

A REVIEW OF THE POPULATION STATUS OF THE HEARD ISLAND CORMORANT *PHALACROCORAX NIVALIS*

K. GREEN^{1,2}, E.J. WOehler¹, P.B. COPLEY¹ & R.T. JONES¹

¹Antarctic Division, Channel Highway, Kingston, Tasmania 7050, Australia

²Current address: National Parks and Wildlife Service, Snowy Mountains Region, PO Box 2228, Jindabyne, New South Wales 2627, Australia
(ken.green@npws.nsw.gov.au)

Received 10 June 1996, accepted 4 August 1998

SUMMARY

GREEN, K., WOehler, E.J., COPLEY P.B. & JONES, R.T. 1998. A review of the population status of the Heard Island Cormorant *Phalacrocorax nivalis*. *Marine Ornithology* 26: 69–74.

The endemic Heard Island Cormorant or Shag *Phalacrocorax nivalis* has the smallest population of all the sub-Antarctic cormorants. Counts at breeding localities suggest that the population has wide variation in production of fledged chicks, ranging from none in some years to over 100 in others. Only one major roost for non-breeding birds is known. Counts of birds at this roost decreased from the mid to late 1980s. Population estimates for the whole island also decreased from over 600 birds to about 250 in an eight-month period in 1987. It is postulated that this was the result of a single event that reduced the population but did not affect the subsequent reproductive effort, which was the highest recorded. This decline is of particular concern in view of the species' endemicity and small population, and greater efforts in monitoring this species' numbers will be required in the future.

INTRODUCTION

The Heard Island Cormorant or Shag was first described as the subspecies *nivalis* of the Imperial Cormorant or Blue-eyed Shag *Phalacrocorax atriceps* (Falla 1937). Marchant & Higgins (1990) recognise five distinct species within this *P. atriceps* grouping, these being *P. atriceps*, confined to the coast of South America, *P. albiventer* at the Falkland Islands, *P. bransfieldensis* on the Antarctic Peninsula and adjacent South Shetland and Elephant Islands, *P. georgianus* on South Georgia, South Sandwich and South Orkney Islands, and *P. nivalis* on Heard Island.

High numbers of Heard Island Cormorants have been seen in roosts, and 'moderate sized flocks' have been recorded since the initial occupation of Heard Island by Australian National Antarctic Research Expeditions (ANARE) in 1947 (Downes *et al.* 1959). Only two small breeding colonies, at Sydney Cove and Saddle Point (Fig. 1), were recorded during the period 1947–1955 (Downes *et al.* 1959). Breeding birds at Sydney Cove moved from a stack 50 m offshore to the main island between 1980 (Johnstone 1982) and 1985 (Burton & Williams 1986). These were the only known breeding localities recorded during visits in 1980, 1985/86, 1986/87 and 1987/88, but one pair at least is known to have bred at Stephenson Roost in 1983 (Vining 1983). It was not until 1992/93 that a third major breeding site, again at Stephenson Roost, was located (Green 1997). Johnstone (1985) considered the small population as no cause for concern because of its apparent high breeding success rate. Pemberton & Gales (1987) suggested that the population of Heard Island Cormorants was vulnerable, comprising of between 600 and 1000 individuals. By 1987, however, numbers were low enough for alarm to be expressed at the population status (Copley 1989).

The population size of the Heard Island Cormorant is unknown but appears to be the smallest of the Antarctic and sub-Antarctic cormorants, when compared to *c.* 11 000 pairs for the Antarctic Cormorant *P. bransfieldensis* and the South Georgian Cormorant *P. georgianus* and close to 1000 pairs for the Crozet Cormorant *P. melanogenis* and the Macquarie Island Cormorant *P. purpurascens* (Marchant & Higgins 1990).

Studies undertaken on Heard Island Cormorants have been intermittent in the 50 years that Heard Island has been under Australian control, so that there are presently no detailed population data available. The present study aims to synthesise all available published and unpublished population data on the species, including those given in not readily available expedition reports, to assess the status of the population. This is of particular importance in view of the species' endemicity and small, but highly variable population.

