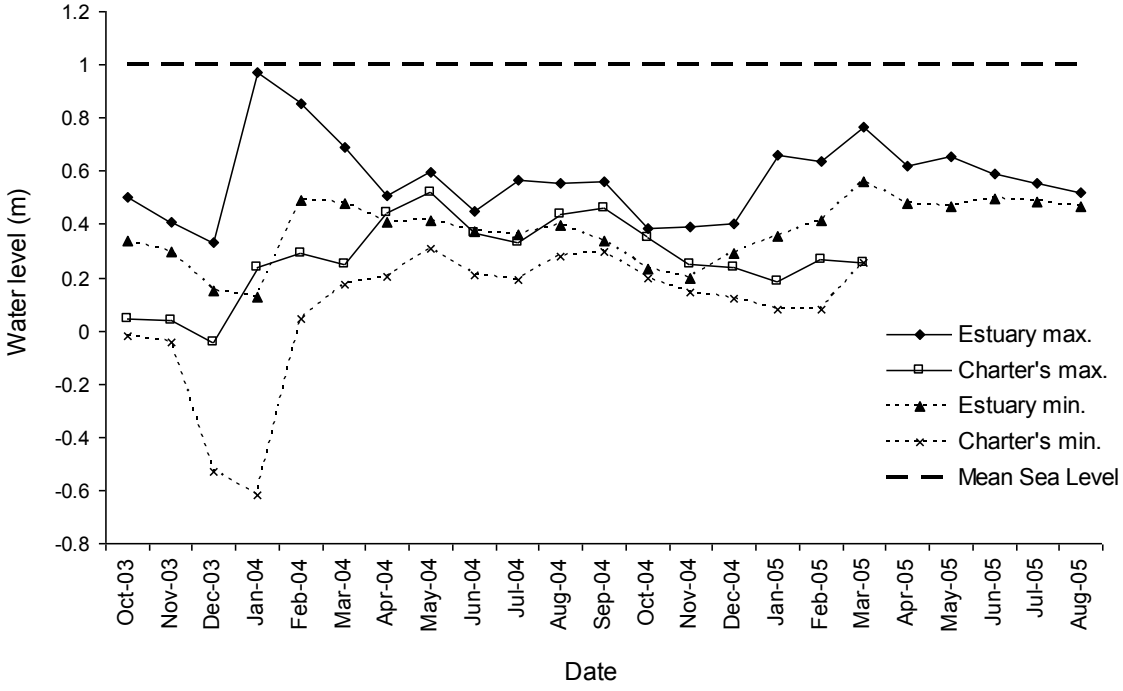

Fig. 3. Maximum and minimum daily mean water levels recorded for each month at the Estuary and at Charter's Creek for the period October 2003-August 2005. Data was unavailable for Charter's Creek after March 2005. Mean sea level is approximately 1m above the mean lake bottom level. Sea water would enter the lake if the mouth was not closed by a sand bar.

CHAPTER 8

Concerns, management suggestions and possible interventions for the conservation of the Great White Pelican *(Pelecanus onocrotalus)* and the Pink-backed Pelican *(P. rufescens)* in north eastern KwaZulu-Natal

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Abstract

To conserve any species, it is necessary to have certain baseline information for that species. Much of this information is uncertain for the Great White Pelican (*Pelecanus onocrotalus*) and the Pink-backed Pelican (*P. rufescens*) in north eastern KwaZulu-Natal, South Africa. An attempt has been made to estimate the population size and breeding success of each species, to model their population viability, to highlight areas of concern, and to make recommendations for their conservation based on these parameters. However it is clear that there are a few vital feeding and breeding grounds in this region, and the conservation of these areas is the over-riding factor in any intervention suggested to enhance the survival of these pelican populations.

Keywords: Conservation, Great White Pelican, Pink-backed Pelican, KwaZulu-Natal, population viability

Introduction

Maclean (1985) and Newman (1992) in their popular field guides, both indicate the distribution of the Pink-backed Pelican (*P. rufescens*) in the southern Cape, South Africa, as stretching from Cape Town to Port Elizabeth, two cities 680 km apart. During the more recent South African Bird Atlas Project however not a single record was submitted for the Pink-backed Pelican in this entire region (Williams & Borello 1997b). Whether this was because the original sightings may have been vagrants in the area or misidentifications of the Great White Pelican (*P. onocrotalus*) as suggested by Williams and Borello (1997a), or whether the population in the area has disappeared during the latter part of the century is not clear. What is clear however, is that the possible disappearance of this species went unnoticed and without explanation. The Pink-backed Pelican has only one regular breeding site in KwaZulu-Natal, South Africa (Williams & Borello 1997b), and if this was to fail then this KwaZulu-Natal population could suffer the same fate. The breeding site in the Durban Botanical Garden cannot yet be regarded as a regular site, and it consists of fewer than five pairs, with little potential to grow in size.

The colonial breeding behaviour (Maclean 1985) of the two pelican species makes their breeding effort easier to monitor, but is a risky habit for the birds as they are dependent on a few potentially suitable sites. If these sites should fail and there are no alternative sites, then their breeding effort in the region is doomed. Being piscivorous (del Hoyo et al. 1992) is also a limiting habit as the inland water bodies that they rely on are also prone to failure. Fortunately for these birds their great mobility (Izhaki et al. 2002) compensates for these foraging failures. Any conservation effort made for the Great White and Pink-backed Pelicans must therefore focus on maintaining the integrity and productivity of their breeding and foraging sites. It is important to

understand their population demographics and dynamics, but there is limited control or influence that can be applied to this aspect of their biology. Population size and percentage change in population size are the best indicators of extinction risk for many vertebrates, and it is also the most cost-effective data to collect (O'Grady et al. 2004).

Colonial waterbird research has contributed to wetland conservation in other parts of the world (Hoffmann et al. 1996), and with several species of colonially nesting birds on Lake St Lucia (Berruti 1980; Johnson et al. 1998), some guidance in the management of the wetlands in north eastern KwaZulu-Natal could be derived from similar research. A declining population is sometimes considered sufficient indication that a species merits conservation attention and some species can be assigned to act as an alert of impending changes in habitat or in other populations. These may be changes that may require some intervention (Dunn 2002).

Materials and methods

Estimates of population size, nest site success, movements, population demographics and survival for the Great White and Pink-backed Pelicans in north eastern KwaZulu-Natal have been made in Chapters 2, 3, 4 and 6 respectively. Chapter 5 is a habitat assessment of this region. These estimates will be used to create a baseline for use in the conservation of the Great White and Pink-backed Pelicans of north eastern KwaZulu-Natal.

Results and discussion

On the assumption that two thirds of a pelican population are breeding adults (Wetlands International 2002), and that only these birds are present at the breeding colony, then a population estimate that ranges between 6000 and 9000 individuals for the Great White Pelican in south eastern Africa seems probable (Chapter 2). This also assumes that this population is discrete, and that there are no other breeding colonies for this population. During the monthly count on Lake St Lucia in September 2005 a total of 6558 Great White Pelicans was recorded. This is higher than the minimum estimation, but this makes allowance for the successful breeding seasons of 1996-2001. A few years of failed breeding could reduce the size of the population to the lower estimate of 6000. For the Pink-backed Pelican, using the same assumptions, the population was estimated at between 600 and 900 individuals (Chapter 2).

Most estimations of population size in south east Africa consider only the Lake St Lucia or Nsumo Pan breeding birds, and these estimates range from 4000 (Berruti 1980) to 6000 (Crawford & Taylor 2000) breeding Great White Pelicans and 240-300 (Taylor 2000) to 500 (Williams & Borello 1997b) breeding Pink-backed Pelicans. The estimations for both species proposed here are higher than these normally suggested figures, mainly because they include the immature and non-breeding adults that are not present at the breeding sites.

Breeding has been shown to be highly erratic for the Great White Pelican, with a failure rate of more 40% (Chapter 3). When breeding is successful the number of nestlings can vary from a few hundred to over 2500. For the Pink-backed Pelican breeding success is less erratic and may even be on the increase (Chapter 3).

There are no apparent major unnatural causes of mortality for either species of pelican, and the only major mortalities are those recorded amongst the nestlings at the

nesting sites (Chapter 4). Their great mobility allows them to be nomadic and opportunistic when foraging, and in the non-breeding season can move out of an area if the area fails as a food source (Chapter 4).

The present breeding site of the Pink-backed Pelican seems secure, and there are many alternative sites that they could probably use if the present one fails. The breeding sites of the Great White Pelican are not reliable and there seem to be no alternatives (Chapter 5; Fig 1).

The population viability analyses (PVA) implied that the mean chance of survival for both the KwaZulu-Natal pelican species was high, and that although their populations might fall in the next 200 years, this fall would be gradual and population numbers would level out during this period. This drop in numbers could be noticeably decreased if the number of breeding catastrophes was reduced and first year survival increased (Chapter 6).

It seems probable that at present the Great White Pelican population in south eastern Africa is stable, and that the Pink-backed Pelican population may even be increasing (Chapter 2). However this scenario is unlikely to persist as the pressures on wetlands in the region increase and the traditional foraging areas deteriorate. It is likely that the influx of water into Lake St Lucia will continue to decrease as water is taken out of the catchments (Fig. 2) (Nanni 1982; Johnson et al. 1998), and that agricultural pressure on the Pongolo River floodplain will intensify to the detriment of the area as a natural food source for a range of birds (Kotze 2002). Rapid growth of the human population represents one of the greatest threats to biodiversity (McKee et al. 2003), and this has happened on the Pongolo River floodplain. The change to both these systems is more likely to impact negatively on the population of the Great White Pelican as a result of their ground nesting, their social foraging habits (Maclean 1985)

and their higher numbers. Low lake levels result in the loss of island breeding sites, and without these islands, the Great White Pelicans seldom even attempt to breed (Chapter 3). As a result of their high numbers and social feeding habit, the Great White Pelican needs large, productive areas of water, and these are the ones under threat. These factors affect the Pink-backed Pelicans to a lesser degree. Their nest sites are safe even if the nearby Nsumo Pan dries up, and the increase in dams in the catchments may even provide more feeding sites than there are presently available for this solitarily feeding species, provided these impoundments are suitable for pelican type foraging and stocked with suitable prey. This creation of dams will not compensate for the loss of natural wetlands, but they could provide foraging areas for many wetland species (Williams 1991). Their lower numbers and their summer breeding habit might imply that they are less likely to over-harvest the fish in the region and that the summer rains should have filled the wetlands by the time they breed in January. The Pink-backed Pelican also has the advantage over the Great White Pelican of being a much smaller bird (Maclean 1985), requiring less food to survive and to feed its nestlings.

