

## CHAPTER 9

### DISTRIBUTION, ABUNDANCE, AND CONSERVATION STATUS OF THE SOUTH AUSTRALIAN GLOSSY BLACK-COCKATOO

#### ABSTRACT

The isolated South Australian subspecies of the glossy black-cockatoo *Calyptorhynchus lathami halmaturinus* is reduced to a small endangered population on Kangaroo Island. This paper synthesizes several surveys and many unpublished records to examine the subspecies' numbers, distribution, and movements. Their distribution has shifted repeatedly in response to fire and land use practices, and is now concentrated on the western end of the Island's north coast. The mean flock size was 7.3 birds, and the median was 4.0. There is a spring (post-breeding) congregation, and some birds appear to leave the eastern end of the Island at this time. Sightings were concentrated in the morning and evening hours, when the cockatoos tend to be most active and conspicuous. Breeding was restricted to a subset of the foraging range, with no nesting records from the eastern end of the Island. Nests were concentrated in a few areas that are largely outside the park system. The population probably includes fewer than 150 total birds and 50 adult females, and has apparently declined by one quarter to one third over the past 15 years. The original cause of the subspecies' decline was habitat destruction, but it is now vulnerable to a range of threats due to its small population size.

## INTRODUCTION

The glossy black-cockatoo is an endemic Australian cockatoo with a highly specialized diet consisting almost exclusively of the seeds of casuarina trees, genus *Allocasuarina*, and a low breeding rate, laying only a single egg per year (Forshaw 1981). The species is rare throughout most its range, and has been listed as endangered in South Australia since 1972. Schodde *et al.* (1993) investigated morphological variation among populations and concluded that the species could be divided into three subspecies: the core population in south-eastern Australia (*C.l. lathami*), an outlying population in central eastern Queensland (*C.l. erebus*), and the South Australian population (*C.l. halmaturinus*), which is distinguished by a disproportionately large bill. Mathews (1912) had originally applied the subspecific name *halmaturinus* exclusively to the Kangaroo Island population, based on the claim that Island females had more yellow on the head than those from the mainland. In fact this variation is between individuals rather than populations, as he realized several years later (Mathews 1916-17, Vol. 6, p. 130). Based on their morphometric analysis Schodde *et al.* (1993) reinstated the name *C. l. halmaturinus*, and applied it to the isolated population that is now restricted to Kangaroo Island but formerly occurred on the mainland as well.

*C. l. halmaturinus* may have disappeared from south-east South Australia and western Victoria as a result of climatic changes during the most recent glacial epoch 12-25,000 years ago (Schodde *et al.* 1993). Since European settlement the subspecies has declined further within South Australia, disappearing from the Fleurieu Peninsula and the southern Mount Lofty Ranges, and is now restricted to Kangaroo Island. Four surveys of the Island since 1980 have each counted fewer than 150 birds (Joseph 1982, Joseph pers. comm., Chapter 2), and some authors have speculated that *C. l. halmaturinus* is

continuing to decline (Garnett 1992a; Low 1993, p. 217). Other factors adding to the concern include indications of a strongly male-biased sex ratio and a low reproductive rate (Joseph 1982; Chapter 2), and the lack of any captive population of the subspecies (Garnett 1992b). Here I review the available information on *C. l. halmaturinus*, including both published and unpublished sources. In particular, I analyze a large number of unpublished records collected by various people over the past 36 years. My goal is to assemble a picture of the subspecies' population size, distribution, movement patterns, and rate of decline, which can be used to guide management decisions and conservation efforts.

## METHODS

I conducted a literature search for published records of glossy black-cockatoos within the range ascribed to *C. l. halmaturinus*. I also used records collected in unpublished surveys of Kangaroo Island in 1987 and 1988 (Joseph, pers. comm.), and by A. Lashmar, a long time resident of the Island. During his 1988 survey L. Joseph distributed reporting forms to Island residents, which National Parks and Wildlife Service staff have since collected. I recorded my own observations of glossy black-cockatoos on Kangaroo Island as part of a study in 1990 - 1993, and beginning in 1991 actively recruited local residents to record their sightings. Records for Kangaroo Island from all sources through 1993 were entered into a computer database for analysis. To avoid biasing results through multiple sightings, I included only the largest group seen at one location on one day. At the end of 1993 the database contained 975 records, including 108 from population surveys, 18 from other published sources (Table 9.2), 304 from journals kept by six volunteer observers, and 142 from my own observations. The remaining 403 records are primarily opportunistic sightings by various observers. For

analyses of flock size I excluded records that included only a nesting pair at the nest, or in which birds were heard but not seen. I used the SYSTAT package (Wilkinson 1992) for statistical analyses.