METHODS

Data for the period 1948–1951 were obtained from Downes *et al.* (1959). One of the two regular breeding colonies was visited in March 1980 (Johnstone 1982). Chick and nest counts were conducted in each of three breeding seasons from 1985/86 to 1987/88. In October and November 1985 nesting colonies at Sydney Cove and Saddle Point were visited on nine and four occasions, respectively (Burton & Williams 1985). In 1986/87 these two colonies were each visited once in December and January and all nests and chicks were counted (Gales 1987). In 1987/88 the nesting colonies were each visited four times; Sydney Cove between October and December and Saddle Point between October and February. On these occasions only nests and chicks were counted

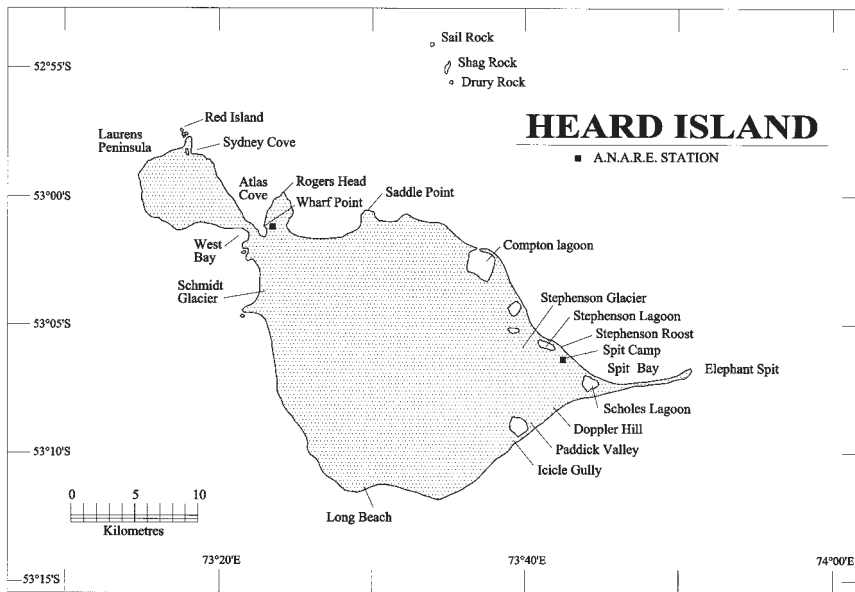


Fig. 1. Heard Island, showing sites referred to in the text.

(Woehler 1989). During 1992/93, a colony of 50 nests with eggs was studied from laying to fledging (Green 1997).

Counts were made of adult and immature cormorants on Heard Island in the summers of 1985/86 (Burton & Williams 1986), 1986/87 (Pemberton & Gales 1987) and 1987/88 (Copley 1989), the winter of 1990 at the Stephenson Roost (Green 1990) and also weekly at the Stephenson Roost in the period 1 March 1992 to 14 March 1993 (Green 1993). Juveniles were identified by their distinctive plumage (Downes *et al.* 1959). Counts were made in the morning, before departure of the birds for sea, or in the evening after birds had returned to roost for the night. The number of breeding pairs was calculated from the number of occupied nests.

RESULTS

Reproductive success

1947–1955

There are few data on Heard Island Cormorants for the period of ANARE occupation between 1947 and 1955. Only 26–28 nests in total were recorded annually at two sites: Saddle Point and Sydney Cove, and the 'usual' number of eggs per clutch was considered to be four (Downes *et al.* 1959). The only notes on chick survival were that 'most birds had two chicks' on 5 December 1954. The data are few and do not indicate annual variability. However, if this was the general level of success, chick production would be about 52–56 a year. However, a more realistic estimate for a good year (if the conditions were generally similar to 1992/93 with a mean clutch size of 2.8 ± 0.4 eggs per nest and survival to fledging of the order of 60% (Green 1997)) would be a chick production of about 44 to 47. Only one record of juvenile survival comes from Downes *et al.* (1959) who recorded sighting 51 juveniles in December 1950 (Table 1).

1979/80

Saddle Point and Sydney Cove were still the only two nesting

sites noted in 1980, with 45 old nests recorded at the former site (Johnstone 1982).

1983

Vining (1983) reported one nest with two chicks at Stephenson Roost in February 1983. No counts were made at other colonies.

1985/86

Saddle Point and Sydney Cove were again the only two nesting sites recorded for this and the next two seasons. In 1985 at Sydney Cove, nesting was reported from the main island cliff with no nesting on the offshore stack. The nesting colony at Saddle Point was in the same location as it had been in the 1940s and 1950s. On 29 October 1985, 16 nests were recorded at Sydney Cove. On 19 November, 13 nests remained, two with two chicks, five with two eggs

and six with three eggs (Burton & Williams 1986). On 26 October there were 74 nests at Saddle Point, with 31 of these remaining on 22 November. Eight nests had a total of 11 chicks. From this and unpublished data, Pemberton & Gales (1987) calculated that a maximum of 43 chicks could have fledged (Table 1). In 1986/87 Pemberton & Gales (1987) saw no cormorants in juvenile plumage, and suggested a low fledging success or low survival of the 1985/86 cohort.