Lake St Lucia is the key to their survival of the Great White Pelican in north eastern KwaZulu-Natal and possibly even in the whole of south eastern Africa. All the other sites in north eastern KwaZulu-Natal together could not possibly support this population of large piscivorous birds (Chapter 2). This does not mean though that these other water–bodies (Fig. 1) are not important, as they can be very productive and support large numbers of birds at certain times (Johnson et al. 1998; Taylor et al. 1999). These smaller water-bodies probably play a more important role in foraging for the solitary feeding Pink-backed Pelican, and it is often these areas that are most under threat from anthropogenic activities (McCulloch et al. 2003).

The successful breeding of the Great White Pelican at Lake St Lucia depends on the correct timing of so many events. The food supply must be good enough to initiate the whole cycle, while the lake conditions at the breeding sites must be ideal, providing security from land predators. While these conditions must persist for several months, the winter dry down period must continue so that the lake and pan levels drop, optimising the feeding conditions when the adults have the extra burden of feeding their nestlings. If conditions become too dry, the breeding areas become vulnerable to predation (M.B., pers. obs.), and if winter rains occur, then the breeding islands are flooded. These optimum dry down conditions will also impact on the young when they leave the colony and fend for themselves.

At Lake St Lucia, the single most important focus of attention for the Great White Pelican is the establishment of secure breeding sites, as these reduce catastrophic breeding failures due to drought or flooding, and reduce first year mortality. In many areas of the world, artificial nest sites have been constructed for a variety of birds and for the Dalmatian Pelican (*P. crispus*) in particular (Crivelli 1996), and these have generally been successful. For the Dalmatian Pelican nesting islands were built in one area using dredged material and floating rafts were constructed in a second area. The pelicans did nest on the artificial islands, but the rafts were subject to storm damage and were not successful (Pyrovetsi 1997). This was a radical intervention and was used with the Dalmatian Pelican because of its threatened status. However if the nesting sites on Lake St Lucia frequently become unsuitable for nesting, then this type of intervention may become necessary in the future. Considering that there are several other species that rely on the islands in Lake St Lucia for successful breeding (Berruti 1980; Johnson et al. 1998), these artificial sites may become of added significance if the island sites keep failing. Birds in the area have taken advantage of

man-made structures in the past, with Pink-backed Pelicans nesting on the wreck of the Catalina aircraft (Berruti 1980) and cormorants (*Phalacrocoracidae*) and darters (*Anhingidae*) using the missile targets placed in the lake by the South African National Defence Force (M.B., pers. obs.). At Walvis Bay in Namibia the Great White Pelican has used the platform at Bird Rock as a nesting site (Crawford et al. 1981). If this intervention was deemed to be necessary, then placing it in an area where it could be observed from a hide on a raised part of the shore could provide an attraction to tourist and possibly generate income. This intervention is radical and would need to be considered in relation to the other needs of all the other lake fauna and the possible negative impacts of such manipulation.

The role and importance of the Pongolo River floodplain has been difficult to assess. It has been shown to be an important foraging area for Great White Pelicans breeding at Lake St Lucia (Whitfield & Blaber 1979), but little is documented about which areas of the floodplain are used, and whether these foraging trips extend as far as the Ndumu Game Reserve and into Mozambique. During 2004 and 2005 very little activity was recorded in the Pongolo system (Chapter 4), but this might simply be the result of Lake St Lucia being a more suitable, richer and safer foraging site. Little breeding took place on Lake St Lucia during these years. The low water levels and drought resulted in the loss of suitable nesting sites, and so the pressure on the adults to feed young birds never materialised. It is important to assess the role of this floodplain during a successful Great White Pelican breeding season. If this floodplain is in fact the alternative foraging site, then is it able to sustain the foraging pressure that a large breeding colony would impose? If this floodplain is vital to the Lake St Lucia breeding effort and it is a failing system, then this will impact negatively on the Great White Pelican breeding success. Tracking of breeding adults would give great

insight into the movements of the birds and the role played by the Pongolo River floodplain and other water-bodies in south eastern Africa during this phase. Satellite tracking is an option, but is extremely expensive. Advances in cell-phone technology may make the tracking of large birds that are very mobile much more cost effective, and this form of monitoring should be considered now that this type of equipment has become available. Cell phone reception in this region of South Africa is adequate for coarse tracking, but the Mozambique area north of the border is not.

Fortunately the pelican species in north eastern KwaZulu-Natal are not noted as being subjected to hunting pressure as they are in Europe (Izhaki 1994; Crivelli 1996), and are not perceived as competition to local fishing. However, if this perception is incorrect, then some education programme may be deemed necessary to change the attitudes of those involved. In central Kenya most hunting of bird species is done by young people while herding or grazing livestock (Gichuki & Terer 2001), and this may also apply to the wetlands of north eastern KwaZulu-Natal and Mozambique. During visits to the Pongolo River floodplain to assess the pelican numbers, several young fishermen were seen to have caught ducks (*Anatidae*) while fishing at the pans (M.B., pers. obs.), and the gill netting of fish in these pans may result in the deaths other birds, especially the diving birds like grebes (*Podicipedidae*), cormorants (*Phalacrocoracidae*) and darters (*Anhingidae*) that might get entangled in the nets. Gill-netting in north eastern KwaZulu-Natal is very common (M.B., pers. obs.; Chapter 5), and this impacts on the fish stocks available to the foraging pelicans. In some areas, like the Muzi Pan, illegal gill-netting is common, and some control over this would be a positive action.

The catching and hunting of pelicans has not been documented, but the size of these birds certainly makes them a promising source of protein The Greater St Lucia

Wetland Park (GSLWP) is now perceived by its neighbours to be the foundation for biodiversity conservation and economic development within the region (Picard 2003) and so education programmes stressing the importance of areas like the Mkhuze and Pongolo River floodplains may be better received and influential than they would have been in the past.

There are several knowledge gaps that need to be addressed in terms of pelican conservation. The most fundamental of these is the establishment of the range of this KwaZulu-Natal population. It is essential to establish whether this population is in fact discrete, or whether there is linking to the populations that are found on the west coast of South Africa and Namibia or to the populations of Zambia and northern Mozambique.

The poorly studied and poorly understood population demographics of the Great White and Pink-backed Pelicans make the modelling of the populations of these birds difficult, and detract from the ultimate value of these models. The accumulation of data of this nature requires setting up a long term exercise which must be carefully planned at the outset. This exercise might include the banding of juveniles at the nest sites with standard metal rings as well as coded colour rings or patagial tags. This would have to be continued for several years, and a programme of re-sightings and recoveries would have to run concurrently. The practice of banding pelicans at their nesting sites is controversial as these birds are prone to abandoning sites if they are disturbed. Banding of Great White Pelicans has been done successfully at the Hardap Dam in Namibia and at Dassen Island in the Western Cape (Underhill et al. 1999; SAFRING unpublished data), where the colonies are quite accessible. The colony at Lake St Lucia is less accessible than these (M.B., pers. obs.) and it is not known whether their being so remote from human disturbance will make this population

more likely to abandon their site. If ringing is to be done, then it should be done late in the nesting period when all incubation is complete and the nestlings are about to fledge. The tree nesting habit of the Pink-backed Pelican makes banding of this species at its nest site problematical as access to the nests is difficult. Vulture nestlings have been ringed in their nest sites by using ladders and a mobile hydraulic lift (J.Wakelin, pers. comm.), but disturbing an entire colony of Pink-backed Pelicans for a prolonged period of time may be unwise. Pink-backed Pelican nestlings also move across the canopy and at are at risk of falling out of the tree and injuring themselves. If banding is to be attempted it would need to be very carefully monitored and perhaps only done at the end of the breeding cycle when the last birds of the asynchronous season are fledging. Banding of adults is also possible using other trapping methods, such as specially designed gin traps set at the birds' loafing areas. This is very time consuming and the results unpredictable.

Human disturbance at the breeding site is another factor that can negatively affect the success of a breeding colony (Crivelli 1996; Carney & Sydeman 1999; Nisbet 2000). At present the breeding colonies of the Great White and Pink-backed Pelicans are not subjected to tourist pressures, and are in protected areas. They are however accessible to poachers and this needs to be monitored. These breeding sites must also be protected from disturbance by aircraft, including microlights (Cowan 1995).

Surveys of population size, age composition and the proportion of breeding birds are needed to improve the quality of any modelling that is done. It is also important to conduct these surveys at various times throughout the year to ascertain current and seasonal variations in population status and in distribution. Age composition is difficult to establish in most birds, but both species of pelican exhibit a range of pre-

definitive plumages, which are both complex and subtle. The Great White Pelican appears to develop through four stages before reaching final adult plumage (Table 1).

When seen from close up, it is possible to distinguish these different plumages, and thereby estimate the age composition of this species. Unfortunately the sub-adults do not necessarily associate with the adults, and tend to disperse to different areas. It is therefore not possible to get an accurate indication of the age composition of a population by sampling a single group and extrapolating this result for the entire population (Brown & Urban 1969). It is not known where the KwaZulu-Natal sub-adults spend their maturing years.

Very obvious during this study was the inconsistency of the recording and reporting of pelican data. Noting that there are '2000 pelicans' in the lake is subtly different from '2000 breeding' or '2000 non-breeding birds', and '2000 non-breeding Great White Pelicans' is more useful still. In the same way, '500 chicks present' is not as informative as '500 large, black chicks in a group, no adults still sitting'. The records used have been collected over more than 50 years by a range of people using a variety of methods and reported in different styles. Counts and observations have generally been fairly haphazard, and there seems to have been little structure and routine in this type of monitoring. This has improved since the introduction of the Coordinated Waterbird Counts in South Africa, and data are now more accurately recorded. Efforts have been made in the past to record colonial breeding in a standard way (Ezemvelo KwaZulu-Natal Wildlife unpublished data), and these should be evaluated and reintroduced. When colonial birds are seen to be nesting some special effort should be made to follow the progress and success of that breeding effort.

