

Nest counts of Stewart Island shags/mapua (*Leucocarbo chalconotus*) in Otago

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ABSTRACT

The Stewart Island shag/mapua (*Leucocarbo chalconotus*) is an endemic New Zealand species that has been classified as 'Nationally Vulnerable' under the New Zealand Threat Classification System. The breeding distribution of this species is split geographically into a northern population along coastal Otago and a southern population on islands in and bordering Foveaux Strait. This study collates and analyses data from the northern population to determine whether this population requires more focussed management to ensure its future sustainability. The species is dichromatic (exhibits two colour morphs) and the two populations can be differentiated visually by differences in ratios of the two morphs. Counts of nests in Otago began in the middle of the 20th century and indicated a rapid northward spread and increase in numbers, quantified as an average 12% annual increase over 15 years; this culminated in a peak of c. 1900 nests in 1987. The subsequent trend is less definitive, but indicates the likelihood of a sustained average decrease of 2% per year. However, the breeding range of this species has continued to spread both north and south, with initiation of nesting at Kinakina Island recorded in 1993, marking a 100-km southward jump that doubled the breeding distribution of the Otago population. We conclude that the Otago population is not at immediate risk and therefore does not require species-specific conservation management. However, since the current status of the Kinakina Island breeding population remains unknown, it is important that an inspection is carried out as soon as possible. We also recommend annual counts of nest numbers at each of the other four breeding locations (Maukiekie Island, Taiaroa Head, Wharekakahu and Green Island), to facilitate the rapid detection of changes in population trends.

Keywords: Stewart Island shag, mapua, *Leucocarbo chalconotus*, population trends, Otago, threatened species

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1. Introduction

1.1 DISTRIBUTION AND ABUNDANCE

The Stewart Island shag/mapua (*Leucocarbo chalconotus*) is a rare, marine species that is endemic to New Zealand. Its distribution is restricted to southern New Zealand, from Oamaru, southeast South Island, to Stewart Island/Rakiura (Lalas 1983, 1993; Marchant & Higgins 1990; Heather & Robertson 2000; Taylor 2000). This distribution is split geographically into a northern population in Otago and a southern population on islands in and bordering Foveaux Strait (Lalas 1983, 1993).

The species is dichromatic (exhibits two colour morphs): adults of the bronze morph are entirely black, and adults of the pied morph are black above and white below; less than 1% of individuals display intermediate plumages. The two populations differ in the ratio of these morphs: the bronze morph predominates in the northern population (65–85% bronze), while the pied morph predominates in the southern population (50–60% pied) (Lalas 1993). Northern birds are also larger than southern birds (Lalas 1993).

Stewart Island shags are colonial breeders that build closely-spaced nest mounds on bare-rock coastal plateaus and slopes that overlook the sea. All large current breeding colonies of both populations are on small islands, with the exception of one colony on the mainland at Taiaroa Head (Watt 1975; Lalas 1983; Marchant & Higgins 1990). Nests are constructed of seaweed or grass consolidated into columnar mounds that reach up to 0.6 m high, have a diameter of 0.4–0.6 m, and are evenly spaced at 1–2 nests/m (Lalas 1983). Nests can be re-used annually (Lalas 1983).

The northern population currently breeds at five locations in Otago and the southern population currently breeds at about¹ six locations on islands in and bordering Foveaux Strait (Fig. 1). Two population estimates have been published for Stewart Island shags, and both encompass the entire species range. The first estimate was deduced from a collation of incidental counts carried out from 1955 to 1975 and indicated that the species totalled about 1500–2000 breeding pairs (Watt 1975). The second estimate was derived from counts carried out in 1980–1981 and totalled 1800–2000 breeding pairs: 900–1000 for each of the northern and southern populations (Lalas 1993).

