

Population changes and biology of the wandering albatross *Diomedea exulans gibsoni* at the Auckland Islands

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Population changes and biology of the wandering albatross *Diomedea exulans gibsoni* at the Auckland Islands

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ABSTRACT

Gibson's wandering albatross *Diomedea exulans gibsoni* is endemic to the Auckland Islands in the New Zealand subantarctic. In 1991 a programme of regular census and population study was initiated to assess the impact of long-line fisheries bycatch on the status of the subspecies. This paper reports on field work carried out on Adams I. in the Auckland Islands group during January and February most years between 1991 and 1997. Over this seven-year period, the average annual number of pairs nesting on Adams I. was 5831. This is the first reliable estimate of the size of the population. Evidence of population changes on the Auckland Is is reviewed. Annual adult survival has been estimated for three years and averaged 97%; females have a 2% lower rate than males. *D. .e. gibsoni* were easily sexed by measurements. Productivity over five breeding seasons averaged 67%. Timing of egg-laying and nest-site fidelity of *D. e. gibsoni* are described and compared with those of other subspecies of wandering albatross.

Keywords: Gibson's wandering albatross, *Diomedea exulans gibsoni*, population monitoring, productivity, survival, morphometrics, Auckland Islands.

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1. Introduction

A large number of great albatross breed in the New Zealand region: the Gibson's wandering albatross *D. e. gibsoni* and the Antipodean wandering albatross *D. e. antipodensis* as well as the southern royal albatross *D. epomophora epomophora* and the northern royal albatross *D. e. sanfordi*. Royal and wandering albatross have been characterised by morphometric differences in the past, but there is also increasing evidence that royal albatrosses feed predominantly inshore (Nicholls et al. 1994), while wandering albatrosses are pelagic (Walker et al. 1995; Weimerskirch et al. 1993; Prince et al. 1998). A proposed new taxonomy elevates each of the four New Zealand great albatross taxa to specific status (Robertson & Nunn 1998). New Zealand wandering albatrosses are smaller and generally darker coloured than other wandering albatross subspecies (*D. e. exulans* and *D. e. dabbenena* in the South Atlantic and South Indian Oceans).

Although the two New Zealand endemic subspecies of wandering albatrosses constitute 50% of all wandering albatrosses, they have been little studied. Recent high bycatch of both *D. e. gibsoni* and *D. e. antipodensis* by long-line fishing boats (Murray et al. 1993) led to concern that the fisheries bycatch may be causing population declines, as documented in the well-studied *D. e. exulans* populations in the South Atlantic and South Indian oceans (Croxall et al. 1990; de la Mare & Kerry 1994; Weimerskirch & Jouventin 1987; Weimerskirch et al. 1997). Wandering albatrosses are long-lived (> 40 years), breed late (> 10 years) and produce a chick only once every 2-3 years, and because of these characteristics are less able to sustain increased bycatch mortality than many other species. By contrast, though royal albatrosses have similar reproductive strategies, they are less frequently caught on long-lines, presumably because they spend far less time than wandering albatrosses in the oceanic waters where most long-line fishing occurs.

In 1991 we began a long-term study of one of the New Zealand wandering albatross subspecies, *D. e. gibsoni* on Adams I. in the subantarctic Auckland Is group. This paper presents findings from the first seven years of the study, focusing on estimates of population size, breeding success, and adult survival, and looking briefly at other aspects of their biology.

The Auckland Is, in the south-west Pacific Ocean, comprise six islands and several islets (Fig. 1). Most *D. e. gibsoni* nest on Adams I., the southernmost island in the group. A few breed on southern parts of the main Auckland I. and there is a small population on Disappointment I.

Adams I (50° 53' S, 166° 10' E) is approximately 20 km long and 7 km wide, with a 600 m high range running east-west along its length. The island has a narrow band of forest and scrub near sea level, with tussock then bare fellfield above. There are no introduced predators and no human habitation. While albatrosses nest on most ridges off the main range of Adams I., there are two large concentrations of birds, both on the southern slopes of the island—the Astrolabe-Amherst colony and Fly Basin colony.