1986/87

A maximum of 27 nests was attended by adults, a figure similar to the period 1947 to 1955. On 4 December 1986, four nests were recorded at Sydney Cove, with six chicks in total; on 18 January six chicks remained. On 10 December there were two nests at Saddle Point with two chicks; on 4 January no chicks remained (Gales 1987). Figures differ in Pemberton & Gales (1987) and seven chicks was given as the total number of survivors for the whole island. Woehler (1989) reported a maximum of two juveniles observed from this cohort in 1987/88 (Table 1).

1987/88

There were 16 nests and 24 chicks at Sydney Cove up to 2 December 1987, by which time all chicks had hatched. There were 18 nests and 24 chicks on 20 December. The extra two nests were possibly occupied by inexperienced breeders who did not contribute to the chick production for the year. At Saddle Point there were 76 nests and five chicks on 10 October. The number of nests decreased to 71 in November and December, while the number of chicks peaked at 71 on 12 December and fell to 70 by 4 February 1988 (Woehler 1989). Total maximum fledging for the island was, therefore, 94 (Table 1). Two young birds were found dead at the eastern end of the island on 16 and 19 February (Copley 1989).

1991/92

A count of 15 fledglings at Sydney Cove on 4 February 1992 was the only count at any breeding colony (Green 1993). One dead juvenile was found in late April 1992 and a count at

Stephenson Roost on 3 May 1992 totalled 135 juvenile birds. The 1991/92 cohort, therefore consisted of at least 136 fledglings (Table 1). A count on 19 December 1992 totalled 133 juvenile birds. If the whole cohort consisted of the 136 observed fledglings then the recorded loss gives a mortality rate of 3.3% a year. The death of two juvenile birds from the 135 live birds observed was confirmed: one hit a radio mast and the second was found dead on the south coast of the island giving an estimated maximum recruitment of 133 (Table 1).

1992/93

A total of 82 chicks fledged at Stephenson Roost in 1992/93 (Green 1997). From 10 March 1993, additional fledglings arrived from breeding colonies, presumably in the north-west of Heard Island. A total of 82 chicks resulted from the 163 adults known to remain in the Spit Bay area (55 nests were built at which 50 pairs produced eggs). It is assumed that only breeding birds travelled to the north-west of the island, (Woehler (1989) for example reported no big roosts of non-breeders in the area in the 1987/88 breeding season). Attempted breeding by the 145 birds that presumably headed to the north-west of the island (at an equivalent reproductive success to the south-east) would have led to successful laying by 66 pairs producing 108 chicks. This is a realistic estimate compared to 89 nests in 1987/88 if it is assumed that the colony at Stephenson Roost was an overflow rather than an alternative site. A possible total for Heard Island for 1992/93 was therefore 190 chicks, with 98 of these confirmed (Table 1).

Roosts

1947–1954

Stephenson Roost might not have been available for roosting in this period as photographic evidence shows that the Stephenson Glacier extended right up to the moraine. Downes *et al.* (1959) recorded roosting around the north-west of Heard Island as being more common than in subsequent years of summer occupation.

1983

There were 215 adults present at Stephenson Roost in February (Vining 1983). If at that time the same proportion of birds on Heard Island was at Stephenson Roost as in early February

1993 (Green 1993) this gives an estimated island population of 524 adults (Table 1).

1985/86

Eight minor roosts were distinguished, six of them in the north-west of the island and two in the south-east. These contained a maximum of 22 birds for one roost with the usual maximum number of ten or less. There was no single-day count for the island. On 18 November 1985, there were 548 cormorants at Stephenson Roost (Burton & Williams 1986), and a further 13 pairs at Sydney Cove and 31 pairs at Saddle Point. This gives a minimum total for the island of 636 birds (Table 1). Juveniles were not distinguished in counts of roosting birds.

1986/87

A total of 340 birds was recorded on 14 January 1987 at Stephenson Lagoon (Pemberton & Gales 1987). Based on all roost sites and breeding sites, Pemberton & Gales (1987) estimated a population size in excess of 600 birds.