Lake St Lucia supports a vast array of plant and animal species, and the conditions that are ideal for some are detrimental to others. Management of this huge and

variable system is extremely complex. Falling lake levels are deleterious to most species, but suit the Great White and Pink-backed Pelicans (Chapter 7). It is impossible to manage this system in a way that suits all species simultaneously, but it is useful to identify indicator species for the different phases through which the lake passes as it cycles. Pelicans, the Great White Pelican in particular, are probably a useful indicator of the health in terms of fish biomass productivity levels of the system when the lake is in the dry down stages of the cycle. They are large, easy to see and count, and totally reliant on the body of the lake for food. Counts have been made monthly for the period January 2004 to December 2005, and these have provided useful data on the relationship of the lake levels and pelican numbers. It would be advantageous if these counts could continue on a regular basis, and possibly include flamingos (*Phoenicopteridae*), as they are also highly visible and might also act as an indicator species of different conditions.

One of the management strategies for the lake is to keep the mouth of the estuary closed to control the salinity levels. Whitfield and Blaber (1979) suggested that the feeding of pelicans on Lake St Lucia followed three phases, the first of which is the pre-incubation phase that lasts from April to June and coincides with the movement of *Mugil cephalus* through the Narrows, to and from the sea. If this route is not available to these fish, then this feeding phase fails, and this may have a negative effect on the initiation of the breeding cycle. It may be this type of event that allows the adults to build up the fat and protein deposits that are necessary to breed. It may be the factor that determines which of the adults will be fit to breed and how many eggs they can afford to lay. The extent of these special migration events in the lake may also determine whether the laying period can be extended over several months, and whether first time breeders will be successful.

Management of the Great White and Pink-backed Pelican populations in north eastern KwaZulu-Natal requires the input, co-operation and action of many people and organizations. These roles are all interrelated and interdependent (Fig. 3). Much of what is shown in this figure applies equally well to many species of both plant and animal throughout KwaZulu-Natal. This organogram for pelicans should not be seen in isolation, but as part of the management, public involvement and awareness, and monitoring programmes for the areas on which pelicans depend.

Although neither pelican species in north eastern KwaZulu-Natal seems to be under immediate threat, their future must be uncertain as the state of their foraging sites will change as water is taken out of the catchments of these systems or as the systems are over-used. Forecasting at this stage is coarse as many aspects of the biology of the Great White and Pink-backed Pelicans are uncertain. These knowledge gaps need to be filled. The most important of these is the establishment of whether the birds of south eastern Africa form a discrete population. The condition of the breeding site of the Great White Pelican is the next concern, as the failure of this site is more likely as water is removed from the Lake St Lucia catchments. The role of the Pongolo River floodplain in a year of successful breeding at Lake St Lucia during which the lake is drying down is an important assessment to be made.

Although the Pink-backed Pelican numbers are lower than those of the Great White Pelican, their persistence in the area seems more secure. Their arboreal nesting habit seems to expose them to fewer anthropogenic threats than the ground nesting habit of the Great White Pelican, and it may be these different habits that will determine the long term success of each of these species.

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Tables

Table 1. Diagnostic features of the different developmental stages of the Great White Pelican related to age (Brown & Urban 1969; Din 1979; Crawford 2005).

Stage	Alternative	Basic Diagnostic features	Possible age
Nestling		Naked pink skin which turns black Brownish black down	0 to 40 days
Juvenile	Juvenile I	Dark brown wings Entirely black on bill	1st year birds
Immature	Juvenile II	Dark brown upper wing surfaces. Legs and bills with mixed black and yellow tones, yellow pouches	2nd year birds
Sub-adult	Juvenile III	Mottled brown and white rather than uniformly brownish upper wing surface Mostly or entirely yellow on bill, pouch and legs	3rd year immatures
Non-breeding adult		Definitive plumage	3-4 years or more
Breeding adult		Develops a knob on forehead, a crest, and a yellow or brown chest	3-4 years or more

Table 2. Summary table of goals, actions and responsibilities for the conservation of the Great White and Pink-backed Pelicans

Goal	Action	Responsibility
Safeguard breeding sites from degradation	Both species presently nest within protected areas, so these sites should already be managed	EKZN Wildlife
Safeguard breeding sites from human interference	Both species presently nest within protected areas, but should they move outside these areas, special attention may become necessary. Regulations regarding aircraft and boat disturbance must be enforced	EKZN Wildlife Land-owners Local communities
Guarantee breeding islands of Great White Pelicans	Consider construction of artificial islands or platforms if inflow into Lake St Lucia drops, and present breeding islands are no longer suitable	EKZN Wildlife
Guarantee breeding sites of Pink-backed Pelicans	Consider construction of artificial platforms in protected areas if present breeding sites fail and birds move to high risk unprotected areas	EKZN Wildlife
Safeguard feeding sites from degradation	Maintenance of the catchments for Lake St Lucia and the Pongolo River floodplain	Department of Water Affairs Landowners Local communities

Safeguard feeding sites from human interference	This applies especially to Lake St Lucia and the Pongolo River floodplain, but also includes sites in the Richards Bay area and other smaller water-bodies. The Pongolo River floodplain is subject to the influence of rapid population growth	EKZN Wildlife Land-owners Local communities Richards Bay Municipality Department of Water Affairs Large corporations
Assessment of the Pongolo River floodplain	This area has changed radically since the last survey was conducted in the area. It is presently the focus of a review.	EKZN Wildlife Department of Water Affairs Landowners Local communities NGO's
Further research on the biology of these two species and their food source	Long term banding programme to produce a life-table for each species of pelican	EKZN Wildlife SAFRING ringer
	Effects of gill-netting on fish populations	EKZN Wildlife
	Range of each species of pelican, and their relationships with other populations	Research possibility
	Effect of the closure of the estuary on fish stocks that are used by pelicans	EKZN Wildlife
	Assessment of the importance of the Pongolo River floodplain when Lake St Lucia fails as a food source	EKZN Wildlife

Standardised methods of counting and recording bird numbers and breeding success	EKZN Wildlife has developed these in the past, and they need to be re-instated or enforced. CWAC has addressed this problem to some extent	EKZN Wildlife CWAC
Regular monitoring	Counts and surveys are needed on a regular basis to provide data for future analyses. Monthly surveys are necessary for determining whether nesting is in progress. During nesting fortnightly visits should take place.	EKZN Wildlife
Public and community awareness and involvement	Information in the form of posters, lectures, personal contact	Greater St Lucia Wetland Park Authority EKZN Wildlife
	Education of schoolchildren, fishermen, local communities	Greater St Lucia Wetland Park Authority EKZN Wildlife NGO's Schools
	Value of the resources to the local communities	Greater St Lucia Wetland Park Authority EKZN Wildlife NGO's

Figures

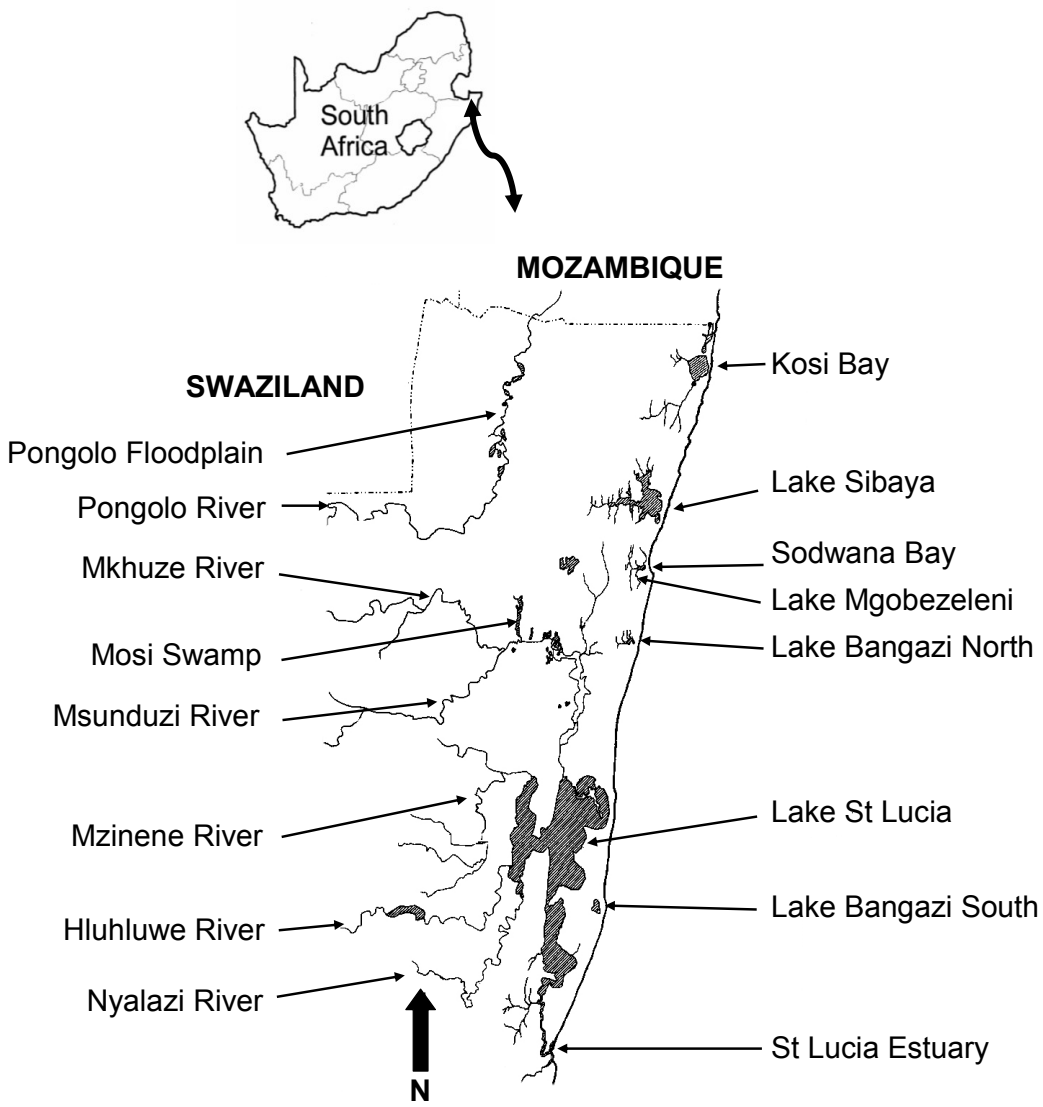

Fig 1. Map of the north eastern KwaZulu-Natal indicating areas of potential Great White and Pink-backed Pelican feeding habitat.