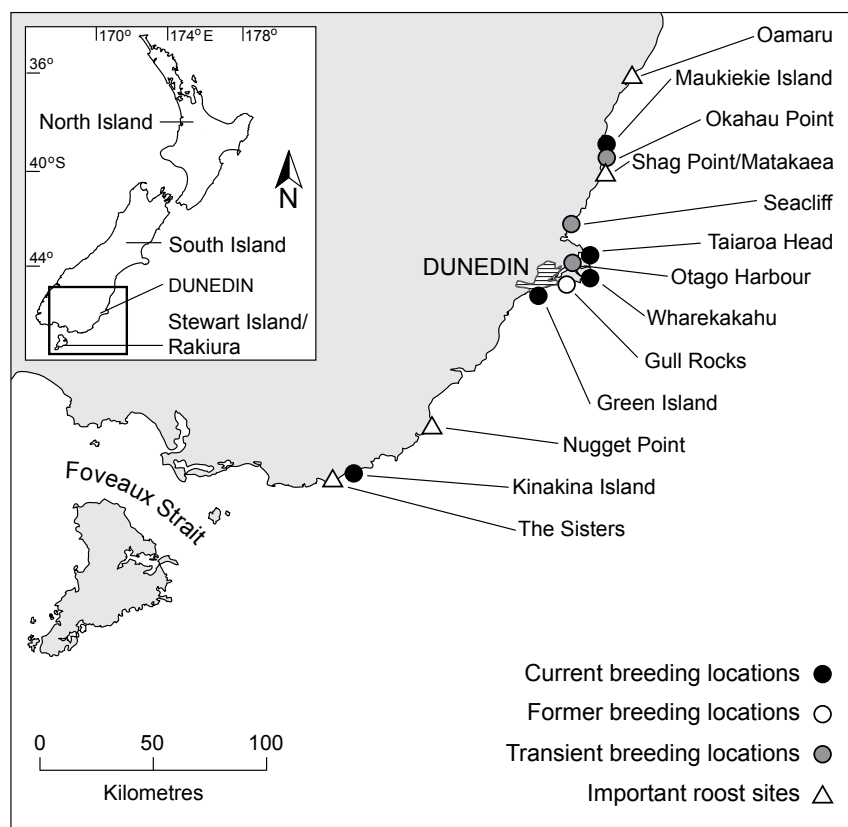
1.2 TAXONOMIC STATUS

The classification and taxonomic relationships of shags are currently in a state of confusion. The total recognised number of shag species worldwide varies from 26 to 40, depending on whether forms are recognised as full species or subspecies. These species are themselves divided between 1–9 genera (reviews in Marchant & Higgins 1990; Johnsgard 1993; Nelson 2005). According to the definitive taxonomic classification of New Zealand birds (Turbott 1990), shags are

¹ Actual number as yet unverified.

Figure 1. Distribution of Stewart Island shags (*Leucocarbo chalconotus*).

The species is separated into two populations: the northern population, which extends from Oamaru south to The Sisters; and the southern population, which is on islands in and bordering Foveaux Strait.



split into three genera: *Leucocarbo*, *Stictocarbo* and *Phalacrocorax*. According to this classification, *Leucocarbo* is a circumpolar genus that encompasses the ‘blue-eyed shags’ through temperate to polar southern latitudes (Turbott 1990).

Worldwide, there are 14 species of ‘blue-eyed shags’, each of which has a restricted, allopatric distribution and a small population (Marchant & Higgins 1990; Johnsgard 1993; Nelson 2005). Six varieties of *Leucocarbo* shags are endemic to the New Zealand region. Kinsky (1970) classified these as two species, each with three subspecies; under this classification, Stewart Island shag was designated as a subspecies of *L. carunculatus* (*L. c. chalconotus*), together with New Zealand king shag (*L. c. carunculatus*) and Chatham Island shag (*L. c. onslowi*). Here, we follow the 1990 classification of Turbott (1990), whereby the six New Zealand varieties of *Leucocarbo* shags were designated as six species, two of which are found on the New Zealand mainland: New Zealand king shag (*L. carunculatus*), which is restricted to the Marlborough Sounds, and Stewart Island shag (*L. chalconotus*). The taxonomic status of these two mainland species could change in the future: Worthy (1996, 1998) and Worthy & Holdaway (2002) have recommended that both should be designated as subspecies of *L. carunculatus* because they lack skeletal differences.

Fossil bones of *Leucocarbo* have been found in northern North Island and along the east coast of the South Island, indicating that these shags were once widespread around New Zealand, and that Stewart Island shags and New Zealand king shags represent relict populations (Worthy 1996, 1998).

1.3 CONSERVATION STATUS

All six species of *Leucocarbo* in the New Zealand region are designated as threatened, due to their restricted distributions and small total populations (Hitchmough et al. 2007; IUCN 2007). The status of the Stewart Island shag has remained unchanged through recent assessments for risk of extinction: since 2000, it has been categorised as ‘vulnerable’ in the IUCN (International Union for Conservation of Nature) Red List (BirdLife International 2000; IUCN 2007), which is the third highest threat category, and as ‘Nationally Vulnerable’ under the New Zealand Threat Classification System (Hitchmough 2002; Hitchmough et al. 2007), which is also the third highest threat category. The key anthropogenic threats to the species have been listed as human disturbance causing disruption of breeding; illegal shooting; drowning in set nets; and predation of accessible birds by introduced mammals (BirdLife International 2000; Taylor 2000; IUCN 2007).

1.4 OBJECTIVES

The desertion of long-established sites and the creation of new ones is a well-documented feature in the breeding activity of Stewart Island shags (Watt 1975; Lallas 1983, 1993), which complicates assessments of chronological trends in nest numbers. Therefore, the purpose of this study was to collate and analyse data from the Otago population to determine whether species-specific conservation management is required to ensure its future sustainability.