1987/88

There was one Heard Island Cormorant at Stephenson Roost on arrival of the expedition on 18 September 1987. The number did not exceed nine until January 1988 (Copley 1989) because most birds were at the breeding colonies during this time. An influx of birds to Stephenson Roost occurred after 19 January 1988, and included juvenile birds after 15 February, with a maximum count of 127 birds on 26 February (the expedition left the island on 2 March). This suggests that the increase at Stephenson Roost consisted of breeding animals and their offspring (Copley 1989) but not all birds had arrived from the breeding sites. This explanation is supported by a similar influx in 1992/93 at a date two weeks later (Green 1993) (breeding also commenced about two weeks later in 1992/93). The population in 1987/88 constituted a maximum 188 breeding birds (including failed breeders) from 94 nests at Sydney Cove and Saddle Point. Prior to the influx, the numbers seen at the eastern end of the island were low. The usual count for eight roosts at the eastern end of the island away from Stephenson Roost was zero to four (Copley 1989). A maximum of 25 birds was seen on 9 October at Long Beach and none were recorded at Stephenson Roost at this time. At the north-western end of Heard Island 'no large numbers of

TABLE 1

Reproductive success of the Heard Island Cormorant for the period 1948–1993, together with estimated maximum recruitment and estimated adult population

Year	Reproductive effort	Estimated maximum recruitment	Estimated adult population	Source of data for estimates
1948–51	c. 26–28 nests	51	“extremely small”	Downes <i>et al.</i> (1959)
1979/80	>45 nests			Johnstone (1982)
1983			524	Vining (1983)
1985/86	43 chicks	0	636	Burton & Williams (1986), Pemberton & Gales (1987)
1986/87	6 chicks	2	>600	Pemberton & Gales (1987), Woehler (1989)
1987/88	94 chicks	92 max	213–250	Woehler (1989), Copley (1989)
1990			339	Green (1990)
1991/92	min 136 chicks	133	330	Green (1997)
1992/93	min 99 chicks	98–190	328	Green (1997)

roosting' cormorants were recorded (Woehler 1989). The minimum adult population at this time then was (assuming two adults per nest) $188 + 25$ or 213 and the maximum count for the whole island in the period 18 September 1987 to 28 February 1988 never exceeded 250 (Copley 1989, Table 1).

1990

On 22 May 1990, the number of cormorants at Stephenson Roost was 278, including juveniles (not differentiated in the count). This number decreased to 214 on 8 June 1990. At a similar date in late May 1992 at Stephenson Roost, the numbers were beginning to decline as nest building began, but numbers were 82% of the maximum count. Assuming an equivalent breeding time and equivalent loss of birds with time to the north-western end of the island as in 1992, the estimated population for 1990 would be a maximum of 339 adults (Table 1). This is in accord with calculations based on recruitment to a population of 250 adults in 1987/88. Assuming two chicks were recruited from the 1986/87 cohort (this was the maximum number of juveniles seen the following year), and of the 94 chicks from 1987/88 (with the mortality of juveniles only over the ensuing 26 months calculated at 3.3% a year) 88 were recruited, this gives an estimate of 340 adults together with any juveniles from the 1989/90 breeding season.

1992/1993

There was very little roosting observed away from Stephenson Roost at the eastern end of the island, and the biggest roost recorded was at Doppler Hill. This contained between seven and 22 cormorants (including zero to five juveniles) between March and May 1992. There was an occasional daytime roost at Paddock Valley and another towards Long Beach, but neither of these showed any evidence of frequent occupation by way of guano or regurgitated casts. In 1992, the maximum count of adults was 309 on 28 April. Allowing a further 20 adults for the southern roosts, and one adult found dead early in the year gives a minimum estimate of 330 adult birds for 1991/92 and with a further adult death in December 1992 gives a maximum estimate of 328 adult birds for 1992/93 (Table 1).

DISCUSSION

Chick production and recruitment to the breeding population

Despite occupation of the ANARE base at Atlas Cove from 1947 to 1955, there is no published account of annual chick production by Heard Island Cormorants from that time. Saddle Point and Sydney Cove were the only known nesting areas. Vining (1983), however, recorded a single nest at Stephenson Lagoon in 1982/83, but despite searches no nest was seen there again until 1992/93. For the only three seasons before 1991/92 for which there are data (1985/86 to 1987/88), the maximum recruitment to the breeding population could have been no higher than about 88, averaging 30 a year. With a success rate equal to the 1992/93 season, the chick production for 1947 to 1955 (with 26–28 known nests) would have been slightly higher at 47 a year with about 43 being recruited into the breeding population assuming sexual maturity at three years of age as with the South Georgian Cormorant (Croxall 1981). This ignores years of total or near-total breeding failure. The mean annual mortality of the Macquarie Island Cormorant for males and females combined is 16.2% (Brothers 1985). On this basis, the recruitment of 30–44 breeders could not sustain a population of more than about 185–272 birds. The highest number

seen on one day in 1985, however, was about 550, and the population over 1985/86 and 1987/88 was in excess of 600 (Table 1, Pemberton & Gales 1987).