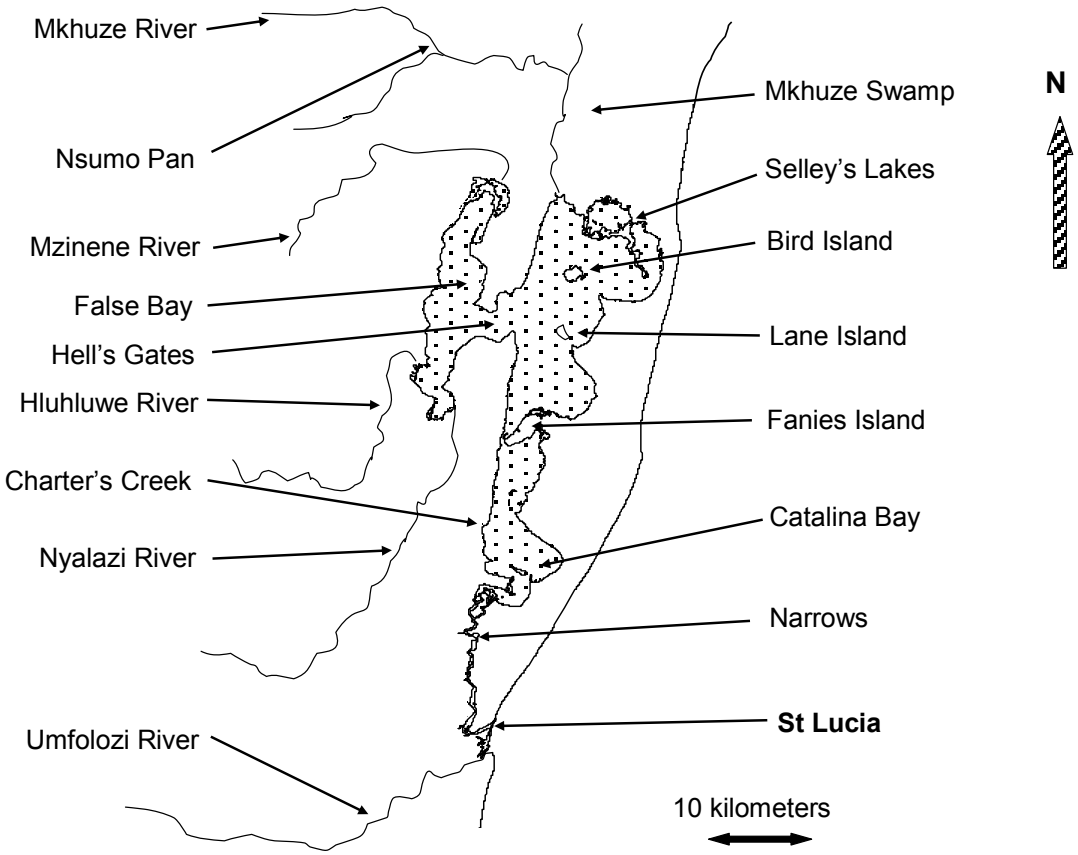

Fig. 2. Map of Lake St Lucia and the associated catchments.

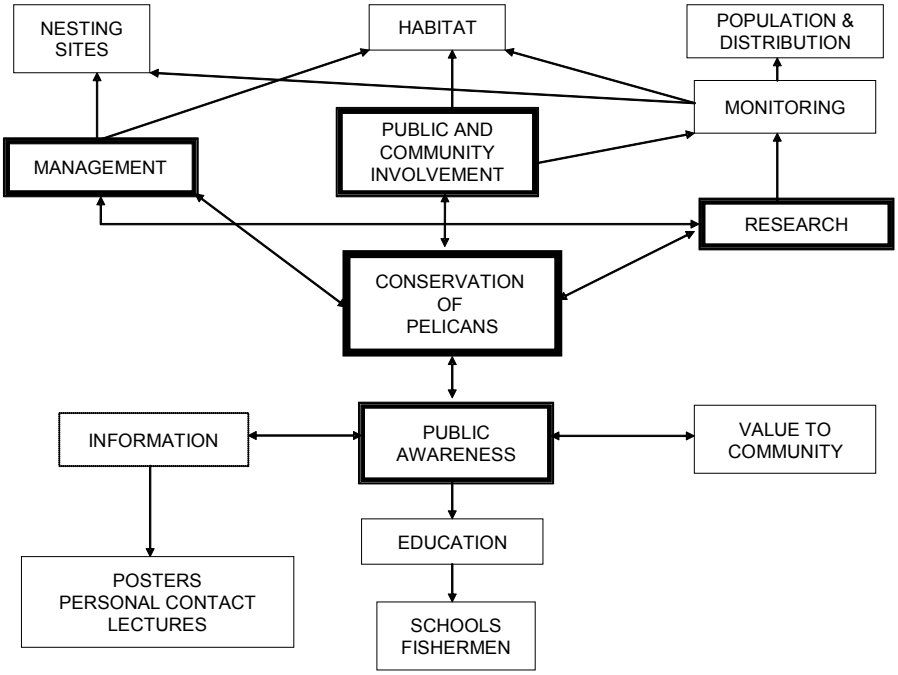

Fig. 3. Chart of the interactions needed for the preservation of the Great White Pelican and Pink-backed Pelican in north eastern KwaZulu-Natal (Adapted from Pyrovetsi (1997)).

CHAPTER 9

Concluding Remarks

This study has been an attempt to gather all the as yet unpublished data that have been collected for the Great White and Pink-backed Pelicans in north eastern KwaZulu-Natal, to analyse and summarise these data, and from this to produce some baseline from which to work in the future.

The Great White and Pink-backed Pelican populations in north eastern KwaZulu-Natal do not seem to have decreased noticeably in size since the 1950s (Chapter 2). However, this does not imply that their future is secure. With increasing anthropogenic changes in the whole of the south eastern part of their range (Nanni 1982), and the negative effects of these changes on wetlands (Chapter 5), these two species have come under increasing environmental pressures, and their survival in the region will be compromised.

The most immediate threats to the survival of the Great White Pelican are the unpredictability and inconsistency of its breeding effort (Chapter 3) and the conditions of its foraging areas (Chapter 5). If Lake St Lucia continues to suffer very low water levels as a result of less runoff from its catchments (Nanni 1982) and by being kept cut off from the sea, then the breeding sites will continue to fail, and this will mean the demise of the breeding effort in north eastern KwaZulu-Natal. If this is to be avoided then the extreme measure of providing artificial breeding sites will have to be considered.

After assessing the use that the Great White Pelican has made of the Pongolo River floodplain over a two year period, it seems that this area may already have

failed as an alternative foraging site for this species (Chapter 5). If this is the case then the pans in Mozambique on the Rio Maputo just beyond the northern border of KwaZulu-Natal (Parker 1999) may be of great significance during the future breeding seasons of the Great White Pelican. If the Pongolo system has failed as a foraging site, then it may impact on the Great White Pelican by limiting the number of birds that can breed at Lake St Lucia, and the colony may become smaller. This will not be a self-imposed limit, but a result of a reduction in the population overall after several years of breeding failure.

Lake St Lucia can sustain a large resident pelican population under certain conditions (Chapter 7). These are generally conditions of low or falling water levels (Chapter 7). This however does not necessarily mean that the birds are in a good enough state to breed. When levels in Lake St Lucia are low, the implications are that the other wetlands in south eastern Africa are dry or at least under stress (R.Taylor, pers. comm.). The high numbers in Lake St Lucia might simply be the result of the failure of foraging in all other areas, and that the lake now represents the only site available for any foraging at all. Under these conditions the adults are unlikely to attempt to breed and will only remain in the area until eventually the lake also fails.

The outlook for Pink-backed Pelican is more positive, but still not certain. The success of its nesting site is not directly dependent on the water level of the Nsumo Pan in the Mkhuze Game Reserve where they breed, and breeding is more predictable and regular as a result (Chapter 3). Their numbers are limited in north eastern KwaZulu-Natal (Chapter 2), and they can feed on smaller water bodies for smaller prey (Din & Eltringham 1974), and this may make this population less vulnerable under adverse environmental conditions. This is the southern limit of their

distribution and so they can disperse northwards if conditions in the north eastern KwaZulu-Natal region fail.

Many of these assessments and predictions are speculative, and will continue to be so until more is known about the movements and range of these populations of Great White and Pink-backed Pelicans. Much more needs to be known about the relationships between these populations and the populations in the rest of sub-equatorial Africa. These populations cannot be adequately conserved if these relationships are not known. If these populations are part of a metapopulation of southern Africa, then the role of this area as a potential source or sink for the metapopulation may be important. Further study is needed of this aspect for these two species, and any opportunity to discover more about this facet of their biology should be used. No ringing has been done on the two pelican populations in KwaZulu-Natal (Underhill et al. 1999). A programme of this nature is ideally a long term project if the intention is to produce a life table or insights into population demography of the two species (Strait & Sloan 1974; Baillie 2001), but even a less ambitious ringing effort has the potential of providing some clues as to the movements of these birds. Every single ringed bird in the population is a potential source of information, and as long as there are no ringed birds dispersing into or moving through this area there is no chance of discovering the extent of their range and movement patterns.

No chances must be missed in accumulating data for the Great White and Pink-backed Pelicans. The breeding efforts of these two species should be closely monitored every year, and the results clearly recorded in a uniform manner, unlike they have been in the past (Chapters 2&3). This is absolutely essential for evaluating their present status and predicting their long term survival.

The ecology of a wetland is determined primarily by what happens outside the wetland boundary, beyond the jurisdiction of those who control the wetland (Kingsford et al. 1999). The survival of the pelicans in north eastern KwaZulu-Natal will depend on the influence that the Greater St Lucia Wetland Park Authority has on this, and also how they manage the pelican breeding colonies entrusted to them. The Great White Pelican and Pink-backed Pelican may well become the indicator species of the quality of the management decisions and conservation effectiveness of this authority.