2. Methods

2.1 SOURCES OF DATA

Sources of data for nest numbers and breeding activity were separated chronologically into three periods: before 1977, 1977–2000 and 2001–2007.

Data from before 1977 were derived from a number of sources. The key publication was Watt (1975), which provided a collation of all available data up to 1974. Invaluable additions were extracted from records by the two Department of Internal Affairs Wildlife Rangers who were sequentially based at Taiaroa Head: notebooks from the late Stan Sharpe, which are held at Hocken Library, Dunedin; and notebooks and photographs taken over a 3-year period at the Taiaroa Head colony by Alan Wright, who allowed access to these. Other data were extracted from the Ornithological Society of New Zealand's Recording Scheme, results from which have been presented as 'Classified summarised notes' in the journal *Notornis* since 1953.

Data from 1977 to 1999 were mainly collected by co-author C. Lalas. However, unfortunately most of the data collected before 1992 were lost (they were stored in a box that was eaten by rats), so records from 1977 to 1991 rely on published information (Lalas 1983, 1993) or counts recently made from photographs that survived the attention of rodents. In some cases, we decided that counts from photographs superseded previous records. Additional data were extracted from entries by Department of Conservation Wildlife Rangers Isobel Burns and Lyndon Perriman in notebooks held at Taiaroa Head.

Data from 2001 to 2007 were collected by co-author L. Perriman and were derived from direct counts. Counts for nearshore islands were made through a telescope from the mainland.

2.2 DATA MANAGEMENT AND RELIABILITY

In Otago, the timing of the breeding season can vary both geographically and annually. Over a 5-year period, Lalas (1983) found that the absolute range of dates over which reproductive activities took place was: nests built May–September; eggs hatched August–November; and chicks fledged November–January. Since chicks typically fledge from mid-December to early January, we designated a breeding season as 1 calendar year, represented by the year in which it began, e.g. 2001 not 2001/02.

Definitive counts for the number of Stewart Island shag nests at one location in 1 year can only be deduced accurately through continual monitoring throughout the breeding season. This is exemplified by the range of values obtained over 5 consecutive years (2002–2006) of monitoring of a small, discrete group of occupied nest mounds at Taiaroa Head by observers hidden from view of the birds behind a screen set 5–15 m from nests (LP, unpubl. data): there was an average of 17 nests (range = 10–21) in this group, of which an average 90%

(range = 75-100%) had eggs and an average 81% (range = 65-93%) had fledged chicks.

The risk of human disturbance precludes accurate counts being made at most colonies because observers cannot approach unnoticed. Shags incubate with their feet placed under their eggs (Johnsgard 1993; Nelson 2005), so a sudden scare could result in eggs being thrown out of nests as birds become airborne. Consequently, observers approaching on foot can result in the disruption of nesting.

Lalas (1993: 15) stated that 'A census taken during the first half of November is sure to give an accurate count of the number of occupied nests in any year' for Stewart Island shags in Otago. However, although this timing avoids the inclusion of birds that occupy nest mounds but do not lay eggs, it is too late in the season to quantify abandonment in years with failed breeding. Therefore, instead we tried to target counts obtained from 1 month earlier than this—the first half of October—to include birds that occupy nest mounds but do not lay eggs.

Given the imprecision in counts, we consider values for annual nest numbers to have an accuracy of $\pm 20\%$.

2.3 STATISTICAL ANALYSES

Trends for changes in population size through time were analysed as density-independent exponential growth functions, following Neal (2004). This approach generated equations in the form $N_t = N_0 e^{kt}$, where N_t = estimate for population size in year t , N_0 = estimate for population size in year 0, and k = average annual exponential growth rate. Equations and their goodness of fit were generated using Microsoft Excel/Chart. Stochasticity was indicated by the coefficient of determination (r^2), which indicates the proportion of variation among data points that is accounted for by the line of best fit. The average annual (arithmetic) growth rate (average change in population size between consecutive years) was calculated using the formula $e^k = N_t / N_{t-1}$.

3. Results

3.1 LOCATIONS OF BREEDING COLONIES AND RECORDS FOR NEST NUMBERS

The known breeding locations of Stewart Island shags in Otago are depicted in Fig. 1. Details and annual data for nest numbers in Otago for the five current breeding locations, and for a sixth location at which there has been long-term breeding, are presented in Appendices 1–6. The results of these are reviewed below, listed north to south, and are then followed by additional information from transient locations.