The present data suggest that such a population would be impossible to sustain on the known production of chicks unless

- 1) the Heard Island Cormorant is longer lived than the Macquarie Island Cormorant,
- 2) there are unknown breeding sites on Heard Island,
- 3) there is immigration from another island, or
- 4) the average chick production over the years 1985–1987, and 1947–1955, was unusually low.

There are no data on the longevity of the Heard Island Cormorant, because this species was not studied during the ANARE occupation of 1947–1955 (Downes *et al.* 1959), and the few visits since that date have not been of sufficient frequency or reliability to initiate a banding study to collect such data. Sufficient effort has, however, been expended with a thorough coverage of Heard Island by helicopter in 1986/87, to be sure that an unknown breeding site did not occur in that season (Pemberton & Gales 1987). Immigration is unlikely, because the species is only recorded from Heard Island. The nearest possible source is the McDonald Islands group 36 km away, but cormorants have not been recorded there (albeit from very few visits) (Johnstone 1982).

This leaves the alternative that the annual chick production over the years 1985–1987, and that estimated for 1947–1955, were low. The Imperial Cormorant group is known to have an uneven reproductive success with high failure rate in some years: Williams & Burger (1979) reported egg mortality of 38.1% and 46.4% for two years at Marion Island, and a chick mortality of 78% (compared with 41% at Crozet Islands: Derenne *et al.* 1976). Brothers (1985) reported egg mortalities of 10%, 27% and 28% over three seasons at Macquarie Island, and the presumed chick mortality was about 39%, 12% and 37% over the same three seasons. In 1992/93, mortality on Heard Island was 41%. This was confined mainly to eggs with virtually no chick mortality after the first few days of life (Green 1997). The data on chick production (Table 1) suggest that chick production on Heard Island is extremely uneven, and that the population goes through boom and bust phases in reproductive success. Periods such as the late 1980s are therefore compensated for by boom seasons such as 1991/92 and 1992/93 when a known 235 and possible 326 chicks fledged. Boom and bust cycles in reproduction probably result in periods of high and low adult mortality respectively, as boom and bust cohorts age and die leading to some cycling of the population level.

Roosts and population estimates

Pemberton & Gales (1987) considered that an accurate assessment of the population size of Heard Island Cormorants would be difficult. For an accurate count, the likely roosting sites would have to be visited early in the morning or late in the evening to ensure that all birds were back from their foraging ground when a count was made. It is possible, although unlikely, that significant numbers roosted in inaccessible areas on Heard Island or on either the McDonald Islands or Shag Rock. Johnstone (1982), for example, reported no cormorants at the McDonald Islands, and Vining (1983) reported none from Shag Rock. These visits were, however, of short duration and have not been repeated. Over 80% of Heard Island is covered by glacial ice and, of the remainder, extensive areas of sand flats close to sea level are unsuitable for nesting and roosting. All 13 roost sites identified by Pemberton & Gales (1987) with helicopter support had a degree of temporal

stability and were in areas normally accessible by boat and foot. Well-used roosts can easily be identified by the presence of guano and regurgitated pellets, particularly when the latter contain polychaete spines. Taking these factors, and the extensive period of time spent on the island, into consideration it is unlikely that any major roost was missed in the subsequent year. Cormorants do not roost at sea due to their wettable plumage (Cooper 1985) and non-breeding Heard Island Cormorants remain on land early in the morning for the first four hours of daylight and in the evening for the last three (Green & Williams 1997). In six months' occupation of the island in 1987/88, Woehler (1989) recorded no large roosts at the north-west end of the island, with a maximum of 14 roosting birds at Wharf Point (on 4 October 1987). At the eastern end of the island Copley (1989) recorded eight minor roosts with the usual number of birds at each being none to four and the maximum three to 28. Stephenson Roost is the most important roost for cormorants at Heard Island (Burton & Williams 1985, Pemberton & Gales 1987, Copley 1989, Woehler 1989) and therefore it is likely that counts of this and breeding birds will reveal population trends. The maximum number of adult birds at Stephenson Roost decreased from 548 on 18 November 1985 to nine on 19 November 1987. The numbers at the roost will vary according to numbers breeding at that time and the numbers at other roosts. Taking this into account the number of adult birds estimated to be on the island decreased from a minimum of 636 in 1985/86 (with similar numbers in 1986/87) to a maximum of 250 in 1987/88. The highest estimates (1985/86 and 1986/87) were for two seasons when the times the expeditions spent ashore were 56 days (1 October to 25 November 1985) using foot transport only and 69 days (14 November 1986 to 21 January 1987) with helicopter transport. In 1987/88 the party was ashore for 167 days from 18 September to 2 March with amphibious and foot transport. This is sufficient time, with frequent counts of all roosts and breeding sites, to ensure adequate counting effort. The concordance of population estimates from two years later (May 1990) based on corrected counts from Stephenson Roost and from an assessment of recruitment to the adult population from the 1987/88 cohort suggests also that these are reasonable estimates. There would, therefore, appear to have been a real decrease in the number of cormorants on Heard Island from a high of over 600 to about 250. This would have taken place between the 1986/87 and 1987/88 expeditions which were only eight months apart.