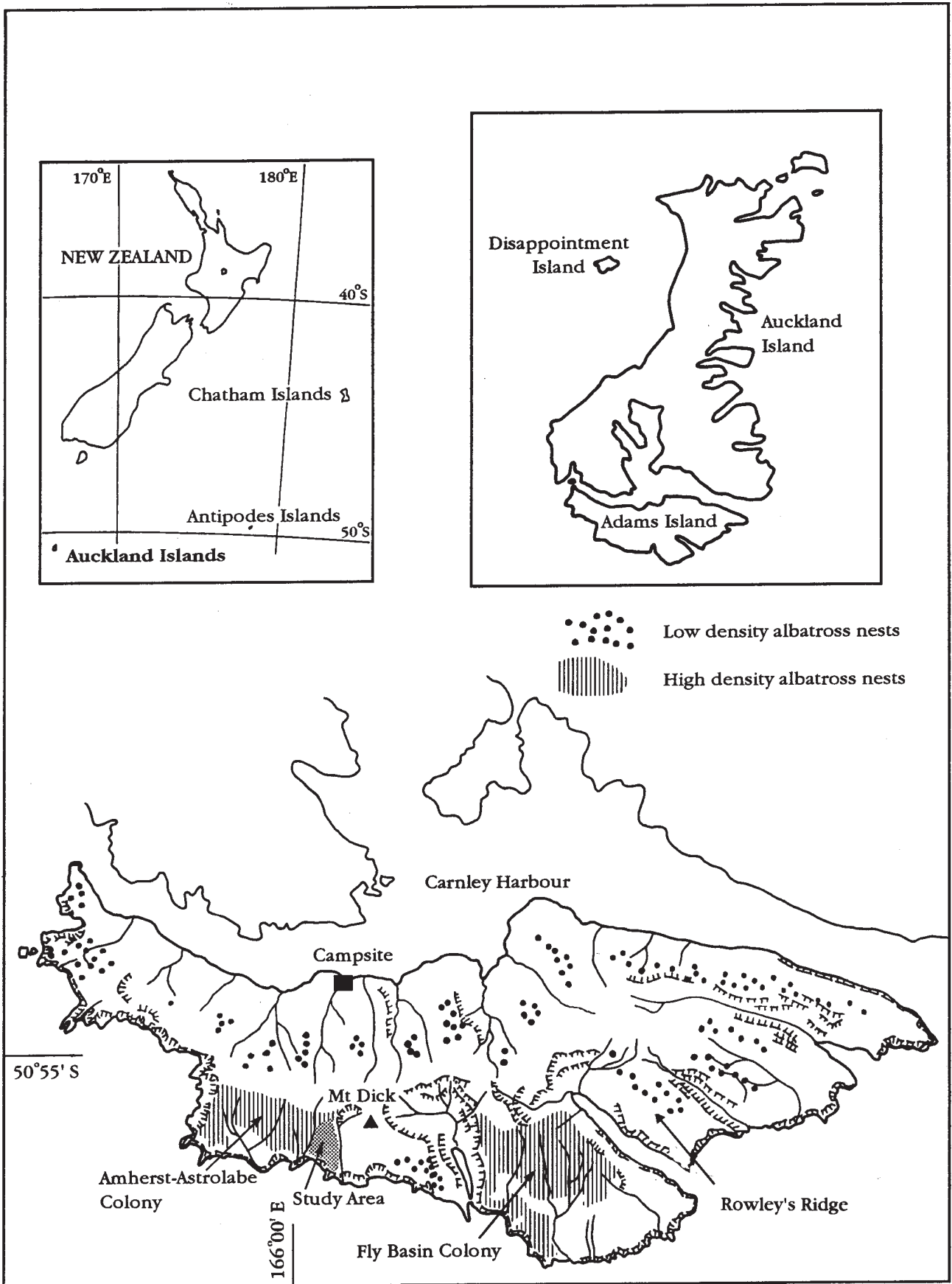


Figure 1. Distribution of nesting areas of Gibson's wandering albatross on Adams I. in the subantarctic Auckland Is.