3.1.1 Maukiekie Island

Maukiekie Island is located off Moeraki peninsula. There are 14 records of nest number counts from this site spanning 46 years (1962–2007) (Appendix 1). The first verification of breeding at this site was in 1962. An aerial photograph from 1947 (*N.Z. Aerial Mapping Ltd* Survey Number 3810, Run Number D/19) shows the c. 2500-m² plateau fully covered in scrub, with no sign of a Stewart Island shag colony. Hence, we can conclude that breeding here was initiated between 1947 and 1962. Since then, c. 2000 m² of scrub has disappeared off the plateau. Nest numbers increased rapidly from c. 110 in 1974 to c. 920 in 1987, but then decreased to c. 600–760 in 2005–2007.

3.1.2 Taiaroa Head

Taiaroa Head is located at the tip of Otago Peninsula. There are 38 records of nest number counts from this site spanning 68 years (1940–2007) (Appendix 2). The first definitive record for attempted breeding by Stewart Island shags at Taiaroa Head was made by Richdale (1953: 41): ‘19/10/40, 44 seen on rocks at Taiaroa Head; many were juvenals [*sic*]. Others had rudimentary nests and some neck-twining was taking place; none of the nests came to anything’. The first record for successful breeding here was eight nests in 1943. Annual numbers reached 200 nests in 1967, and have fluctuated typically between 300 and 600 nests since 1969.

Buller (1888: 159) presented the earliest description of breeding by Stewart Island shags in Otago in a quote from P. Seymour: ‘A large colony ... built on a terrace at the foot of a small cliff on Otago Peninsula’. Watt (1975: 269) attributed this record to c. 1886 at Taiaroa Head because ‘While Seymour’s description is not an accurate one for the present location, no other site is known’. However, we doubt that there was a colony at Taiaroa Head in the latter half of the 19th century. No white patch indicative of a Stewart Island shag colony appears in a painting of the western (harbour mouth) side of Taiaroa Head entitled ‘Otago Heads N.Z.’ by F. Fodor, dated 6 January 1885 and reproduced in McLean (1985). Also, we have found a location that does suit Seymour’s description: a broad ledge c. 30 m wide by c. 20 m long at 45°52.6’S, 170°44.4’E on the outer coastline of Otago Peninsula near Cape Saunders and c. 0.5 km south of Puddingstone Rock, which is frequented by Stewart Island shags. Buller (1888: 162) also described

seeing two bronze form Stewart Island shags, 'which I observed at the mouth of Port Chalmers in February 1865', without any mention of a colony. We expect that Buller would have visited, or at least mentioned, a colony at Taiaroa Head if one existed there in 1865.

3.1.3 Wharekakahu

Wharekakahu is an island off Otago Peninsula. There have been eight records of nest number counts from this site spanning 30 years (1978–2007) (Appendix 3). The first record for breeding at this site was in 1980, with c. 35 nests. Nest numbers rose steadily to c. 210 in 1984 and then dropped to c. 150 nests in 1987. There was then an 18-year gap in counts until 2005, when c. 130 nests were counted. This number decreased to c. 105 nests in 2006 and c. 46 nests in 2007.

3.1.4 Gull Rocks

Gull Rocks is located off Otago Peninsula. There are 22 records of nest number counts from this site spanning 42 years (1966–2007) (Appendix 4). The date for the initiation of breeding remains unknown. The earliest five records are from 1966 to 1975 and indicate nesting throughout these 10 years; these records include two counts: 60 nests in 1966 and c. 50 nests in 1969. No surveys were made here in 1976 and 1977, but there was no nesting through the next 4 years, 1978–1981. This was followed by the most recent records for nesting at this site: eight nests in 1982 and 20 nests in 1983. No nesting was recorded in any of the 11 surveys through the subsequent 24 years from 1984 to 2007, indicating that nesting at Gull Rocks ceased in the early 1980s.

3.1.5 Green Island

Green Island is located off Brighton, south of the Otago Peninsula. There are 20 records of nest number counts from this site spanning 51 years (1957–2007) (Appendix 5). The date for the initiation of breeding remains unknown. The earliest record of breeding was made in 1957 by Gillham (1960), during a survey of vegetation in shag colonies. The earliest three counts were of c. 60–75 nests in 1968, 1977 and 1979. These were followed by a jump to c. 185 nests in 1980, and typically 100–200 nests annually for subsequent counts up to 2007.

3.1.6 Kinakina Island

Kinakina Island is located off Waipati Beach, the Catlins. One nesting record was made at this site in 1994 (Appendix 6). There is no indication that breeding took place here prior to 1986, as no nest mounds were found during a visit in January 1986 (CL, unpubl. data). However, there were c. 9 nests here during the 1993 breeding season. Therefore, breeding here was initiated between 1986 and 1993. Two more recent surveys outside the breeding season indicate that nest numbers increased after 1993: Graeme Loh (Department of Conservation, pers. comm.) counted 37 nest mounds on 7 April 1996 and 51 nest mounds on 7 July 2001. The current status of this colony remains unknown.