## RESULTS AND DISCUSSION

### Historical records

There are several records attributable to *C. l. halmaturinus* from the southern Mount Lofty Ranges and Fleurieu Peninsula from the 1800's, and a number of further sightings span the period 1932 to 1977 (Table 9.1). The drooping sheoak *Allocasuarina verticillata* woodland that is the cockatoos' typical habitat was formerly present on the Eyre Peninsula and in south-eastern South Australia (Wood 1937, p. 57), and there has been some speculation that the subspecies' range included these areas before settlement (Forshaw 1981; Garnett 1992b), but there are no records. No estimates of historical population sizes are available, but the cockatoos were reportedly "quite numerous in the seventies of the last century in the southern portion of the Mt. Lofty Ranges", and "very plentiful in the ranges south of Adelaide in the early days of the colony" (Mathews 1916-17, vol. 6, p. 131). On the basis of a seasonal pattern of mainland sightings, Parker suggested that glossy black-cockatoos flew between the mainland and Kangaroo Island (Forshaw 1981), and there is one direct observation of a crossing (Joseph 1989). It is therefore unclear how long resident birds remained on the mainland, as opposed to appearing only as seasonal or vagrant visitors. In any case, all sightings on the mainland ended by the late 1970's.

Table 9.1. Published records of *C. l. halmaturinus* on mainland South Australia

<b>Year</b>	<b>Location</b>	<b>Observer</b>	<b>Reference</b>
1840's	Adelaide hills	E. Ashby (second hand)	Mathews 1916-17
1850-51	Fleurieu peninsula	M.S. Clark, (second hand)	Clark 1888-89, in Baird 1986
1885	Black Swamps	S.A. White	Mathews 1916-17
1932	Second Valley	G. Lord	Joseph 1989
1934	Between Thylungra and Parawa	G. Lord	Joseph 1989
1934	Southwest coast of Fleurieu Peninsula	G. Lord	Joseph 1989
1940's	Stirling	P. Chapman	Joseph 1989
1965	Granite Island	D. C. Paton	Joseph 1989
1966	Second Valley Forest Reserve	G. Lord	Joseph 1989
1969	Parawa	A. Cockingham	Joseph 1989
1969-77	Near Mt Bold Reservoir and Onkaparinga River	H. Mulder	Joseph 1989
1977	Section 70, Hundred of Myponga	A. Cockingham	Joseph 1989

Glossy black-cockatoos were also widely distributed on Kangaroo Island before European settlement (Table 9.2). While anchored at the eastern end of the Island (probably in Hog Bay) in January 1803, Nicholas Baudin collected “black cockatoos with splashes of red in their tail-feathers”, which were almost certainly glossy black-cockatoos (Cornell 1974). E. Ashby collected the first South Australian museum specimen on the Island’s north coast in 1905 (Ashby 1926). S.A. White commented in 1912 that, “From all appearances these birds are becoming rare, and they seem to keep to the western end of the island” (White 1913). Occasional records continued to accumulate prior to World War II, but were much more frequent beginning in the 1950’s, presumably as a result of increased interest in ornithology (Table 9.2).

### **Recent changes in distribution**

There are indications of several shifts in the cockatoos’ distribution on Kangaroo Island in recent decades. Some involved their permanent disappearance from areas where drooping sheoak woodland was cleared. In other cases the cockatoos appear to have come and gone as fire and land use practices affected food availability. The effect of fires is best documented on the Island’s west coast, where the population has fluctuated repeatedly. Although some early accounts mention glossy black-cockatoos on the Island’s north coast, most refer to the west coast as their population center (White 1913; Terrill & Rix 1950; Condon 1967; Glover 1968). After major bush fires swept the west coast in 1958 however, Wheeler (1960) described the area near the Breakneck River as “devastated ... and almost void of bird life”. There are just two records of 3-4 cockatoos on the west coast in the 1960’s (Glover 1971; Lendon 1979). In 1970 there was another large fire, and the cockatoos were not seen again until small numbers began appearing in 1978. From 1983 to 1991 observers noted flocks of up to 20 birds fairly regularly. Again in 1991 a fire burned most of the foraging habitat on the west coast. No further sightings

Table 9.2. Published records of *C. l. halmaturinus* on Kangaroo Island.