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APPENDIX A

Previous studies on the Great White Pelican (*Pelecanus onocrotalus)* and the Pink-Backed Pelican (*P. rufescens*)

Taxonomy

This order of birds is uniquely defined by being totipalmate, having all four toes connected by webbing. Other characteristics common to the order include the absence of a brood patch, unfeathered gular patches, presence of an oil (uropygial) gland and a reduced hyoid structure (Johnsgard 1993). They all feed on aquatic vertebrates or invertebrates, are colonial breeders and lay one or two egg clutches, with the egg having a chalky surface (del Hoyo et al. 1992). Nestlings are born in a highly altricial state, blind and naked, and dependent on their parents for food and protection (Johnsgard 1993). In their taxonomic treatment of pelicans, Brown et al. (1982) and del Hoyo et al. (1992) agree on the following classification.

Class:	Aves
Order:	Pelecaniformes
Sub-order:	Pelecani
Family:	Pelecanidae
Genus:	*Pelecanus*

There are seven species of pelicans, and they can be divided into three groups, based on similar characteristics of size and behaviour. Although this represents a loose grouping, it does give some indication of comparative biological traits, such as age at maturity and modal clutch size (Johnsgard 1993).

Group 1:

This group includes the largest of the pelicans. They nest on the ground in dense colonies, and are communal feeders. The group includes:

P. onocrotalus: Great White Pelican

P. crispus: Dalmatian Pelican

P. conspicillatus: Australian Pelican

P. erythrorhynchos: American White Pelican

Group 2:

The pelicans of this group are smaller, nest and roost in trees, form looser colonies and feed singly. The group includes:

P. rufescens: Pink-backed Pelican

P. philippensis: Spot-billed Pelican

Group 3:

This is the only pelican that plunge dives to feed.

P. occidentalis: Brown Pelican

(Johnsgard 1993)

Great White Pelican

a. Names:

Pelecanus onocrotalus Linnaeus, 1758, Syst. Nat. (10^{th} ed.); Caspian Sea. *onocrotalus* (L) = a pelican (del Hoyo et al. 1992)

Other vernacular names: English**:** White Pelican, Eastern White Pelican, African White Pelican, European White Pelican, Roseate Pelican, Rose-coloured Pelican, Rosy Pelican (Johnsgard 1993). Zulu: iVubu, iFuba, iKhungula (Maclean 1985).

b. Subspecies:

Although African birds are on average slightly larger than those in the rest of its range, the racial division of the African population has been dropped (Brown et al. 1982).

c. Measurements:

Measurements are summarised in Table 1.

d. Description:

Adult: Summarised in Table 2.

Nestling: The nestling of the Great White Pelican hatches naked, with a pink skin. The skin turns black after a few days, and this is followed by the growth of a thick, brownish-black down. The nestling becomes paler as the juvenile plumage emerges. The bill, legs and feet change from pink to dark grey or blackish (Feely 1962; Brown & Urban 1969; Maclean 1985; Johnsgard 1993).

e. Identification:

In the hand:

The feathers of the forehead come to an acute point (Johnsgard 1993). The Great White Pelican is larger in measurements than the Pink-backed Pelican (Maclean 1985).

In the field:

The primaries and secondaries are black dorsally and ventrally. This contrasts with the white feathers of the rest of the body when the bird is in flight. Bare parts on the face are more extensive and the pouch is yellow. In breeding plumage, the knob and crest on the head are diagnostic (Brown & Urban 1969).

f. Voice:

They are generally silent when not breeding. Grunts, moos and bellows at breeding and courting sites (Feely 1962; Maclean 1985).

g. Habitat:

Throughout their range these birds are found near water. Generally they favour large water-bodies that are shallow and still or slow flowing. They are found in coastal bays, deltas, lagoons, estuaries, lakes, pans and dams (Cyrus & Robson 1980; Maclean 1985). Water can range from fresh to saline to alkaline, provided that it is stocked with food (Brown & Burke 1969). In east Africa and Nepal they are found at high altitude, but generally they favour lowlands (del Hoyo et al. 1992). Nesting is normally restricted to islands or areas that are inaccessible to land predators (Brown & Urban 1969).

h. Habits:

The Great White Pelican feeds, loafs, roosts and breeds socially. Typically they feed from daybreak till late morning, making most of their catches before 10:00 hours. This is followed by a period of loafing, during which time the birds preen, bathe, rest or sleep. A second feeding period follows in the afternoon, but this tends to be more irregular and shifting, with a peak between 17:00 hours and dusk. At dusk the birds fly off as a group to their roosting sites, which are sometimes the same as their loafing sites. Loafing and roosting usually takes place on exposed, flat areas, such as the sand banks along the edge of the water, but occasionally they will loaf in shallow water. Birds are sometimes seen on the water at night, especially on moonlight nights (Din & Eltringham 1974b).

These birds soar effortlessly using thermals to assist them to reach altitudes of up to 1700 m (Whitfield & Blaber 1979). They typically fly in a 'V' formation, but this can sometimes take the form of only one arm of the 'V' (M.B., pers. obs.).

i. Distribution:

Pelecanus onocrotalus is found mainly in sub Saharan Africa, where it is usually residential around its breeding areas. Irregular movements are associated with changes in local conditions and the availability of food and water. It breeds widely in this region, with nesting sites limited to certain localities. Breeding occurs from the Senegal delta through the Lake Chad basin to the Ethiopian highlands. From there breeding continues down the Rift Valley to the eastern and western seaboards of Southern Africa. Breeding also occurs from Greece in eastern Europe to west-central China and southern Vietnam, although there is no recent information for these western areas (Johnsgard 1993).

In southern Africa *P. onocrotalus* breeds regularly at Lake St Lucia (KwaZulu-Natal), Dassen Island (Western Cape) and Bird Rock Platform (near Walvis Bay, Namibia) (Crawford 2005). When conditions were suitable this species has also bred in Namibia at Lake Oponono, Etosha Pan and Hardap Dam; in Botswana at Lake Ngami, Sua Pan and the Nata River delta (Williams & Borello 1997a); at Vondeling Island (Western Cape) (Marine and Coastal Management, unpublished data); and on the Zambesi River (Mozambique) (Cyrus & Robson 1980).

P. onocrotalus is restricted mainly to the eastern and western seaboards of South Africa, but also extends into the Free State and North West Province as well as Mpumalanga. In these inland areas they are generally present in low numbers (Williams & Borello 1997a).

j. Population and demography:

In Table 3, figures shown in brackets indicate the number of individuals. This is done by multiplying the number of breeding pairs by 3 (Wetlands International 2002).

k. Movements:

Some European populations have been shown to be migratory, with birds moving mainly into Africa and also into southern Asia (Johnsgard 1993). Although African birds are resident, they may move long distances. This is assumed to be in response to water levels, food availability and breeding sites (Brown et al. 1982). The greatest distance recorded for a ringed bird in southern Africa is 209 km from the ringing site (Underhill et al. 1999). However birds have been seen further away from known breeding sites than this, and so their potential movements from breeding grounds must at least match these dispersal distances (Crawford 2005).

Juveniles have been shown to disperse great distances in Africa, with some individuals from Lake Shalala in Ethiopia moving over 1000 km southwards along the Rift Valley into Kenya (Urban & Jefford 1977).

l. Foraging and food:

On Lake St Lucia the birds regularly form large foraging flocks of several hundred up to several thousand individuals (Feely 1962; M.B., pers. obs.). This is in contrast to (Din & Eltringham 1974b, a) who estimated the average foraging flock size in the Ruwenzori National Park in Uganda to be 8,5 birds. On smaller water-bodies they normally form smaller foraging groups, and may even forage solitarily at times, although there is a CWAC record of a group of 1000 pelicans on Lake Futululu, which is a small lake (Taylor et al. 1999). Solitary feeding is also sometimes associated with turbid water, while groups are bigger when the birds are foraging in clear water. Birds on the Pongolo River floodplain have been seen foraging at night (Whitfield & Blaber 1979).

When feeding socially they swim in a 'C'-shaped formation, which is thought to drive the fish forward. They then all thrust their heads into the water simultaneously in an attempt to capture their prey. When prey is very abundant this synchronized fishing method breaks down and the birds forage individually within a loose group (Johnsgard 1993).

Their prey consists mainly of fish that are under 100mm long and weigh less than 100g, although they are able to feed on fish over 2kg in mass (Brown & Urban 1969; Whitfield & Blaber 1979).

m. Breeding:

Like all the larger pelicans, the Great White Pelican nests colonially, on the ground (del Hoyo et al. 1992). Normally this species favours islands for its nesting sites, but will nest on the mainland if the area is inaccessible to land predators (M.B., pers. obs.). Under abnormal circumstances nesting can take place in areas where they have nested in previous years even though the nest site may be exposed to predation (M.B., pers. obs.). Nesting sites are flat areas that may be covered with short vegetation or that may be bare (Johnsgard 1993).

In the study area, the Great White Pelican has bred only in the Lake St Lucia system. They have bred on Bird Island, Lane Island and more recently have favoured the Selley's Lakes area in the northern region of Lake St Lucia (Ezemvelo KwaZulu-Natal Wildlife unpublished data).

The Great White Pelican is essentially a winter breeder in south eastern Africa (Johnsgard 1993). The breeding season however is highly variable, and the presence of a secure nesting site and an available food supply might be the initiating factors. It is not uncommon for there to be several waves of breeding within a single year, and these may coincide with suitable foraging conditions and available fish stocks (Brown & Urban 1969).

It is believed that Great White Pelicans breed initially at 3 to 4 years of age. Birds start forming closely groups in which the individuals are closely spaced. Groups of males in full breeding condition form in the region of the breeding site, and gradually females are attracted. These groups become very closely packed and perform a wide range of group displays. Individual birds leave the group to pair off, and then congregate at the breeding site. Normally two eggs are laid in a very simple nest, sometimes simply a scrape in the

ground, and both birds incubate the eggs (Brown & Urban 1969). Pelecaniform birds have two peculiar features related to their breeding strategy. Their eggs have a chalky texture, and the parent birds have no brood patch. Incubation involves trapping the eggs between the feet and the belly to supply the necessary warmth (Johnsgard 1993). Incubation lasts for 37 – 41 days. The nestling is altricial, and is naked and red when it hatches. It then turns black before growing a cover of dark brown down. This is the only pelican nestling that has dark brown down, all others being white. The nestling has a very short bill when it hatches. The bill grows steadily until the bird fledges, when it becomes the characteristic pouched bill of this family (Brown & Urban 1969).

1 – 3 days: Naked pink nestling

3 – 14 days: Naked black nestling

14 – 28 days: Black downy stage

28 – 42 days: Downy feathering stage. Grey-brown feathers appear on wings and back.