This colony can be reliably allocated to the northern (Otago) population of Stewart Island shags, as there was a predominance of the bronze morph among

adults and juveniles encountered on 8 January 1994: the bronze morph accounted for 38 (69%) of the 55 individuals seen at Kinakina Island and for 36 (77%) of the 47 birds seen near The Sisters (46°39'S, 169°15'E), c. 10 km further west. For the combined total of 97 adults and juveniles seen here, 73% were bronze and 27% were pied.

3.1.7 Additional transient breeding locations (listed north to south)

There are two breeding records from Okahau Point (45°23'S, 170°52'E), which is located midway along Moeraki peninsula: c. 20 nests in 2002 and 2003 on a small rock platform with an area of c. 20–30 m². This small headland, which is described and depicted in Lalas et al. (1999), has been monitored continually since 1981 because it abuts a 1.6-ha Queen Elizabeth II Trust Covenant established to protect breeding yellow-eyed penguins (*Megadyptes antipodes*).

There has been one breeding record from a small islet located 200 m off Seacliff (45°41'S, 170°38'E), Blueskin Bay: one nest in 1980. This location has only been checked at about 3–5-year intervals; at best it could hold about five nests and so could never be an important breeding location.

There have been three breeding records from a platform beacon in Otago Harbour (upper harbour beacon number 13; 45°50.2'S, 170°30.9'E), off Blanket Bay, Roseneath: five nests in 1980 and 1981, and three nests in 1982 on a triangular wooden platform with an area of c. 8 m². This beacon was removed in c. 1983. Otago Harbour has been monitored in most years since 1977 and no other breeding has been recorded (CL, pers. obs.). We found one other record for Stewart Island shags nesting within Otago Harbour: an entry dated 5 October 1957 in S. Sharpe's notebook, which recorded four or five nests on a harbour beacon.

3.2 TRENDS IN NEST NUMBERS

The records presented in Appendices 1–6 provide nine annual estimates for the total number of Stewart Island shag nests in Otago (Fig. 2). The first estimate, which is for 1973–1974 (entered as 1973.5 in Fig. 2), is the sum of the 1974 record for Maukiekie Island, the 1973 record for Taiaroa Head and the chronologically nearest records from the other two locations (1969 for Gull Rocks and 1977 for Green Island). The next five estimates are for 1979, 1980, 1983, 1984 and 1987, and each represents the sum from all breeding locations in those years. The last three estimates are for 2005, 2006 and 2007, and each represents the sum from all breeding locations in those years, with the exclusion of Kinakina Island, for which nest numbers remain unknown.

Estimates for annual nest numbers in Otago showed two different and statistically significant trends through time: the first corresponding to an average 12% annual increase from c. 530 nests in 1973 to c. 1900 nests in 1987; and the second to an average 2% annual decrease from c. 1900 nests in 1987 to c. 1150–1300 nests in 2005–2007 (Fig. 2).

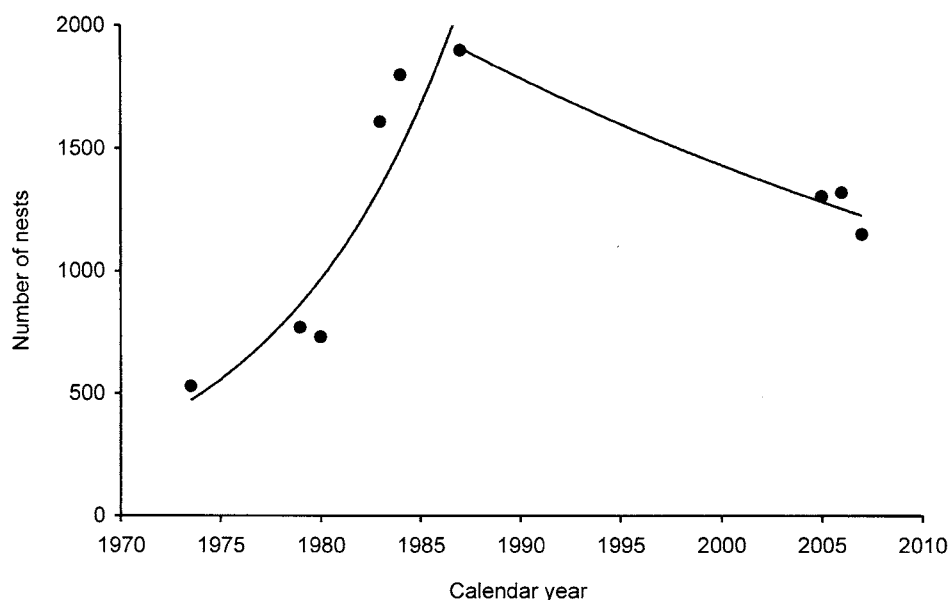


Figure 2. Annual numbers of Stewart Island shag (*Leucocarbo chalconotus*) nests in Otago for the 9 years from 1973 to 2007 with counts for all colonies. The two exponential lines of best fit indicate trends in nest numbers and are presented as average annual arithmetic changes. Left line: average 12% annual increase from 1973 to 1987 ($n=6$, $r^2=0.881$, $P<0.01$; $y=446e^{0.110x}$, where x = years elapsed since 1973). Right line: average 2% annual decrease from 1987 to 2007 ($n=4$, $r^2=0.950$, $P<0.05$; $y=1908e^{-0.022x}$, where x = years elapsed since 1987).