Year	Date	Number	Location	Notes	Reference
1803	14 Jan		American River	Baudin's expedition	Cornell 1974
1905			Western River Cove		Campbell 1906
1887		2	Western River	Collected male, female, and egg	Ashby 1926
1912	Apr	2	South West River		White 1913
1940		"a number"	Between American River and Rocky River Homestead	Between 24 Jan and 7 Feb	Cleland 1942
1954	10 Jan	3	"Nine miles north of Stokes Bay"		Gibbs 1955
1954	Apr	"at least 2"	Western River		Lendon 1979
1955	Spring	6	Breakneck River		Jeffery 1957
1955	Spring	"several"	Rocky River		Jeffery 1957
1959	30 Sept	40	American River	Eight birds seen regularly	Wheeler 1960
1963	12 Aug	"small flock"	Muston		Cooper 1963
1965	Nov	3	Sandy Creek		Lendon 1979
1966	14 Aug	7	American River		Glover 1968
1967	25 Oct	5	American River		Cleland & Sims 1968
1969	28 Dec	4	Flinders Chase National Park	All males	Glover 1971
1980	Oct	Combined total of 115	Kangaroo Island	Survey of the Island	Joseph 1982
1988	19 Nov	60	Waterfall Creek	Forty birds seen the next day	Bebbington 1990
1993	May-June	Combined total of 136	Kangaroo Island	Survey of the Island	Chapter 2

have been reported since shortly thereafter, although there is evidence that a few cockatoos had fed there briefly just after the fire (Chapter 2).

The population has also fluctuated on the Island's eastern end, for less obvious reasons. We know from Baudin's account that the cockatoos were present there prior to colonization (Cornell 1974), and there are many records from the last three decades. During the intervening period, however, they seem to have been largely absent from this region. In reporting a sighting at the town of American River, Wheeler (1960) remarked that "until recent years this species was only known further to the west of American River". At Antechamber Bay on the extreme eastern end of the Island, A. Lashmar recorded glossy black-cockatoos on a regular basis starting in 1963 (unpub. data). He had not noted them there earlier, dating back to at least 1935 (Lashmar 1935, 1936, 1937, 1938, 1946). It is possible that the clearance of the Island's eastern end destroyed the cockatoos' food sources there, and that they returned only after drooping sheoak grew back on some of the cleared land.

### **Current distribution**

The records database shows that the population has been concentrated on the north coast west of Cape Cassini in recent years (Fig. 9.1), as noted in published surveys (Joseph 1982, Chapter 2). The south coast is conspicuously lacking in sightings, with only four records. The cockatoos' distribution closely follows that of drooping sheoak, and the almost complete absence of cockatoos from the south coast is probably due to the rarity of these trees there (Chapter 2). No cockatoos have been recorded on the west coast since the 1991 fire. The majority of the population occurs on privately owned land, but glossy black-cockatoos have been recorded in Flinders Chase National Park and in Cape Torrens, Parndana, Western River, Latham, Nepean Bay, and Lashmar Conservation Parks.

To examine the breeding distribution I used nesting records from published sources (Ashby 1926; Joseph 1982 and pers. comm.), and from my own observations (12 nests, unpub. data). I only considered nests that were confirmed either by seeing the female inside a hollow on more than one occasion, or by observing an egg or nestling. I did not include several nests in man-made nest boxes on the western north coast, as these boxes may have artificially altered the breeding distribution and certainly biased the chance of observing nests. Because in many cases it was unclear whether a nest failed or succeeded, I did not try to discriminate between the two outcomes. Of the 18 nesting records, all but three are from the western north coast between Cape Forbin and Cape Cassini. None are from east of Emu Bay, which is striking because over half of the sightings in the database are from this part of the Island. A habitat survey found few hollow-bearing eucalypts near drooping sheoak woodland in this area (Chapter 2), which probably explains the lack of breeding activity there. Nesting was very concentrated, with only four locations accounting for 15 of the 18 nests. This highlights the conservation importance of protecting these breeding “hot spots”, particularly as only three nests were in parks.