42 – 56 days: Feathering stage. Feathers grow on rest of body.

56 – 70 days: Free-swimming to flying stage. Become paler overall.

(Brown & Urban 1969)

Nestlings start grouping into pods at about 20 – 25 days, and these pods may contain 100 or more young. The size of the pod varies during the day, often growing to its largest when the temperature is at its highest (Brown & Urban 1969).

Both parents take a part in the feeding of the nestling, and it is at this stage that they can be involved with long distance foraging flights. In KwaZulu-Natal the Great White Pelican nests in the northern area of Lake St Lucia, and if the lake cannot supply sufficient food for the colony, the breeding adults have to fly to an alternative area to forage (Whitfield & Blaber 1979). This might involve a trip to the Pongolo River floodplain, or even to the pans of the Rio Maputo, a round trip of 250 – 300 kilometers (Parker 1999).

n. Conservation:

The Great White Pelican is not known to have a globally unfavourable conservation status, and estimates of their population range between 265100 and 292900 (Wetlands International 2002). The populations in Europe have suffered considerably since the beginning of the twentieth century from the effects of industrialization and human pressures. Although their numbers have decreased sharply, the remaining colonies are now fairly stable (Crivelli & Schreiber 1984).

The African populations appear to have escaped most of these negative impacts in spite of the free use of DDT and endrin in much of this area. Some colonies may have been displaced to other areas, but there is no immediate threat to this species in Africa (Crivelli & Schreiber 1984).

In south eastern Africa Lake St Lucia is the key to the survival of this species. It provides both the nesting sites and most of the foraging for this population. The St Lucia system is under some pressure as result of the vagaries of the climate and the negative impacts of man (Nanni 1982). If this system fails, then it is unlikely that this species will breed in this region, and numbers will decline markedly.

The Great White Pelican is classified as a near-threatened species (Crawford & Taylor 2000).

Pink-Backed Pelican

a. Names:

Pelecanus rufescens Gmelin, 1789, Syst. Nat., 1(2):571; w Africa.

Rufescens (L) = rufous or pinkish, in reference to plumage colour (del Hoyo et al. 1992).

Other vernacular names: Zulu: iVubu, iFuba, iKhungula (Maclean 1985)

b. Subspecies:

None

c. Measurements:

Summarised in Table 4

d. Description:

Adult: Summarised in Table 5

Nestling: The nestling of the Pink-backed Pelican hatches naked with a pink skin. It becomes covered with a white down which turns progressively greyer (Johnsgard 1993).

e. Identification:

In the hand:

The black area in front of the eye is diagnostic. Its measurements also separate this species from the Great White Pelican, which is the only other pelican within its geographical range (Johnsgard 1993).

In the field:

The Pink-backed Pelican is generally greyer overall than the Great White Pelican. There is less contrast between the less black flight feathers and the rest of the body than in the Great White Pelican. The black smudge in front of the eye is also diagnostic in the field, as is the dark grey crest in the early breeding season. The pink tinge on the feathers on the back in breeding season is not a clear feature. Care is needed to separate this species from the juveniles or immatures of the Great White Pelican (Maclean 1985; Johnsgard 1993; Ryan 2005).

f. Voice:

They are generally silent away from colonies. At breeding grounds they produce various guttural sounds (Maclean 1985; Johnsgard 1993). Young utter quacking cries and groaning

calls resembling the lowing of cattle. Adults and young engage in bill clapping (Burke & Brown 1970).

g. Habitat:

Like the Great White Pelican, the Pink-backed Pelican is found on virtually any water-body that is shallow and still or slow flowing, and which produces an adequate food supply. It can utilize smaller pans and ponds as it is generally a solitary feeder. In areas where the sea is shallow and calm, this species can also be found feeding just off shore at low tide (Brooke 1984). They are found in coastal bays, deltas, lagoons, estuaries, lakes, pans and dams (Cyrus & Robson 1980; Maclean 1985). Water can range from fresh to saline to alkaline. Nesting takes place in trees, but these nets sites need not be near water (Burke & Brown 1970).

h. Habits:

Unlike the Great White Pelican, Pink-backed Pelicans tend to feed solitarily. They loaf, roost and breed socially, but in smaller and looser groups than the Great White Pelican (Johnsgard 1993). These birds appear to be less social than Great White Pelicans, but this may simply be that the numbers in south eastern Africa are low, and as a result large groups do not form. Typically they feed from daybreak till about noon, followed by a period of loafing, and then a second feeding period that ends about half an hour before sunset. Loafing usually takes place on exposed, bare sand banks along the edge of the water, but roosting at night is in trees (Din & Eltringham 1974b).

They make use of man-made structures for resting during the day, and even utilize electricity powerlines in the Richards Bay area (M.B., pers. obs.). They fly strongly but rely on thermals to gain altitude (Johnsgard 1993).

i. Distribution:

P. rufescens breeds widely but locally in sub-Saharan Africa. Breeding has been recorded from Senegal and Gambia in the west to the Gulf of Aden in the east, and from there

southwards through the Rift Valley to South Africa. Breeding has also been recorded in western Madagascar, the Red Sea coast of Saudi Arabia and in Yemen (Johnsgard 1993).

Most South African field guides show the distribution of the Pink-backed Pelican to include the Cape coast from Cape Town to Port Elizabeth (Maclean 1985; Newman 1992). Not a single record was submitted for this area for the South African Bird Atlas Project. Conversely the North West Province is shown by field guides as an area void of Pink-backed Pelicans, but the South African Bird Atlas Project show a high reporting rate (Williams & Borello 1997b). This seems to indicate that the distribution of this species has changed considerably over the last 50 years as areas have either become unsuitable or favourable for this species.

However it is most frequently recorded along the eastern littoral belt of northern KwaZulu-Natal. Elsewhere it is rare and is restricted to open waterbodies and estuaries. These areas include eastern Mpumulanga and Limpopo, and the panveld of the North West Province (Taylor 2000).

j. Population and demography:

In Table 6, figures shown in brackets indicate the number of individuals. This is done by multiplying the number of breeding pairs by 3 (Wetlands International 2002).

k. Movements:

No distinct migration patterns have been recorded for Pink-backed Pelicans. In western Africa there is an exodus of birds in the wet season with a return in the dry season (Brown et al. 1982). No juvenile dispersal has been recorded, but this is certainly the case. Birds in the KwaZulu-Natal population generally move northwards towards and into Mozambique (Brooke 1984).

l. Foraging and food:

Pink-backed Pelicans feed solitarily, although at times they may form small loose clusters (Din & Eltringham 1974b). They have also been seen to feed on the fringes of groups of

Great White Pelican (M.B., pers. obs.). In these cases, however, they do not feed in the synchronous way of the Great White Pelican.

In the Ruwenzori National Park the food consists mainly of cichlid fish and fish fry, with males targeting larger fish, and females feeding predominantly on fish fry. The usual prey ranged from 80–290 grams, and the adult consumed about 776 grams of food each day, equivalent to 14.4 % of body weight (Din & Eltringham 1974b; Johnsgard 1993).

m. Breeding:

The Pink-backed Pelican is one of only two species of tree-nesting pelicans in the world. They nest colonially, generally in the rainy season (del Hoyo et al. 1992).

Breeding dates: The breeding season is variable, and may be related to the rainfall patterns in the various regions (Johnsgard 1993).

Nesting sites: The Pink-backed Pelican is a tree-nesting species. Occasionally nests are placed in low bushes, reed beds and rarely even on the ground (Johnsgard 1993).

There are between 35 and 40 regular or traditional nesting sites recorded throughout its range, most of these falling in Senegal, Guinea, Nigeria, Ethiopia, Uganda, Kenya and Tanzania. Only two are found south of the Zambezi, one in northern Botswana and the other in the Mkhuze Game Reserve in KwaZulu-Natal (Johnsgard 1993). Most of the studies done on this species have been centered on colonies in Kenya and Uganda (Burke & Brown 1970; Din & Eltringham 1974a).

The Pink-backed Pelicans that nest on the edge of the Nsumo Pan in the Mkhuze Game Reserve form the only regular colony in south eastern Africa. These birds start their breeding in mid-summer. Although the major effort occurs at this time, breeding in the colony is asynchronous, and may continue into autumn (M.B., pers. obs.). Breeding has occurred at other sites in the past, but the present site which has been in use since 1984 is now well established. A few birds have taken up residence in the Botanical Gardens in Durban, and have bred there for the first time in the 2003-2004 season (M.B., pers. obs.).

The choice of this particular breeding site at Nsumo Pan is intriguing. The pan regularly dries up in the winter months, and in December 2003 when breeding began, the pan had been completely dry for four months. Even when the pan is full, the breeding birds use it as a bathing and drinking site, rather than for foraging. Birds can be seen flying off in the morning, once the thermals have started, to forage elsewhere. This area is conveniently situated between what are believed to be their primary feeding grounds, Lake St Lucia and the Pongolo River floodplain (Whitfield & Blaber 1979; Heeg & Breen 1982; Taylor 2000), and is also part of the Mkhuze floodplain (Johnson et al. 1998). The south bank of the Nsumo Pan is lined with mature fever trees (*Acacia xanthophloea*) which provide suitable nest sites, and the area is protected from human disturbance. All these factors may contribute to this being the site of choice.

Choice of tree type and location varies depending on local conditions. In Uganda *Euphorbia dawei* trees were used, and the nest site was about 7km from Lake George. There are several other sites in Uganda where colonies are set up away from water (Din & Eltringham 1974a). In Kenya the birds chose fig trees, 19km from Lake Victoria and 24km from their other feeding site (Burke & Brown 1970). In South Africa both sites that have been used have been near water-bodies, where *Acacia robusta* on the Hluhluwe River and *A. xanthophloea* at the Nsumo Pan have been the tree of choice. Birds have remained faithful to some sites for many years, as at Rakewa in Kenya, where the same breeding area has been used for at least 200 years (Burke & Brown 1970). At some sites the breeding is intermittent (Din & Eltringham 1974a).

Trees in colonies can be negatively affected by birds defecating on the foliage, and this can lead to the death of the trees. Birds do not nest in dead trees (Burke & Brown 1970).