2. Methods

In a 53 ha study area within the Astrolabe-Amherst colony we banded 197 birds in January 1991 with numbered stainless steel bands. This comprised the majority of pairs nesting in the study area that year. Attempts to visit Adams I. in 1992 were unsuccessful, but in January 1993, 1994, 1995, 1996, and 1997 the band numbers of all birds present in the study area were recorded and all unbanded nesting birds were banded. In each of these years except 1991, when only a portion of nests were mapped, every nest in use in the study area was individually marked and its location mapped.

Adult wandering albatross show strong fidelity to their colony and nest site and their survival can be calculated from annual checks for banded birds in the study colony. However, the birds' deferred breeding strategy (Tickell 1968) complicates measurement of adult survival. We estimated adult survival for 1993, 1994, and 1995, using the maximum likelihood method of Cormack (1964, 1972). Although all years' recapture data were used to make the estimates, survival in the last year (1997) is inestimable using Cormack's method, and unreliable for the second last year (1996) when used on birds with deferred breeding (Rothery & Prince 1990).

We measured the minimum bill depth, culmen length, bill depth at the base and nail, tarsus length, mid-toe length, wing length and weight of a large sample of birds, and were able to sex a smaller sample by their behaviour. We used discriminant function analysis to develop a method of reliably sexing birds, and assigned a sex to most of the birds nesting in our study area.

Breeding success in 1995 and 1996 was determined from the number of chicks about to fledge from marked nests in early December of each year, but for the 1993 and 1994 seasons breeding success was assessed by inspecting marked nests in early January of the following year, and for 1991 by inspecting marked nests in January 1993. Chicks were regarded as having successfully fledged from nests which were surrounded by a large area of urea-burnt and trampled vegetation, had down, secondary chick nests, and sometimes piles of large black squid beaks nearby.

At the beginning of the 1995 and 1996 seasons, all newly constructed nests in the study area were marked and checked every one or two days to determine the timetable of egg laying. In 1997 a smaller sample of about 25% of the nests in the study area were marked and checked in this fashion.

Nest site fidelity was assessed in 1993, 1994, and 1995 by searching for the last nest used by birds breeding in the study area, and measuring, with compass and tape measure, the distance and direction moved between nest sites.

In 1991, occupied nests on almost the whole of Adams I. were counted, but in 1993 and 1994 only nests in the two main colonies were counted. In 1995 and 1997 almost the whole island was counted again. Occupied nests on Disappointment I. were counted in 1993 and on the southern end of Auckland I. in 1995. All areas on Adams I. with albatrosses were counted at least once between 1991 and 1997, and the two main colonies on Adams I. were counted

in 1991, 1993, 1994, 1995, and 1997. While up to 10% of *D. e. exulans* eggs (Croxall et al. 1990) and 5% of *D. e. antipodensis* eggs (unpubl. data) are lost by the time egg-laying is complete, the egg-loss rate for *D. e. gibsoni* is unknown. To minimise the variation in census totals caused by early egg loss, we aimed to carry out the counts around the same dates each year. The counts were made as soon after completion of laying as possible: mid to late January in 1997 and early to mid February in all other years.

Nests were counted from the ground except during 1995 and 1997, when parts of Adams I. and the southern end of Auckland I. were counted from a helicopter. During ground counts, the areas to be counted were divided into easily recognised blocks. Within each block, four observers spread out so that they were between 20 and 25 m apart, and then walked in parallel lines through the block, zigzagging where necessary to cover all the ground. Prior to 1997, observers would occasionally move up to 30 m from the next observer. Observers on the outside marked the edges of the counted strip with fluorescent tape or spray paint so that the same ground was not counted twice. In some areas away from the two main colonies, when albatross density was low, different, less accurate techniques were used. Observers either spaced themselves further apart, or birds were counted through binoculars from a vantage point overlooking a block.