### **Population size and structure**

Surveys of glossy black-cockatoos were conducted on Kangaroo Island in 1980, 1987, 1988, and 1993, and counted 115, 15, 52, and 136 birds respectively (Joseph 1982, pers. comm., Chapter 2). The two published surveys (the first and last of these) involved more searching effort and clearly produced more complete counts than the intervening two. Because the weather conditions and time spent searching varied among the four surveys, they do not provide reliable information on the population trend during this period. Taken together however they do suggest that the total population size is probably

below 150 birds. Joseph (1982) counted 24 adult females, and Pepper (Chapter 2) counted 36.

To examine flocking patterns I excluded database records that included only a breeding pair at the nest. In the remaining 923 records, the mean flock size was 7.8 and the median was 5.0 (Fig. 9.2). Although the largest recorded flock contained 60 birds (Bebbington 1990), 95% of the sightings were of fewer than 24 birds. The size distribution shown in Fig. 9.2 probably errs on the low side. Flocks sometimes spread out widely, making them easy to under-count without a thorough search. In particular, the 4.2% of sightings made up of single birds probably overestimates how often the cockatoos are solitary, as I have rarely encountered single birds that were out of hearing distance from other individuals. Average flock sizes varied considerably between localities (Fig. 9.1).

Most records in the database do not include age or sex, but this information was recorded during surveys and by several other observers. There are records of only one single-sex flock, composed of all males (Glover 1971), and no flocks made up entirely of immature birds. Most records with plumage information indicate an excess of males. Adult females are the most easily identified age/sex category, due to their conspicuous yellow head markings. Only the three later surveys distinguished birds that were not females from those not identified by sex. These agreed remarkably well on the proportion of adult females, with figures of 33%, 32%, and 38% (Joseph, pers. comm., Chapter 2). In the most recent survey, the 101 birds identified by both sex and age category had an adult sex ratio of 1.4 males per female (Chapter 2). No comparable data exist on sex ratios in the other subspecies, but there are hints that a biased sex ratio may not be unusual for the species. Mathews (1916-17, vol. 6, p.130) commented on the relatively low frequency of individuals with yellow head markings, and Schodde *et al.* (1993) also noted a paucity of females among *C. l. erebus* at one location. Male-biased

sex ratios have been reported in other cockatoos, apparently as a result of greater female mortality (e.g., Carnaby's cockatoo *Calyptorhynchus funereus latirostris* (Saunders 1982), pink cockatoo *Cacatua leadbeateri* (Rowley & Chapman 1991), and galah *Cacatua roseicapilla* (Rowley 1990)).

The surveys are consistent in reporting an unusually low proportion of immature birds. Joseph (1982) reported five first-year juveniles among 115 birds (4.3%) in 1981, and one possible juvenile out of 52 (1.9%) in 1988 (Joseph, per. comm.). In a survey conducted during the 1993 nesting season Pepper (Chapter 2) noted no dependent juveniles, but counted 10 out of 97 birds (10.3%) with subadult plumage. In captivity subadult plumage is retained for about two years by females and up to seven years by males (Courtney 1986). No comparable data on age structure is available from the other glossy black-cockatoo subspecies.

### **Seasonal and daily movement patterns**

Joseph (1982) reported a winter increase in flock sizes at several locations on the north coast, and I observed the same pattern at Latham Conservation Park on the north coast (unpub. data). This could reflect either migration, or local aggregation and dispersal. When records from all regions were combined however, a pattern of seasonal aggregation became apparent (Fig. 9.3). Average flock size reached a minimum of 3.8 in March and a maximum of 13.1 in August, after most nestlings fledge. Even when flocks are at their smallest they typically contain more than one pair with their single young of the year.

To further investigate the pattern of seasonal movements I examined the records by region. Because most sightings were within 5 km of the coast, I divided the Island into the Dudley Peninsula, four coastal strips of 5 km width, and the remaining interior. The coastal regions included the west coast (Cape Borda to Cape du Couedic), the south coast

(Cape du Couedic to Prospect Hill), the western north coast (Cape Borda to Cape Cassini), and the eastern north coast (Cape Cassini to Prospect Hill). The same seasonal changes in flock size occurred within most regions, indicating local aggregation and dispersal rather than movements between regions (Fig. 9.4). A notable exception occurred in spring when flock sizes dropped on the Dudley Peninsula and barely increased on the eastern north coast, suggesting that some birds leave the eastern end of the Island in spring.