Trees are sometimes shared with other birds. Breeding storks, egrets, darters, cormorants, and weavers are commonly found in association with Pink-backed Pelican colonies (Din & Eltringham 1974a; M.B., pers. obs.). Nests are built on the tops of these trees, with the more

dominant birds taking up the highest nests. Pelicans favour the crown of the tree for nest building, and seldom use the lower branches (Din & Eltringham 1974a).

Nest structure and nest building:

The nest is a relatively small structure, made up dried branches and twigs, with a small central depression in which the eggs are laid. Old nests that have survived the non-breeding season are rebuilt or repaired (Burke & Brown 1970). The nesting material is collected by the male, and may include both living and dead branches (up to 2m long) and twigs collected from trees and bushes, from the ground and from disused nests. The female accepts the material from the male at the nest site, and is responsible for the construction of the nest. Trees used by Pink-backed Pelicans, and the materials collected for the building are often thorny, and the resulting interlocking of thorns may help to produce a structure strong enough to survive the weather and the constant trampling during development of the nestling. *Caparis tomentosa* is used in this way in the Ruwenzori National Park (Din & Eltringham 1974a). Nests are constructed in a fork or on lateral branches, and are sometimes built close enough to overlap with each other. This results in the formation of a platform of two or three nests together, and when adults are incubating, their bodies sometimes touch. Adults do not normally defecate in the nests, but the young do, and this produces a hard central part to the nest. Nest sites are chosen to include a "resting branch" near to the nest. These branches are used during preening, changeovers, nest building and feeding the nestling when it is larger (Din & Eltringham 1974a).

Din and Eltringham (1974a) estimated the number of nests per tree to range from 1 to 7, with an average of 2.97. In these *Euphorbia dawei* trees, 98% of the nests were in trees that exceeded 10m in height. These figures could be different in other types of trees that have a different shape. The colony is not as closely packed as in the Great White Pelican, but this is probably simply a result of there being limited nest sites available in a tree (Burke & Brown 1970; Din & Eltringham 1974a).

Eggs and incubation period:

Eggs are chalky and white when laid, and become dirty during incubation. The coarse shell may be streaked with blood initially (Burke & Brown 1970).

Eggs are laid 2 to 3 days after the completion of nest building, and egg deposition can take 2 to 5 days (Burke & Brown 1970). The average interval between laying was 2.2 days (Din & Eltringham 1974a).

Clutch size for 155 nests, containing 307 eggs, varied between 1 to 3 eggs (av. 1.98).

1 egg: 9.8%

2 eggs: 82.5%

3 eggs: 7.7 % (Din & Eltringham 1977)

Table 8 summarises the egg size and egg mass of the Pink-backed Pelican.

Incubation is carried out by both sexes. Nest relief takes place quickly but infrequently, and is accompanied by head bobbing. Each parent spends about 24 hours at a time on the nest, with changeover taking place between 12:00 and 15:00. When not incubating, the parent bird is away from the nest feeding (Din & Eltringham 1974a).

Incubation starts immediately the first egg is laid, and is estimated to be 30 days for all the birds studied by Din and Eltringham (1974), but 33-34 days by Burke and Brown (1970). Pipping took between 20 and 24 hours.

Development of the nestling:

Hatching is asynchronous within each nest, with nestlings hatching in the same sequence as they were laid. The average brood-size at hatching for 174 broods was 1.9 in each of three breeding seasons, with 64.9% of the nest producing two nestlings each (Din & Eltringham 1974a).

The nestling is helpless and blind when it hatches and takes about 70 to 75 days to leave the nest on their first practice flights. During this time they undergo the following plumage changes

1 – 7 days: Naked pink nestling

8 – 14 days: White down on back

15 – 21 days: White down over whole body except upper neck and head+ Flight feathers and scapulars start

22 – 28 days: Down thickens, primary and secondary coverts start

29 – 35 days: Down thickens, tail feathers start

36 – 42 days: Thick down except on head, other feathers continue developing, short crest becomes noticeable

43 – 56 days: Down reduced. All flight feathers present but still growing, some contour feathers starting

57 – 85 days: Down replaced by contour feathers. All other feathers almost fully developed

(Din & Eltringham 1974a).

During this developmental stage the parents are aggressive towards other birds and intolerant of stray nestlings.

During the first 10 to 12 days after hatching, the nestling cannot stand, and can only shuffle around the nest. One of the parent birds will always be with the nestling during this stage, and the nestling remains hidden under this parent (Burke & Brown 1970). Growth is rapid as they feed on semi-digested food regurgitated onto the nest by the adult (Din & Eltringham 1974a).

After this early stage, the nestlings are left unattended while the parent birds forage. The nestlings are more mobile, and start to move around the nest. They take food directly from their parent's gullet. During these stages, the nestlings may clamber from one nest to another, and will sometimes form small groups. There can be considerable mortality during this time as a result of reduced parental attention. These deaths can result from exposure to

the sun and rain, or from falling from the nests. Nestlings that fall to lower branches within the tree are still fed, but those that fall into bushes or on to the ground are abandoned and die (Burke & Brown 1970; Din & Eltringham 1974a).

At this stage when the nestlings are left unattended and exposed to the sun, they begin temperature regulatory behaviour, which involves panting or rapid flapping of the gular pouch (Din & Eltringham 1974a).

Feeding rate starts at about 30 feeds per day at the start of this nestling stage, but declines to between 10 and 25 in the third week, and between 5 and 10 during the fourth to sixth weeks. After this they are fed no more than once a day, and on some days may not be fed at all. When the nestlings are large, they are often fed from the resting perch near to the nest (Din & Eltringham 1974a).

The time taken to feed the nestlings ranges from the usual 4-5 minutes to as long as 20 minutes. Feeds are usually given in two stages, with a break of about 30 minutes between them (Burke & Brown 1970).

Competition for food between siblings results in high mortality, as the larger nestling always feeds first. The smaller nestling is also subjected to attacks by the large nestling, and moves to the edge of the nest for protection. These nestlings may be pushed out of the nest and then get hanged in the branches of the tree. This is more common as the larger nestlings of about 8-9 weeks old (Din & Eltringham 1974a).

Nestlings display a begging behaviour by throwing the head back and forth, flapping their wings and uttering cries. If this produces no response, the nestling will point its bill towards the adult's bill and peck at it or the adult's feet. Head bowing, head wagging and self-pecking displays are also seen (Din & Eltringham 1974a). Nestlings may exhibit violent convulsions before and after feeds, involving fighting with other young, branch biting and biting of their own wings (Burke & Brown 1970).

Nestlings spend 70-80% of the time resting or sleeping during the first two weeks. This proportion decreases with time, and the nestlings begin to preen. At four weeks they are able to stand and preen (Din & Eltringham 1974a).

The first flights are short and clumsy, and the nestling remains in the area of the colony. Initially the nestling returns to the natal tree to be fed (Din & Eltringham 1974a), but later may be fed in trees several hundred meters away from the colony. This can continue for a few weeks, but once the young has left the colony, parental feeding stops (Burke & Brown 1970).

Behaviour of adults during nesting period:

Male birds in full breeding plumage start congregating in large numbers in the trees at the breeding site and perform a variety of displays. This attracts other birds to the colony, and pair formation starts amid great activity, with birds flying from tree to tree, and groups of birds jabbing and pecking at each other. Once they have paired off, nest building starts. The male collects the building material while the female does the building (Burke & Brown 1970).

Copulation takes place at the nest site, and starts as soon as the birds have paired off. Observed copulations occurred with a frequency of 1.5 copulations per hour (range 1-6), and most of these took place between 08:00 and 09:30 and between 12:00 and 15:00. Copulations last about 5 – 10 seconds. He copulates with her each time she has finished arranging the nesting material he has brought her. This may be repeated 30 to 50 times a day during the early stages of building, and this process can go on for seven or eight days with the number of copulations decreasing during this period. During the nest building phase, males have been seen to copulate with females in nearby nests when the other male was absent (Din & Eltringham 1974a).

During the breeding season the adults perform a variety of behavioural displays. These are described later.

All duties are shared by the parent birds after the eggs have been laid. They continue to brood the nestling for about 10-12 days after hatching, after which both parents can be away from the colony site simultaneously (Johnsgard 1993). Both parents take a part in the feeding of the nestling. From the Nsumo Pan this normally involves long distance foraging flights to Lake St Lucia, or the Pongolo River floodplain if the Mkhuze floodplain cannot sustain the breeding population (Whitfield & Blaber 1979; Heeg & Breen 1982; Taylor 2000).

Adults that do not belong to a nesting group are chased away from the nest area. However when there are no breeding adults at the site, intruders may try to copulate with the passive nestlings. Intruders and juveniles may rearrange sticks on the nest or attempt to build simple nests nearby. These branches invariably fall from the tree, and so the original nest slowly disintegrates. Up to 95% of the nests can be completely destroyed this way by the end of the season, and the nestlings are left perched on the bare branches (Din & Eltringham 1974a).

Displays:

The Pink-backed Pelican has a variety of behavioural displays (Table 9). These are always performed on a tree branch or in the nest, and therefore always in a stationary position (Burke & Brown 1970; Din & Eltringham 1974a).

n. Conservation:

It is difficult to make population estimates for this species, and consequently their conservation status is uncertain. However Crivelli and Schreiber (1984) believe that this species is not threatened because of the presence of many colonies over a wide region. The species is not known to have an unfavourable conservation status (Wetlands International 2002).

In South Africa the Pink-backed Pelican is classified as vulnerable, as it breeds regularly at one locality only where fewer than 300 birds occur (Taylor 2000). It has lost a considerable amount of suitable habitat, and this trend is expected to continue.

The breeding area falls within the boundaries of the Mkhuze Game Reserve (Johnson et al. 1998), and so is afforded a degree of protection from the interference of man. However the foraging areas on which it relies are not all in protected zones, and these areas are subject to increasing human pressures. Probably the most significant of these is the Pongolo River floodplain (Taylor 2000).

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Tables

Table 1. Body measurements of the Great White Pelican.

	Unsexed	Males	Females
	min – (ave) – max	min – (ave) – max	min – (ave) – max
Length (cm)	140 – (-) – 178	165 – (177) – 216	101 – (136) – 150
Wingspan (cm)		272 – (286) – 305	226 – (264) – 266
Wing (mm)		650 – (702) – 735	605 – (-) – 618
Tail (mm)		150 – (181) – 210	135 – (-) –190
Tarsus (mm)		130 – (142) – 150	115 – (-) –135
Culmen (mm)	413 – (-) – 450	370 – (418) – 455	275 – (314) – 345
Mass (kg)		9 – (11,5) – 15	5.4 – (7.6) – 9

(Din & Eltringham 1977; Maclean 1985)

Table 2: External features of the Great White Pelican.