In 1997, an attempt was made to assess the accuracy of ground counts. During the counts a spot of paint was sprayed next to each nest. When the count of the block was completed, counters walked once more through it in straight lines at approximately right angles to the routes previously taken. During this walk they checked each nest within 15 m of the line walked and recorded the number of painted and unpainted nests.

In an attempt to assess recent changes in the size of the wandering albatross population at Adams I. we repeated a count undertaken there 24 years ago. On 1 February 1973, Rowley Taylor and Ben Thorpe counted all occupied nests seen along a transect of 'Rowley's Ridge,' on the southern slopes of Adams I. The transect was walked from about noon until mid-afternoon, and all occupied nests seen by eye and binocular were counted (R.H. Taylor, pers. comm.). On 26 January 1997, we repeated this count, with two people walking the same transect, taking the same time, and counting in the same manner.

On 6 February 1997, four people re-counted Rowley's Ridge using the standard parallel strip technique to compare the results from this technique with those of the transect counts.

3. Results

3.1 ADULT SURVIVAL

Survival estimates for 3 years are presented in Table 1. Average male survival of 98% was higher than that of females (96%), but not significantly so ($T = 1.2$, 4 d.f., $P = 0.28$).

TABLE 1. ESTIMATED ANNUAL SURVIVAL RATES OF *Diomedea e. gibsoni* RECORDED ON ADAMS I. (STANDARD ERRORS IN BRACKETS).

	1993	1994	1995	MEAN
All birds	0.96 (0.02)	0.97 (0.02)	0.98 (0.02)	0.97
Males	0.98 (0.03)	0.98 (0.02)	0.99 (0.02)	0.98
Females	0.94 (0.04)	0.95 (0.03)	0.99 (0.02)	0.96

3.2 MORPHOMETRICS AND DISTINGUISHING SEXES

At 20 nests that were closely monitored at the beginning of the 1995 and 1996 breeding seasons, we were able to judge the sexes of incubating birds from their behaviour. We either saw an egg being laid (two nests) or we recorded a changeover at the nest within four days of the egg being laid (18 nests). The arriving birds were assumed to be males, because four days is usually insufficient time for the female to lay, go to sea, and return.

We measured the bills of 33 of these known sex birds and found that males were significantly larger in all bill measurements than females. We used discriminant function analysis to derive rules for assigning sex to birds using bill measurements. The discriminant function is given by:

$0.456 \times \text{min depth} - 0.346 \times \text{max depth} + 5.992 \times \text{depth at nail} + 0.193 \times \text{length}$
with values greater than 263.965 indicating a male.

This function correctly classified all of the birds of known sex. The most powerful single discriminator was bill depth at the nail. The means and standard deviations of bill depth at the nail indicated that birds with nails more than 39.6 mm deep were more likely to be males than females and that in large samples this measure would misclassify only 0.5% of birds. Minimum bill depth was a less reliable discriminator, misclassifying 6% of birds in large samples. Birds with minimum bill depths greater than 34.1 were more likely to be males than females.

Using the rules described above, we assigned sex to all birds we measured. Where a full set of bill measurements was taken, we used the discriminant function; otherwise we used the bill depth at the nail or the minimum bill depth. Where two birds of a pair were assigned to the same sex, the bigger bird in any dimension was assumed to be the male. Table 2 summarises the measurements of male and female *D. e. gibsoni*.

3.4 BREEDING BIOLOGY

The estimated mean breeding success (the number of chicks fledged per breeding pair) in the study area between 1991 and 1997 was 67% (Table 3).

In the summer of 1994/95 the median egg laying date was 6 January. 10% of eggs were laid before the nests were first checked on 30 December and 95%

TABLE 2. MEASUREMENTS OF *Diomedea e. gibsoni* ADULTS, ADAMS ISLAND.