The frequency of sightings peaked in the morning and evening (Fig. 9.5). This reflects the fact that the cockatoos are most active and vocal during these times. These are also the times of day when they tend to move between different locations where they feed, drink, roost, or nest. Actual activity peaks were probably sharper than Fig. 9.5 indicates, because the times were not corrected for seasonal changes in the time of sunrise and sunset, which actually constrain the birds' activities.

These seasonal and daily cycles make timing important in population surveys. Counts are likely to be most complete if conducted during the post-breeding aggregation, and should emphasize searches during the morning and evening hours.

### **Trend in population size**

Long term population trends on Kangaroo Island could not be estimated from the records database, because it contains only 31 records prior to 1979. However, anecdotal reports suggest the population has declined considerably over the past 50 years. For example, before World War II flocks of 30 to 40 glossy black-cockatoos frequented Newland Bay and the town of American River, but now no more than 10 birds are usually seen (N. Swanson pers. comm.). At the mouth of the Middle River, T. Chapman (pers. comm.) noted flocks of 30 to 40 birds regularly some 50 years ago, and L. Bell (pers. comm.) recalls flocks of up to 50. Since most drooping sheoaks have been cleared from

the area however, flocks of fewer than 10 are seen only rarely. A resident of the south coast reported seeing the cockatoos up until sheoaks were cleared from the area in the mid 1970's (Joseph, pers. comm.). Most of this decline appears to be closely associated with extensive clearing of native vegetation since World War II. The previous extent of drooping sheoak woodland is not well documented, but it was clearly reduced considerably in the course of clearing most of the Island for agriculture (Chapter 2).

The database did contain enough records to quantify population trends over the past 15 years. The frequency with which observers recorded sightings is not a useful indicator, because it reflects the level of human interest more accurately than the abundance of cockatoos, but flock sizes probably reflect population density reasonably well. In a linear regression, the log transformed flock sizes from 1979 through 1993 showed a strong trend toward shrinking flock sizes ( $R = .173$ ,  $N = 897$ ,  $p = .000$ ). This result could have been biased by an increasing tendency for observers to record small flocks as interest in the species increased. In particular the database included the journals of volunteer observers who have recorded all sightings at a specific location in recent years. To reduce the potential bias I repeated the analysis without these journal records. The resulting trend was weaker but still statistically significant ( $R = .091$ ,  $N = 606$ ,  $p = .025$ ). A regression on untransformed flock sizes (excluding journal records) indicated the mean has declined by 36%, from 12.9 to 8.3, during this 15 year period (Fig 6). In principle, flock sizes could fall independently of population size, for example in response to the food supply becoming more evenly distributed. However, the distribution of drooping sheoak is unlikely to have changed substantially over the past 15 years, and the most plausible explanation for the falling flock sizes is a shrinking population of cockatoos.

I also compared the two most complete population surveys on a locality by locality basis, including only those locations covered by both surveys. The 1980 survey

counted 115 birds (Joseph 1982), while the 1993 survey found only 86 birds in the same locations (Chapter 2). This represents a decrease of 25% over 13 years, in parallel with the decrease in average flock size. Thus all available evidence indicate that the population is continuing to decline at a substantial rate, and may have fallen by one quarter to one third during the past 15 years.

A population viability analysis of the Kangaroo Island population using computer simulations (Chapter 10) showed that its dynamics could not be predicted without better demographic information, especially on mortality rates. It also suggested, however, that given the low reproductive rate the population could not be stable without mortality rates far lower than have been reported for other cockatoo species.

### **Potential causes of decline**

The glossy black-cockatoo is particularly vulnerable to ecological disruptions because of its specialized diet and low reproductive potential. Not surprisingly, habitat destruction has been blamed for its decline in various parts of its range (e.g., Barrett 1949; Cleland & Sims 1968; Garnett 1992a). Most foraging habitat has been lost to land clearance, although selective harvesting, fire, and grazing by livestock and rabbits *Oryctolagus cuniculus* have also been implicated (Green & McGarvie 1971; Bishop & Venning 1986; Cooke 1987). Habitat loss through land clearance has clearly been the primary cause of decline for *C. l. halmaturinus*. Virtually every permanent disappearance of the birds from a specific locale has coincided with the clearance of drooping sheoak woodland, both on the mainland (Cleland & Sims 1968; Joseph 1989), and on Kangaroo Island (Chapter 2).