Possible causes of a population decrease

Four known causes of major perturbations in seabird population parameters in the Southern Ocean are 1) human disturbance (Williams 1984, Jouventin *et al.* 1984, Thomas 1986, Wilson *et al.* 1990), 2) introduced predators (Johnstone 1985), 3) changes in availability of prey (Whitehead *et al.* 1990), or 4) climatic changes (Jouventin & Weimerskirch 1990).

On Heard Island, where there is no permanent human occupation, the direct effect of humans is probably not important in affecting the population. In 1948 and 1949, eggs were taken for food, but from 1951 it was considered that the species was rare and these activities ceased (M. Downes pers. comm.). Other incidental mortality appears to be low with one juvenile becoming entangled in a fishing net (Downes *et al.* 1959) and an adult dying after hitting the Spit Camp radio mast in 1992 (pers. obs.). These are the only known cases of human-induced mortality in recent years. There are no introduced vertebrates on Heard Island to cause increased mortality.

There appears to be no real shift in the diet that could explain

the presumed high mortality between 1985/86 and 1987/88 (Green *et al.* 1990) and competition with other species is low. Espitalier-Noel *et al.* (1988) stated that the diet of the Crozet Cormorant at Marion Island overlapped with that of the Gentoo Penguin *Pygoscelis papua*, due to their similar foraging range and methods. Over the past 30 years, the population of Gentoo Penguins on Heard Island has increased from about 9000 breeding pairs to 16 600 breeding pairs in 1987/88 (Woehler 1991), but information on the diet of Gentoo Penguins from 1986/87 and 1990 suggests that the overlap in prey species taken by both Gentoo Penguins and Heard Island Cormorants is minimal (Klages *et al.* 1990, Green & Wong 1992). Other piscivorous species increasing on Heard Island are King Penguins *Aptenodytes patagonicus* (which have no prey species in common with Heard Island Cormorants – Klages *et al.* 1990), Black-browed Albatrosses *Thalassarche melanophrys* (Woehler 1991) and Antarctic Fur Seals *Arctocephalus gazella* (Green *et al.* 1989, 1990). The diet of Black-browed Albatrosses at Heard Island is unknown, but it is unlikely to overlap with that of Heard Island Cormorants. No fish species important to Heard Island Cormorants occurred commonly in the diet of fur seals (Green *et al.* 1989, 1990). The Heard Island Cormorant does not, therefore, appear to be facing significant direct competition for food from other species breeding on Heard Island. Even if there was competition, this would have to be allied to a food shortage to cause such a major reduction in population. There was no evidence of a large die-off from starvation or disease. No dead birds were found on arrival at Heard Island in 1987/88, but more importantly, birds were in sufficiently good condition to breed and make this the most successful breeding season recorded to that time.

The loss of over half the population from the island in eight months without any effect on the remainder or on subsequent breeding suggests that this was a single event rather than a series of events. The Heard Island Cormorant feeds in waters in a direction of about 70° from the Spit Bay camp and about 20 km from shore (K. Green & E.J. Woehler unpubl. data). With sudden increases in wind speed, generally from the south-west, this means that they must fly back to land into increasing winds. Observations on cormorants from Spit Bay through 1992/93 confirmed that many had difficulty flying into strong south-westerlies. Wind speeds on Heard Island can frequently exceed 100 knots, a speed considered beyond the capability of any cormorant to return to shore. It is possible that such an event occurred in the eight months between the 1986/87 and 1987/88 expeditions, resulting in a loss of a significant part of the population. It is also possible that the 'missing' birds were at the McDonald Islands only 36 km away and the survey by Johnstone (1982) occurred at a time when no cormorants were at those islands. The Macquarie Island Cormorant is, for example, also found at the Bishop and Clerk Islands 33 km south of Macquarie Island, but this occupation is permanent rather than transitory, as would have to be postulated for the Heard Island Cormorant at the McDonald Islands.