	SEX	<i>n</i>	MEAN	SD	RANGE
Weight (kg)	males	31	6.8	0.8	5.5-8.6
	females	33	5.8	0.7	4.6-7.3
Wing span (cm)	males	30	143.1	3.4	135.9-150
	females	34	138.7	2.9	131.0-143.0
Wing (cm)	males	38	65.9	1.9	62.0-67.0
	females	38	63.5	1.8	60.0-67.0
Tarsus (mm)	males	35	119.3	3.0	108.8-126.0
	females	36	113.2	2.4	106.7-117.0
Mid-toe (mm)	males	40	160.8	4.5	146.1-167.7
	females	50	152.0	3.5	145.0-161.9
Culmen length (mm)	males	362	151.1	4.2	136.1-162.3
	females	371	144.8	3.8	132.7-157.2
Max. bill width (mm)	males	9	42.2	1.4	40.6-45.1
	females	15	40.3	1.1	38.7-42.8
Max. bill depth at base (mm)	males	362	60.2	1.9	54.9-66.7
	females	371	56.8	1.9	43.8-62.2
Min. bill depth (mm)	males	590	35.5	1.3	30.2-42.6
	females	566	32.3	1.1	28.9-38.1
Max. bill depth at nail (mm)	males	362	41.6	1.1	37.5-45.0
	females	371	38.0	0.9	35.4-40.2

were laid by 19 January. The last egg was laid between 2 and 8 February. In 1995/96, nests were not checked until 6 January, by which time 59% of eggs had already been laid. The estimated median laying date was 4 January, 95% of eggs were laid by 16 January, and the last egg was laid between 31 January and 12 February. In 1996/97 the median laying date was 7 January, the first egg was laid on 29 December, 95% were laid by 18 January, and the last was laid on 5 February.

The distance between subsequent nesting attempts of failed breeders that returned the following year, and successful breeders that returned after two years was 20.2 m and 22.5 m, respectively, and not significantly different ($T = 0.622$, 100 d.f., $P = 0.535$). However, failed breeders were significantly more likely to return to the same nest (18%) than successful breeders (1.25%) ($\chi^2 = 7.290$, 1 d.f., $P = 0.007$). Repeated nesting attempts by the same pair did not seem to take them further and further from their first nest site as you would expect if they moved at random. On average the first subsequent nesting attempt was 22.0 m from the initial nest and the second subsequent nest 24.5 m, and this difference was not significant ($T = 0.693$, 120 d.f., $P = 0.489$). In both cases about 5% of nesting attempts were in nests the pair had used before.

TABLE 3. ESTIMATED BREEDING SUCCESS IN THE STUDY AREA BETWEEN 1991 AND 1997. SAMPLE SIZES IN BRACKETS.

1991	1993	1994	1995	1996
67% (88)	78% (139)	68% (122)	63% (191)	61% (221)

3.4 POPULATION MONITORING

Complete counts of the two largest albatross breeding areas on Adams I. were made during the 1991, 1993, 1994, 1995, and 1997 visits and numbers have fluctuated substantially between years (Table 4), largely because of the variable effect of the previous seasons breeding success. The numbers present in 1995 may also reflect a year or two of high recruitment, judging from the number of new, unbanded birds breeding in the study area that year.

For the few parts of the Auckland Is not counted in 1997, but counted in earlier years, we estimated the number of pairs breeding that year by assuming the between-year variation was the same as that recorded in the two largest colonies (Table 5) and extrapolating from the earlier counts.

If changes in the numbers in the two main blocks are representative of changes in the whole population, the total number of pairs attempting to breed each year ranged from 4826 to 7417 with a mean of 5831 pairs (Table 6). Although counts in 1997 appear higher than previous years, the results are not significant ($R^2 = 0.71$, $P = 0.07$) and were probably caused not by a population increase, but by a slightly greater count effort in 1997, the count being undertaken earlier before some nest failures had occurred, and because breeding success in 1996 was low causing many 1996 breeders to return again in 1997.

In 1997 we assessed the accuracy of our counts in four blocks and found that we detected an average of 99.4% of the nests present (Table 7).