At Taiaroa Head, there was a statistically significant increase in annual nest numbers over the first 45 years from the initiation of breeding, corresponding to an average 10% annual increase from c. 8 nests in 1943 to c. 620 nests in 1987; however, this trend visually did not closely track nest numbers (Fig. 3). Therefore, we also analysed nest numbers at Taiaroa Head from 1973 to 2007, which is the same period as depicted in Fig. 2 for Otago. This showed that there were two different and statistically significant trends through time, which are concomitant with trends seen in the Otago population: an average 4% annual increase from c. 310 nests in 1973 to c. 620 nests in 1987 (excluding the anomalous 70 nests in 1980), followed by an average 5% annual decrease from c. 570 nests in 1996 to c. 315 nests in 2007 (Fig. 3). Five years (1991–1995) were not included in these analyses because numbers fluctuated erratically between 250 and 540 nests (Fig. 3).

At Maukiekie Island, nest number records spanned the same 9 years as for the total number of Stewart Island shag nests in Otago. Again, there were two separate trends in this dataset, but only the first of these was statistically significant (Fig. 4). This corresponded to an average 19% annual increase from c. 110 nests in 1974 to c. 920 nests in 1987. The apparent average 1–2% annual decrease from the recorded peak years in the 1980s to the recent c. 650–760 nests for 2005–2007 was not statistically significant.

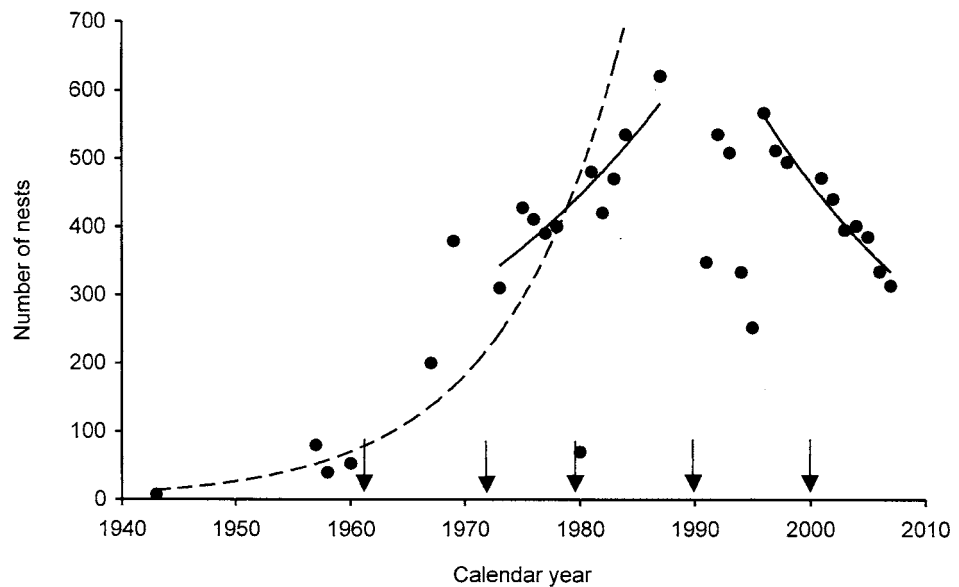


Figure 3. Annual numbers of Stewart Island shag (*Leucocarbo chalconotus*) nests at Taiaroa Head counted in 32 years from 1943 to 2007. Nest numbers were also obtained for an additional 5 years (1961, 1972, 1979, 1990 and 2000; indicated by arrows), but these were excluded from analyses due to failed breeding. Exponential lines of best fit indicate trends in nest numbers and are presented as average annual arithmetic changes. Dashed line: average 10% annual increase from 1943 to 1987 ($n = 16$, $r^2 = 0.901$, $P < 0.001$; $y = 10.3e^{0.096x}$, where x = years elapsed since 1943) (excludes anomalous year 1980 with 70 nests). Left solid line: average 4% annual increase from 1973 to 1987, the same period of increase depicted in Fig. 2 ($n = 10$, $r^2 = 0.795$, $P < 0.001$; $y = 343e^{0.038x}$, where x = years elapsed since 1973) (excludes anomalous year 1980 with 70 nests). Right solid line: average 5% annual decrease from 1983 to 2007 ($n = 10$, $r^2 = 0.939$, $P < 0.001$; $y = 5622e^{-0.048x}$, where x = years elapsed since 1983).