These hypotheses are by necessity speculative. The Heard Island Cormorant remains one of the least known bird species in the Southern Ocean. Since its recognition as a full species it now meets the IUCN criteria for a classification of Endangered, although it is not so classified as yet (Collar *et al.* 1994). Nearly 50 years of *ad hoc* studies of this species has left us with such an incomplete knowledge of population processes that it has gone through a massive reduction to leave less than 250 adult birds without knowledge or concern. It is of vital

importance to gain a better understanding of population processes of this endemic species. A mark-recapture study to establish population size is long overdue and a long-term banding study to examine demographic data over a number of years would give a greater insight into causes of population fluctuations of the endemic Heard Island Cormorant.

ACKNOWLEDGEMENTS

We thank ANARE expeditioners to Heard Island from various years. John Cox drew the figure. David Pemberton (Tasmanian National Parks and Wildlife Service) and Peter Shaughnessy (CSIRO Division of Wildlife and Ecology) commented on an earlier draft of this paper.

REFERENCES

- BROTHERS, N.P. 1985. Breeding biology, diet and morphometrics of the King Shag, *Phalacrocorax albiventer purpurascens*, at Macquarie Island. *Aust. Wildl. Res.* 12: 81–94.
- BURTON, H.R. & WILLIAMS, D.L. 1985. Heard Island 1985 report. Kingston: Australian Antarctic Division.
- COLLAR, N.J., CROSBY, M.J. & STATTERSFIELD, A.J. 1994. Birds to watch 2. The world list of threatened birds. *BirdLife Conserv. Ser.* 4: 1–407.
- COOPER, J. 1985. Diving patterns of cormorants Phalacrocoracidae. *Ibis* 128: 562–570.
- COPLEY, P.B. 1989. Summary of bird observations, east Heard Island, 1987–88. In: Kirkwood, R.J., Woehler, E.J. & Burton, H.R. (Eds). Heard Island 1987/88 ANARE Report. Kingston: Australian Antarctic Division. pp. 10–24.
- CROXALL, J.P. 1981. Aspects of the population demography of Antarctic and sub-Antarctic seabirds. *Com. Nat. Franc. Rech. Antarct.* 51: 479–488.
- DERENNE, P., MARY, G. & MOUGIN, J.-L. 1976. Le Cormoran á ventre blanc *Phalacrocorax albiventer melanogenis* (Blyth) de l'archipel Crozet. *Com. Nat. Franc. Rech. Antarct.* 40: 191–219.
- DOWNES, M.C., EALEY, E.H.M., GWYNN, A.M. & YOUNG, P.S. 1959. The birds of Heard Island. *ANARE Sci. Rep. Ser. B. Zool.* 1: 124–128.
- ESPITALIER-NOEL, H., ADAMS, N.J. & KLAGES, N.T. 1988. Diet of the Imperial Cormorant *Phalacrocorax atriceps* at sub-Antarctic Marion Island. *Emu* 88: 43–46.
- FALLA, R.A. 1937. Birds. *B.A.N.Z.A.R.E. Rep. Ser. B.* 2: 1–304.
- GALES, R.P. 1987. Bird observations. In: Ledingham, R. (Ed.). Heard Island 1985 Report. Kingston: Australian Antarctic Division. pp. 47–53.
- GREEN, K. 1990. Heard Island 1990 ANARE Report. Kingston: Australian Antarctic Division.
- GREEN, K. 1993. Heard Island 1992 ANARE Report. Kingston: Australian Antarctic Division.
- GREEN, K. 1997. Biology of the Heard Island Shag, *Phalacrocorax nivalis*. 2. Chick growth and survival. *Emu* 97: 67–75.
- GREEN, K., BURTON, H.R. & WILLIAMS, R. 1989. The diet of Antarctic Fur Seals *Arctocephalus gazella* during the breeding season at Heard Island. *Antarct. Sci.* 1: 317–324.
- GREEN, K. & WILLIAMS, R. 1997. Biology of the Heard Island Shag, *Phalacrocorax nivalis*. 3. Foraging, diet and diving behaviour. *Emu* 97: 76–83.