On Rowley's Ridge, 206 nests were counted on a transect in 1973. Using a very similar technique, 76 nests were counted on the same transect in 1997. Soon afterwards, using our standard strip technique, 390 nests were found in the same transect.

TABLE 4. NUMBER OF PAIRS OF GIBSON'S WANDERING ALBATROSS BREEDING IN THE TWO MAIN COLONIES ON ADAMS I.

	1991	1993	1994	1995	1997
Amherst-Astrolabe	1056	1054	1034	1368	1422
Fly Basin	2475	2695	2399	3382	3854
Total	3531	3749	3433	4750	5276

TABLE 5. NUMBER OF PAIRS OF *D. e. gibsoni* BREEDING ON THE AUCKLAND IS IN 1997.

	ADAMS I.		AUCKLAND I. ²	DISAPPOINT- MENT I. ³	TOTAL
Amherst- Astrolabe	Fly Basin	All other areas ¹			
1422	3854	1717	72	352	7417

¹ 99% of this area was counted in 1997 and the rest extrapolated from counts in 1995.

² Extrapolated from counts made in 1995.

³ Extrapolated from counts made in 1993.

TABLE 6. ESTIMATED NUMBER OF PAIRS OF *D. e. gibsoni* BREEDING ON THE AUCKLAND IS, EXTRAPOLATED FROM NUMBERS IN THE TWO MAIN COLONIES AND A COMPREHENSIVE COUNT IN 1997.

	1991	1993	1994	1995	1997
Number of pairs	4964	5270	4826	6678	7417

TABLE 7. NUMBER OF *D. e. gibsoni* NESTS MARKED AND RE-COUNTED ON TRANSECTS THROUGH FOUR CENSUS BLOCKS ON ADAMS I. IN 1997.

BLOCK NO.	NESTS COUNTED	NESTS MARKED	PERCENTAGE MARKED
3	30	30	100
4	83	82	98.8
5	60	59	98.3
6	308	307	99.7
Total	471	468	99.4

4. Discussion

4.1 ADULT SURVIVAL

Our three estimates of male and female survival are within the range recorded for other wandering albatross species and show similarly wide inter-annual variation (Weimerskirch et al. 1997; Croxall et al. 1998) causing difficulties in early detection of trends. Croxall et al. (1990) found it took about 10 years to detect long-term decline in the *D. e. exulans* population at South Georgia.

4.2 MORPHOMETRICS

Our measurements show that sexes of *D. e. gibsoni* are most easily distinguished using maximum bill depth at the nail, and that males are larger than females in every measured dimension.

4.3 BREEDING BIOLOGY

Breeding success on Adams I. during 1991-97 (67%) is about the same as that recorded for *D. e. exulans* for the same period on South Georgia (Croxall et al. 1998), but less than on the Crozet Islands (about 75%, Weimerskirch et al. 1997) or for *D. e. antipodensis* on Antipodes I., 1994-97 (76%; K. Walker & G.

Elliott unpubl. data). Breeding success has been slowly rising for *D. e. exulans* at both South Georgia (Croxall et al. 1998) and the Crozet Is (Weimerskirch et al. 1997), but no comparable early information exists for *D. e. gibsoni*.

The median laying date (4–7 January) was earlier than previously reported. Recording a visit to the Amherst–Astrolabe colony on 13 January 1890, Chapman (1891) wrote ‘I do not suppose that one half of the nesting birds were laying yet’. Bailey & Sorensen (1962) quote C.A. Fleming’s field notes for 1943 which suggest that only 42% of birds appeared to have laid by 22 January. The most likely explanation for the apparent change is that the earlier estimates are unreliable, being based on only single-day visits to the islands when it would have been difficult to distinguish between breeding and non-breeding birds.