GREAT WHITE PELICAN	PRE-BREEDING	POST BREEDING	IMMATURE/SUB-ADULT (for 3-4 years from hatching)	JUVENILE
Head	White cosmetically tinged pink. Occipital crest (may be longer in female). Swollen bare knob on forehead: flesh coloured in male, orange in female.	White, no pink tinge. No crest. No knob.	Greyish-brown to white.	Dull buff-brown to pale grey. Short crest of loose, soft feathers.
Neck	White dorsally Brown ventrally	White	Greyish-brown to white.	Dull buff-brown to pale grey. Soft loose darker (sometimes rusty) feathers down hind-neck.
Mantle	White, cosmetically tinged pink.	White	Greyish-brown to white.	Dull buff-brown to pale grey.
Back	White cosmetically tinged pink.	White	Greyish-brown to white.	Dull buff-brown to pale grey.
Rump	White cosmetically tinged pink.	White	Greyish-brown to white.	Dull buff-brown to pale grey.
Breast	Stiff lanceolate feathers vary from yellow to brown. (May be staining from substrate)	White - no yellow or brown.	Greyish-brown to white.	Dull buff-brown to pale grey.
Abdomen	Variable, white to brown	White	Greyish-brown to white.	Whitish unless stained rusty-brown.
Primaries	Black with white shafts.	Black with white shafts.	Black	Brown
Primary coverts	Black with white shafts.	Black with white shafts.	Grey to white	Black
Secondaries	(30-35) Distally black. Proximally ashy on outer webs	Distally black. Proximally ashy on outer webs	Dark grey to ashy brown.	Brown.
Dorsal wing coverts	White.	White.	Grey to white	Brown.

Ventral wing coverts	White.	White.	Grey to white	Brown.
Axillaries	White.	White.	Grey to white	Grey
Retrices	(22-24) White.	White.	Grey to white	Grey
Bill	Laterally: dull greyish-blue. Distally: orange-yellow with light red streaks from reddish edges. Dorsal midrib: Greyish-blue and tapering, terminating in bright red nail.	Uniformly pink with light red nail.	Becomes more yellow.	Greyish-black
Pouch	Proximally bright orange-yellow	Medium yellow	Blackish with yellow patches	Black
Eye	Iris red to crimson	Red-brown	Iris grey-brown	Iris grey-brown
Naked skin on face	Males: forehead and around eyes pinkish-yellow Females: Forehead pinkish, around eyes bright orange.	Pale pink		Dull grey
Legs and feet	Orange or pinkish. Tinted crimson during courtship.	No reddish tints	Flesh coloured	Black

(Feely 1962; Brown & Urban 1969; M.B., pers. obs.; Maclean 1985; Johnsgard 1993)

Table 3. Population status of the Great White Pelican.

Population	Breeding range	Wetlands International 2002	Johnsgard (1993)	del Hoyo (1992)	Crivelli (1984)
South Asia (non-breeding)	W. Central Asia	15 000 to 30 000	Total for Asia 6 845 to 10 000		Total for Asia 15 000 to 20 000
Europe, W. Asia (breeding)	E. Europe, W Asia	20 100 to 32 900 Decreasing	br. pairs (20 535 to 30 000)		br. pairs (45 000 to 60 000)
W. Africa	W. Africa	60 000 Stable	50 000 to 75 000 br. pairs	69 000 br. pairs (207 000)	75 000 br. pairs (225 000)
Eastern Africa	Eastern Africa (Ethiopia-Zambia)	150 000 Stable	(150 000 to 225 000)		
South Africa	Southern Africa (S. of the Zambezi R.)	20 000 Increasing		6 000 br. pairs (18 000)	

Table 4. Body measurements of the Pink-backed Pelican.

	Unsexed	Males	Females
	min – (ave) – max	min – (ave) – max	min – (ave) – max
Length (cm)	135 – (-) – 152	136 – (147) – 153	126 – (134) – 140
Wingspan (cm)		226 – (234) – 242	216 – (224) – 236
Wing (mm)		595 – (605) – 615	545 – (560) – 580
Tail (mm)		160 – (172) – 185	140 – (166) – 180
Tarsus (mm)		90 – (96) – 100	75 – (87) – 100
Culmen (mm)	300 – (-) – 360	335 – (357) – 375	230 – (305) – 335
Mass (kg)		4.5 – (6) – 7	3.9 – (4.9) – 6.2

(Din & Eltringham 1977; Maclean 1985)

Table 5: External features of the Pink-backed Pelican.

Pink-backed Pelican	Pre-breeding	Post breeding	Immature/sub-adult (for 2-3 years from hatching)	Juvenile
Head	Crown pale grey. Face whiter. Pointed, long, grey crest	Crest shorter or absent	Whitish-grey	Grey, tufted crown
Neck	Pale grey hind-neck. Throat downy and whiter	Greyish	Grey	Grey
Mantle	Pale grey, with pinkish tinge. Feathers with white shafts.	Pale grey.	Grey	Grey
Back	Pale grey, tinted pink cosmetically.	Lacks pink. Greyish-brown.	Grey	Pale whitish-grey. Whiter then in adult.
Rump	Pale grey, tinted pink cosmetically.	Lacks pink. Greyish-brown.	Becomes greyer.	Pale whitish-grey. Whiter then in adult.
Breast	Patch of stiff, lanceolate, yellowish feathers.	More greyish.	Greyish-brown.	Browner than adult.
Abdomen	Whiter, washed pink.	Lacks pink.	Pale grey	Pale whitish-grey. Whiter then in adult.

Primaries	Blackish-grey above, pale grey below. White shafts.	--	--	Blackish-brown
Primary coverts	Blackish-grey above, pale grey below. White shafts.	--	Blackish-brown.	Brown, edged whitish.
Secondaries	Greyish-brown, edged silvery-grey.	--	Greyer	Dark brownish-grey, with paler edges.
Secondary coverts	Pale grey.	--	Greyer.	Brown edged whitish.
Dorsal wing coverts	Pale grey with darker brown-black shafts.	--	--	Not elongated
Ventral wing coverts	White with pinkish tint.	Lacks pink	Whitish	Greyish
Axillaries	White with pinkish tint.	Lacks pink	Whitish	Greyish
Retrices	(20) Greyish-white with blackish shafts	--	--	Pale brown to greyish-brown.
Bill	Yellow with yellow-red nail.	Fades to grey. Orange-pink nail.	--	Dull grey to greyish-pink.
Pouch	Deep yellow, internally deep red. Striped externally, with closely spaced vertical black/brown lines.	Fades to pale yellow to flesh-coloured, with yellow-brown vertical lines.	--	Yellow-green to greyish-pink.
Eye	Iris red or brown. Eyelids: male deep yellow, female dark orange.	Iris variable (yellow, red, brown, black)	--	Iris yellow-brown.

Naked skin on face	Greyish to flesh. Pink patch above eye, yellow patch below eye. Black patch in front of eye.	Colours fade to grey or blackish.	--	Dull grey to greyish-pink.
Legs and feet	Red	Fade to greyish-yellow.	--	--

(Burke & Brown 1970; Din & Eltringham 1974a; Maclean 1985; Johnsgard 1993; M.B., pers. obs.).

Table 6. Population status of the Pink-backed Pelican.

Population	Breeding range	Wetlands International 2002	(Johnsgard 1993)	(Newton & Symens 1996)	(Williams & Randall 1995)	(Crivelli & Schreiber 1984)
Saudi Arabia and Yemen	Saudi Arabia	--	40 br. pairs (120)	1 500 to 2 000	--	--
Africa	Tropical Africa & Red Sea	50 000 to 100 000 Stable	--	--	4 000 to 6 000 br pairs (12 000 to 18 000)	No estimate possible
Southern Africa	Central & eastern	--	--	--	Below 250 br. pairs (Below 750)	--

Table 7. Breeding dates for the Pink-backed Pelican in Africa

Region	Main breeding season	In relation to rainy season
South Africa	December – April	During rainy season
Nigeria	Starts September - November	End of rainy season
West Africa	Starts September - November	End of rainy season
Western Kenya	Starts August - November	End of rainy season
Uganda	Starts August - November	End of rainy season
Eastern Kenya	Starts May – June	End of rainy season
Tanzania	Starts May – June	End of rainy season
Ruwenzori (Uganda)	Mid-July – early December	Second rainy season
Rakewa (Kenya)	August – January	End of heaviest rainy season

(Burke & Brown 1970; Din & Eltringham 1974a; Brown et al. 1982; Johnsgard 1993).

Table 8. Pink-backed Pelican egg size and mass.

	(Din & Eltringham 1974a)		(Winterbottom 1971)
Egg Dimensions	Range for 159 eggs	Mean ± s.d.	Range
Length (mm)	72 – 93	82.1 ± 3.8	72.0 – 82.0
Breadth (mm)	50 – 54	54.6 ± 1.8	54.0 – 56.0
Mass (g)	90 – 144	119.8 ± 11.9	--

Table 9. Pink-backed Pelican displays during nesting (Din & Eltringham 1974a).

Courtship displays and pair formation		
Bill clapping	Male throws his head backwards and claps his bill together 2-3 times while flapping his wings. Female performs the same display less vigorously.	Attracts female to future nest site.
Head wagging	Male slowly moves his head from side to side while holding the head low on the shoulders.	Function unclear.
Bill open	Male sits with bill open, pouch extended and hanging below the mandible. He flaps his wings and displays the red interior of the pouch to other birds flying past.	Function unclear. May be to attract female or deter male.
Bow	Male arches his neck bowing the head, and extends the pouch.	A rare display.
Recognition displays		
Head bobbing	Adult greets partner on arrival at nest tree.	May confirm that the bird belongs to that nesting area.
Bill raising	All nesting birds synchronously raise their heads and bring their beaks together.	Threat to birds flying past or to one of the group.
Nest demarcation	Sitting bird marks the nest boundary by touching it with its bill while opening wings slightly.	During nest building to mark nest site.
Threatening displays		
Bill pointing	Bird stretches out its neck and extends its pouch while pointing with its bill.	Low intensity threat.