- GREEN, K., WILLIAMS, R., WOEHLE, E.J., BURTON, H.R., GALES, N.J. & JONES, R.T. 1990. Diet of the Heard Island Cormorant *Phalacrocorax (atriceps) nivalis*. *Antarct. Sci.* 2: 139–141.
- GREEN, K. & WONG, V. 1992. The diet of Gentoo Penguins *Pygoscelis papua* in midwinter at Heard Island. *Corella* 16: 129–132.
- JOHNSTONE, G.W. 1982. Zoology. In: Veenstra, C. & Manning, J. (Eds). Expedition to the Australian Territory of Heard and McDonald Islands 1980. Canberra: Division of National Mapping. Technical Report 31. pp. 33–39.
- JOHNSTONE, G.W. 1985. Threats to birds on sub-Antarctic islands. In: Moors, P.J. (Ed.). Conservation of island birds. Case studies for the management of threatened island species. *Int. Council Bird Preserv. Tech. Publ.* 3: 101–121.
- JOUVENTIN, P. & WEIMERSKIRCH, H. 1990. Long-term changes in seabird and seal populations in the Southern Ocean. In: Kerry, K.R. & Hempel, G. (Eds). Antarctic ecosystems. Ecological change and conservation. Berlin: Springer-Verlag. pp. 208–213.
- JOUVENTIN, P., STAHL, J.-C., WEIMERSKIRCH, H. & MOUGIN, J.-L. 1984. The seabirds of the French Subantarctic islands and Adélie Land: their status and conservation. In: Croxall, J.P., Evans, P.G.H. & Schreiber, R.W. (Eds). Status and conservation of the world's seabirds. *Int. Council Bird Preserv. Tech. Publ.* 2: 609–625.
- KLAGES, N.T.W., PEMBERTON, D. & GALES, R.P. 1990. The diets of King and Gentoo Penguins at Heard Island. *Austr. Wildl. Res.* 17: 53–60.
- MARCHANT, S. & HIGGINS, P.J. 1990. Handbook of Australian, New Zealand and Antarctic birds, Vol. 1. Ratites to ducks. Melbourne: Oxford University Press.
- PEMBERTON, D. & GALES, R.P. 1987. Notes on the status and breeding of the Imperial Cormorant *Phalacrocorax atriceps* at Heard Island. *Cormorant* 15: 33–40.
- THOMAS, T. 1986. L'effectif des oiseaux nicheurs de l'archipel de Pointe Géologie (Terre Adélie) et son évolution au cours des trente dernières années. *Oiseau* 56: 349–368.
- VINING, R. 1983. Heard Island 1983 scientific reports. Sydney: Garvan Institute of Medical Research.
- WHITEHEAD, M.D., JOHNSTONE, G.W. & BURTON, H.R. 1990. Annual fluctuations in productivity and breeding success of Adélie Penguins and fulmarine petrels in Prydz Bay, east Antarctica. In: Kerry, K.R. & Hempel, G. (Eds). Antarctic ecosystems. Ecological change and conservation. Berlin: Springer-Verlag. pp. 214–143.
- WILLIAMS, A.J. 1984. The status and conservation of seabirds on some islands in the African sector of the Southern Ocean. In: Croxall J.P., Evans, P.G.H. & Schreiber R.W. (Eds). Status and conservation of the World's seabirds. *Int. Council Bird Preserv. Tech. Publ.* 2: 627–635.
- WILLIAMS, A.J. & BURGER, A.E. 1979. Aspects of the breeding biology of the Imperial Cormorant, *Phalacrocorax atriceps*, at Marion Island. *Gerfaut* 69: 407–423.
- WILSON, K.-J., TAYLOR, R.H. & BARTON, K.J. 1990. The impact of man on Adélie Penguins at Cape Hallet, Antarctica. In: Kerry, K.R. & Hempel, G. (Eds). Antarctic ecosystems. Ecological change and conservation. Berlin: Springer-Verlag. pp. 183–190.
- WOEHLE, E.J. 1989. Summary of bird observations, west Heard Island, 1987–88. In: Kirkwood, R.J., Woehler, E.J. & Burton, H.R. (Eds). Heard Island 1987/88 ANARE Report. Kingston: Australian Antarctic Division. pp. 1–9.
- WOEHLE, E.J. 1991. The status and conservation of the seabirds of Heard Island and the McDonald Islands. In: Croxall J.P. (Ed.). Seabird status and conservation; a supplement. *Int. Council Bird Preserv. Tech. Publ.* 11: 263–277.