The laying timetable of *D. e. gibsoni* (29 Dec – 5 Feb; median 4–7 Jan) is about a week later than *D. e. exulans* on Marion I. and Crozet Is (22 Dec – 12 Jan; 20 Dec – 19 Jan, respectively: Marchant & Higgins 1990), two weeks later than *D. e. exulans* on South Georgia and the Kerguelen Is (respectively 10 Dec – 8 Jan, mean 24 Dec, Tickell 1968; and 10 Dec – 15 January, Marchant & Higgins 1990), and three weeks later than its near neighbour *D. e. antipodensis* (K. Walker & G. Elliott unpubl. data) on Antipodes Is.

D. e. gibsoni are less likely to re-use the same nest in successive seasons than are *D. e. exulans*. On South Georgia 20% of *D. e. exulans* re-use the same nest (Tickell 1968) and on the Crozet Is 23.3% of breeders and 37.9% of failed breeders do (Marchant & Higgins 1990). By comparison, only 1.25% of *D. e. gibsoni* breeders and 18% of failed breeders re-use the same nest. In addition, the average distance moved between subsequent nesting attempts is greater for *D. e. gibsoni* (22 m) than for *D. e. exulans* on South Georgia (7 m; Tickell 1968).

The Auckland Is are further from the Antarctic convergence than the other two islands, and are consequently warmer and more thickly vegetated. The differences in nest site fidelity may be a response to these micro-habitat differences, but this aspect remains unstudied.

4.4 POPULATION SIZE AND TRENDS

We estimate that each year between 1991 and 1997, an average of 5831 pairs of *D. e. gibsoni* nest on the Auckland Is. This is the first reasonably reliable estimate of the size of the population.

The 50–100 pairs of *D. e. gibsoni* that nest on the southern end of Auckland I. itself could either be the remnants of much larger numbers of birds that used to breed there, or they could be outliers of the main breeding area which may always have been on Adams I.

The Auckland I. ecosystem has undergone dramatic changes since the early 1800s. Pigs were introduced in 1807, and cats, mice, and dogs between 1806 and 1840 (though dogs subsequently died out) (Taylor 1968). Pig populations went through an irruptive phase (Challies 1975), and the combined effect of high numbers of pigs and the other predators could have decimated albatross nesting colonies, though there is little direct evidence of their effect on albatross populations. However, the evidence that albatross numbers were ever

high on Auckland I. is equivocal. McCormick (1875, 1884) reported 'considerable numbers' of albatrosses on eggs at the northern end of the island (probably Enderby I.) in November 1840, but these were almost certainly royal albatross, as *D. e. gibsoni* do not lay until late December. Castaways on southern Auckland I. found no albatrosses there on four trips to the tops in 1864 (Musgrave 1866). It is possible that albatross numbers had already been greatly reduced before the castaways visited the southern Auckland I., but this would suggest that the pig irruption occurred at least 40 years earlier than Challies (1975) thought it had.

Albatross numbers were very low on Auckland I. by 1944 when a survey team that traversed all the high points on the Auckland Is found 'while Adams Island is a well-established nesting ground for albatrosses, [it] is the only place on the Auckland Islands where they can be found in any great numbers' (Eden 1955).

No systematic counts were made on Adams I. prior to the 1991-97 series, so population trends remain unknown. However, there are indications that the Adams I. population may have been much larger last century.

The earliest published information on the size of the wandering albatross population on Adams I. was by Chapman in 1891. He gives a detailed description of collecting wandering albatross eggs on 13 January 1890 from the Amherst-Astrolabe colony, almost certainly from within the present day study area. He gathered 100 eggs 'from about 25 acres of ground'. A year later, in February 1891, Captain Fairchild 'went up after albatross eggs at the same place ... and we got two hundred eggs on about five acres ... They were more numerous this year ... and were within a few feet of each other, all sitting on their eggs' (Chapman 1891).

Though it is not surprising in a biennial breeder that the theft of one season's eggs resulted in virtually the entire population trying to breed the following year, the original density of nests seems at least twice as high as that found now, even allowing for inaccuracies in the early area measurements. In 1997, in the best season we have recorded, there were only about 50 eggs in 25 acres of the Astrolabe-Amherst colony compared to 100 in an apparently poor season (judging from the number which bred in 1891) in the same general area in 1890.