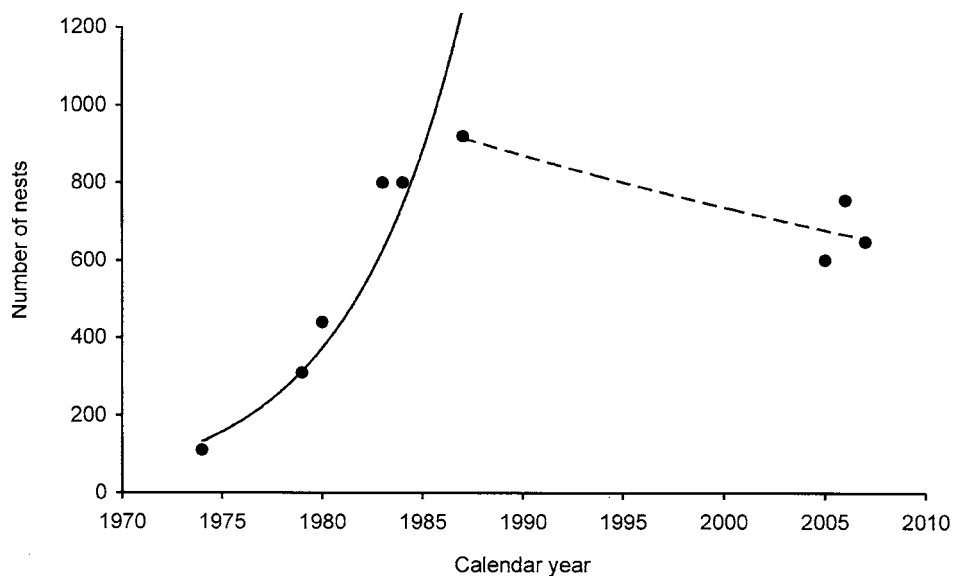


Figure 4. Annual numbers of Stewart Island shag (*Leucocarbo chalconotus*) nests at Maukiekie Island counted in 9 years from 1974 to 2007. The two exponential lines of best fit indicate trends in nest numbers and are presented as average annual arithmetic changes. Left (solid) line: average 19% annual increase from 1974 to 1987 ($n = 6$, $r^2 = 0.933$, $P < 0.01$; $y = 132e^{0.173x}$, where x = years elapsed since 1974). Right (dashed) line: the apparent average 1-2% annual decrease between the recorded peak years (1983-1987) and the last 3 years (2005-2007) is not statistically significant; the line plotted here is from 1984 to 2007 ($n = 5$, $r^2 = 0.611$, $P > 0.05$; $y = 866e^{-0.012x}$, where x = years elapsed since 1984).

3.3 FAILED BREEDING YEARS

Failed breeding years are defined qualitatively as years when no nesting occurred at a particular location or when all, or practically all, nests were abandoned before chicks fledged.

At Taiaroa Head, five breeding failures were recorded in the 65-year span of breeding records from 1943 to 2007 (Fig. 3; Appendix 2). The five failed breeding years spanned a 37-year period and occurred at approximately 10-year intervals (range 7–11 years). In the first two failed years (1961 and 1972), no eggs were seen. In the other three failed years, nesting began but was abandoned: in 1979, c. 400 nests were occupied in October but no chicks were fledged; in 1990, there were only c. 13 nests with eggs, and all but three of these were abandoned in late October and only one chick was fledged; and in 2000, occupied nests were not counted but only four chicks were fledged. It should be noted that we are unsure of the accuracy of records for the number of failed years before CL began surveys in 1977. Field notes by rangers at Taiaroa Head highlighted any obvious atypical activity by local seabirds, but nests of Stewart Island shags were out of view from the land before the colony moved c. 50–100 m in 1980.

We also found records for failed years at two other Otago breeding colonies: 2 years at Maukiekie Island (Appendix 1) and 2 years at Green Island (Appendix 5).

Records indicate that there was only 1 year during which breeding failure occurred at more than one location: 1990 was a failed year at all three locations. For three other records, failed breeding was recorded at one site but neither of the others: no nesting at Maukiekie Island in 1967 corresponded to an apparently normal year at Taiaroa Head (no data for Green Island); failure at Green Island in 1978 corresponded to a normal year at Taiaroa Head (no data for Maukiekie Island); and failure at Taiaroa Head in 1979 corresponded to a normal year at both Green Island and Maukiekie Island.