The two crucial habitat elements for the species are *Allocasuarina* trees which provide food, and large eucalypts which provide shelter, roosting sites, and nest hollows. Although *C. l. halmaturinus* has been known to forage on slaty sheoak *Allocasuarina*

*muelleriana* occasionally, it is almost completely dependent on drooping sheoak for food (Cleland & Sims 1968; Joseph 1982; Pepper 1993). The presence of drooping sheoak is not the only factor affecting the cockatoos' distribution however. A survey of foraging activity showed that cockatoo distribution is also affected by geographic variation in the food quality of drooping sheoak, in terms of the amount of seed produced per cone (Chapter 2).

The restricted breeding range suggests that shortages of suitable nest hollows may also be an important factor limiting population size. This is consistent with the results of a successful nest box trial on the north coast. Twelve nest boxes made from hollow logs were installed in 1992 and monitored through two breeding seasons (J. Pepper & T. Dennis, unpub. data). At least four nests were started by glossy black-cockatoos, and two fledged young. There was intense competition for the boxes from other species, including several that have either been introduced or recently increased in numbers. The nest boxes were used by four pairs of yellow-tailed black-cockatoos *Calyptorhynchus funereus*, six colonies of feral Honeybees *Apis mellifera*, and an uncertain number of brushtail possums *Trichosurus vulpecula*. At least one of the failed nests was apparently disrupted by a brushtail possum that took up residence in the box. Little corellas *Cacatua sanguinea*, which first appeared on the Island as regular visitors in the 1970's (Baxter 1989), have also been observed to displace nesting glossy black-cockatoos (Pepper, unpub. data).

Immediate steps are needed to halt the subspecies' decline, but more research is also needed to guide an effective management strategy. Better demographic data are needed to estimate a minimum viable population size and to evaluate the likely success of management actions. Studies of breeding biology will clarify why so few young are fledged, why nests are concentrated in a few areas, and the role of nest hollow availability and competition from other species. Measurements of nestlings may also help reveal

whether food shortages are affecting recruitment (Saunders 1986). Studies on foraging behavior and the ecology of drooping sheoak will help determine how much foraging habitat is needed to support the desired population size, and what factors influence its quality as a food source.

### **Prognosis and prospects**

The current population of *C. l. halmaturinus* is too small and geographically limited to be secure in the long term. Even if its size was stable, it would be vulnerable to chance events such as disease, drought, food shortage, and fire. This was demonstrated by a single fire in Flinders Chase National Park in 1991 that destroyed a population center and eliminated about 14% of the Island's foraging habitat (Chapter 2). The population is also subject to inbreeding and loss of genetic diversity. Lande & Barrowclough (1987) argued that "every effort should be made to preserve evolutionarily important amounts of genetic variation by maintaining effective population sizes of at least several hundreds of individuals". In contrast, the actual breeding population is probably no larger than about 100, and the effective (genetic) population size is likely to be smaller because of both unequal reproductive success among pairs (unpub. data), and the long term pair bonds typical of the genus (Crow & Kimura 1970). These considerations, together with the evidence for a continuing decline, suggest that the subspecies is close to the brink of a spiral into extinction.

On a more optimistic note, the Australian National Conservation Agency has recently approved a Recovery Plan for the subspecies that is currently being implemented (Chapter 11). The goals of the plan include both increasing the population size on Kangaroo Island, and ultimately re-introducing the subspecies in its former range on the mainland. The stage is thus set for *C. l. halmaturinus* to become a case study in the conservation of a habitat specialist vertebrate with a long life span and low reproductive

rate. The results will have implications for a range of species, including the growing number of endangered populations of cockatoos and other parrots (e.g., Forshaw 1981, Joseph 1988, Joseph et al. 1991, Emison & Joseph 1992, Beissinger & Snyder 1992).

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Figure 9.1. Map of Kangaroo Island showing localities with at least five records in the database. The areas of the circles are proportional to average flock size, which varied from 2.7 to 22.5. (Note: all records from the two west coast localities are from prior to the 1991 fire.)