It is possible that albatross numbers were even higher before Chapman's and Fairchild's visits. Following the discovery of the Auckland Is in 1806, seals were intensively hunted there until the 1830s, when they were virtually extinct (McLaren 1948). They were still occasionally hunted until at least Chapman's visit, since he followed a sealer's track over Adams I. Sealers supplemented their diet with albatross eggs, as did sailors passing the Auckland Is on the trade routes to South America (Goddard 1940), and elsewhere in the subantarctic egg harvesting is known to have had a profound effect on some albatross populations (Tickell 1968).

Members of a Government expedition to the Auckland Is in the summer of 1972/73 spent 19 days banding wandering albatross on Adams I. and estimated there were about 7000 pairs nesting there that year, with about 200 pairs on Disappointment I. and about 50 pairs on Auckland I. (Robertson 1975). They made no attempt to systematically count all the albatross nests; in the very large Fly Basin colony, for example, a day spent banding albatross on a transect line

was the only basis for the population estimate in that area (R. Russ pers. comm.) and elsewhere the assessment was made from transect counts as described for Rowley's Ridge. Our data indicate that such transect counts can underestimate the numbers present by 80%. If the transect counting method used in 1997 on Rowley's Ridge is comparable with that used in 1973, the population on Rowley's Ridge has decreased by 63%. If such a decrease has occurred consistently throughout the Auckland Islands, there must have been about 20 000 pairs nesting there in 1973.

The number of albatrosses breeding each year is highly variable, and comparison of two single counts 24 years apart does not provide a good estimate of population change. However, the 1997 count was above average for the five years of our study and if 1973 was also an above-average year, the real change in population must be something like we measured. If 1973 was a below-average year, then the real population change was even greater than we detected. Comparison of the 1973 and 1997 counts provides an estimate of the minimum decline that occurred over those 24 years.

It is not possible now to know the real size of the wandering albatross population on Adams I. in 1973, let alone 1806, but there are indications that the 1973 estimate of 7000 pairs (Robertson 1975) was very low.

What has been the cause of the apparent decline since at least the early 1970s?

Since the albatross egg collecting last century, there has been no significant disturbance to Adams I., and any changes in *D. e. gibsoni* numbers on Adams I. this century are unlikely to be the result of changes in the breeding grounds. This is also true of Disappointment I., which anyway, because of its size, supports only a small proportion of the total population. Possibly the most likely factor in the apparent decline of wandering albatross on Adams I. over the last 25 or more years is increased mortality through bycatch in the southern ocean long-line fishery. The fishery began in New Zealand waters about 1962 and, from the outset, albatrosses were a bycatch (Murray et al. 1993).

Satellite telemetry studies currently in progress show that both breeding and non-breeding *D. e. gibsoni* routinely forage in the Tasman Sea and the seas to the east of New Zealand (Walker et al. 1995; unpubl. data), and fisheries data indicate their range overlaps with areas used intensively by long-liners (Weimerskirch et al. 1997, Murray et al. 1993). *D. e. gibsoni* were regularly caught by long-liners off the coast of New Zealand (Murray et al. 1993) and recently a bird from our study area was caught north-east of Sydney, Australia, 3300 km from Adams I., while foraging to feed its chick.

Between 1988 and 1992, mitigation measures and reducing fishing effort caused a significant decline in numbers of seabirds caught in New Zealand seas (Murray et al. 1993). It remains to be seen whether the population of *D. e. gibsoni* are responding to these changes in fishing practice.

There are signs of some recovery of *D. e. exulans* populations on the Crozet Is, Kerguelen Is and on Amsterdam I., apparently as fishing effort has declined within the main foraging areas of the breeding birds (Weimerskirch et al. 1997), but not on South Georgia, where a different pattern of fishing exists (Croxall et al. 1998; Prince et al. 1998). The South Atlantic and Indian Ocean wandering albatross studies have shown the relationships with changing fishery location,

extent and practices are complex and the same complexities are already obvious in the New Zealand region.

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