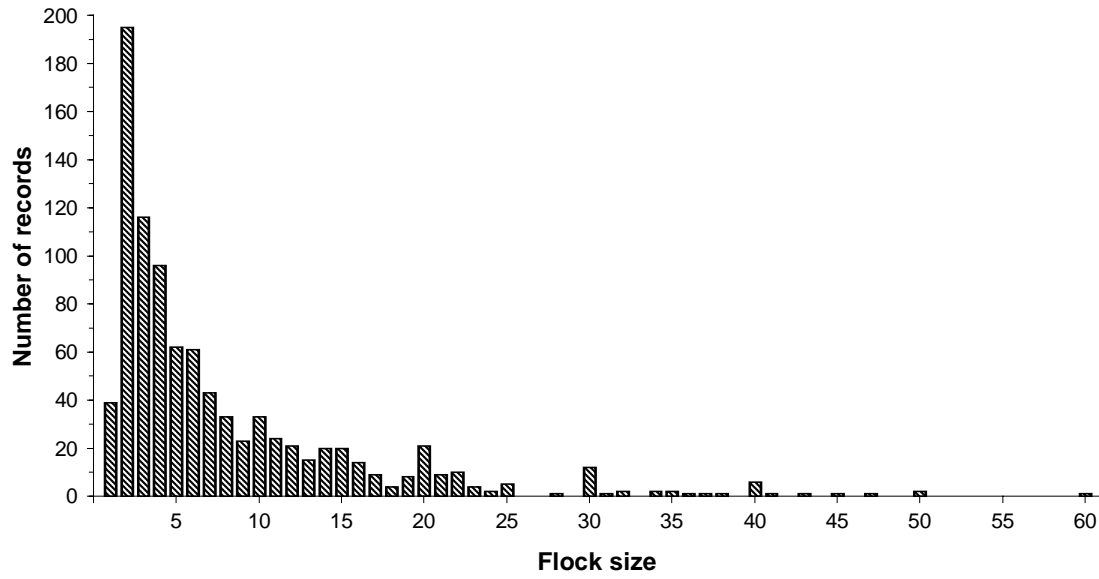


Figure 9.2. Frequency distribution of flock sizes based on all records in the database, including estimated flock sizes.

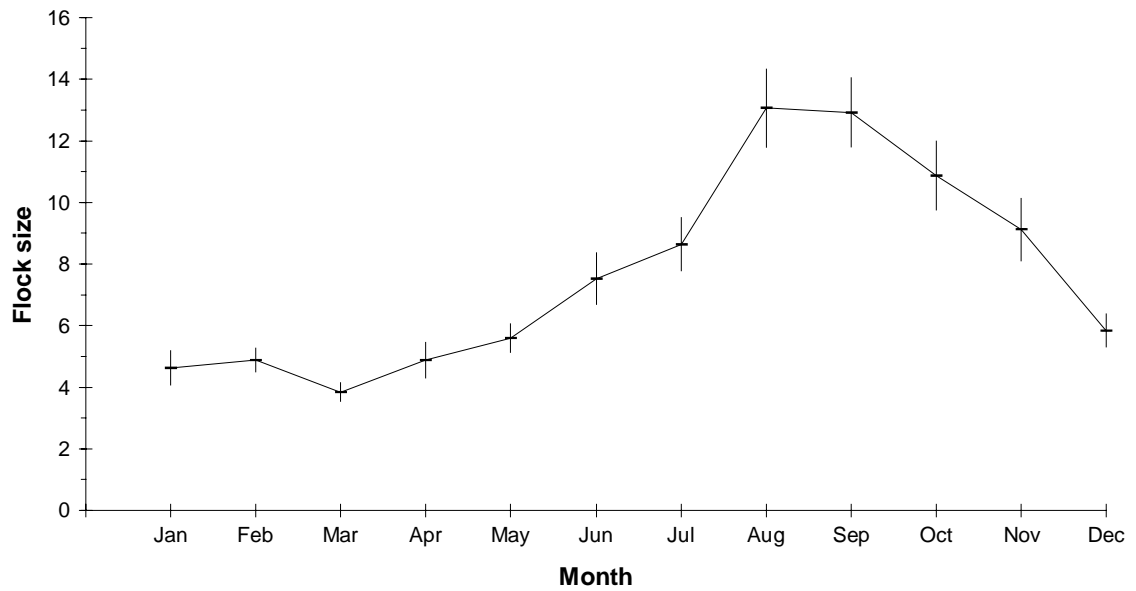


Figure 9.3. Monthly changes in flock size on Kangaroo Island. Means for all years combined are shown with standard errors.

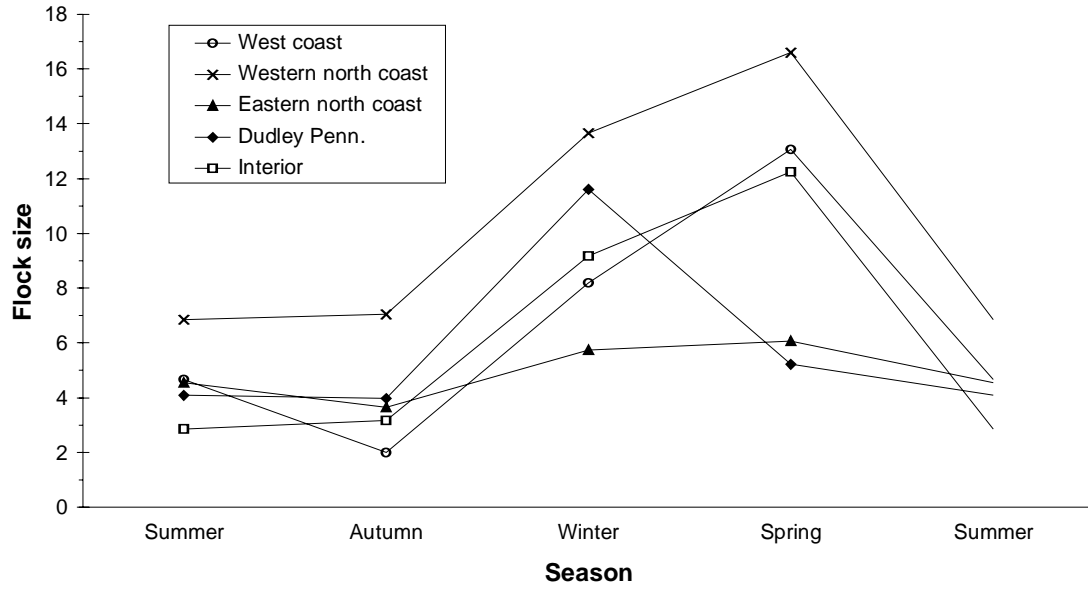


Figure 9.4. Seasonal changes in average flock size on Kangaroo Island by region. Summer = Dec. - Feb., Autumn = March - May, Winter = June - Aug., and Spring = Sept. - Nov. See text for definitions of regions. Nesting was observed during Autumn and Winter.

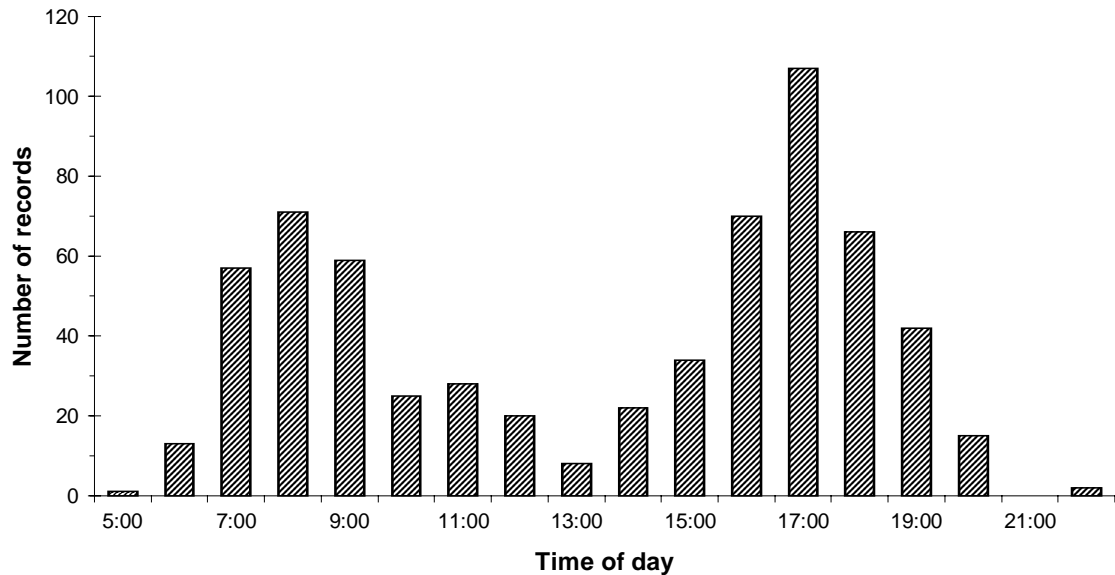


Figure 9.5. Frequency distribution of sightings on Kangaroo Island by time of day. Horizontal axis labels refer to the starting time of the one hour period represented by the bar. For prolonged sightings the time of first contact was used.

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