3.4 IMPORTANT ROOST SITES

Roost sites are locations that birds occupy overnight away from breeding colonies. Lallas (1993) listed three locations for roost sites that were continually occupied by the northern (Otago) population of Stewart Island shags: islets off Shag Point/Matakaea (45°28'S, 170°50'E); North Otago and Nugget Point (46°27'S, 169°49'E), the Catlins; and various sites within Otago Harbour. These three remain the most important roost site locations, each with c. 100–150 birds. However, the number and distribution of roost sites have increased, spreading along the coast in both directions. All known roost sites with more than 20 birds are listed below north to south, together with an indication of numbers and the proportion of bronze morph birds at locations we have surveyed since 1993.

A northward spread in distribution is indicated by counts made in 1997 and 1998, when the first records for more than five Stewart Island shags roosting north of Maukiekie Island were made in the vicinity of Oamaru, North Otago: two late-afternoon counts of 49 birds (61% bronze) on 13 January 1997 and 34 birds (82% bronze) on 24 February 1998 on a foreshore slope south of

Bushy Beach at Cape Wanbrow (45°08'S, 170°59'E). The largest numbers recorded on islets off Shag Point were 98 birds (66% bronze) on 16 March 1994 and 173 birds (69% bronze) on 23 January 2001 (both early-morning counts).

The main roost site within Otago Harbour is on the foreshore slope at the northwestern tip of Quarantine Island (45°49.7'S, 170°37.8'E), where two evening counts recorded 59 birds (76% bronze) on 17 April 2000 and 72 birds (78% bronze) on 15 May 2000. Elsewhere in Otago Harbour, a total of 5-30 birds roost on three harbour platform beacons: upper harbour number 3 (45°49.8'S, 170°37.2'E), and lower harbour numbers 19 (45°48.0'S, 170°38.6'E) and 10 (45°47.9'S, 170°42.3'E).

We have found only two roost sites along the outer coastline of Otago Peninsula. The more northern is on the broad ledge at 45°52.6'S, 170°44.4'E near Cape Saunders, which was mentioned earlier as the likely location of the breeding colony at Otago Peninsula described in Buller (1888) (see section 3.1.2). The largest number recorded from here was 100 birds (61% bronze), seen during an early-morning count on 19 November 2007. Further south, Stewart Island shags frequent Gull Rocks, but numbers at this site remain unknown because we lack early-morning or late-afternoon counts.

Islets off Nugget Point remain the most important roost site south of Otago Peninsula, exemplified by a late-afternoon count of 148 birds (72% bronze) on 15 April 2003 and an early-morning count of 152 birds (70% bronze) on 6 March 2007. No breeding has been recorded here during typically 2-3 visits per year over 31 years (1977-2007) (CL, pers. obs.). Watt (1975: 270-271) cited 'a report of two downy chicks at The Nuggets in March 1973 - G. Hamel pers. comm.', and Hamel (1973: 352) described this observation as 'Nuggets 3/3/73, two pied, six bronze; behaviour of two suggested parent and chick'. However, the occurrence of chicks in March seems unlikely, as it is at least 1 month later than the fledging of chicks at Taiaroa Head. Regardless of the interpretation of this record, Nugget Point has not as yet become a breeding location.

Kinakina Island, the southernmost roost site listed in Lalas (1993), has now become a breeding location. Our previously mentioned record of 47 birds (77% bronze) near The Sisters on 8 January 1994 indicates a southern extension in distribution of the northern population of Stewart Island shags.

4. Discussion

4.1 RECENT CHANGES IN DISTRIBUTION

During the 1980s, breeding by Stewart Island shags began at Wharekakahu but ceased at Gull Rocks. In the early 1990s, the northern (Otago) population encompassed four breeding locations: Maukiekie Island, Taiaroa Head, Wharekakahu and Green Island (Lalas 1993). Nesting has continued at all four breeding locations and, in addition, nesting was recorded at Kinakina Island during the 1993 breeding season. This record could indicate the creation of a fifth breeding location and a doubling in the extent of the breeding distribution along the coastline (increasing from 85 km to 190 km when regarded as a northeast-southwest strip of coastline).

In the early 1990s, the species' distribution extended from Maukiekie Island, Moeraki, south to a roost site at Kinakina Island, the Catlins (Lalas 1993). The distribution has since spread in both directions: the northern limit has extended 30 km, from Moeraki to a roost site at Cape Wanbrow, Oamaru; the southern limit has extended 10 km, from Kinakina Island to a roost site at The Sisters. This equates to a 20% increase in distribution of the Otago population, from 190 km to 230 km.

4.2 TRENDS IN NEST NUMBERS

Annual nest numbers of Stewart Island shags in Otago tripled over the 15 years from 1973 to 1987, increasing from c. 530 to c. 1900 nests. Most of this increase was attributable to an eight-fold increase from c. 110 to c. 920 nests at Maukiekie Island, which coincided with this becoming the largest breeding colony for all Stewart Island shags. Breeding here was instigated between 1947 and 1962, and marked a 45-km northward spread in breeding distribution from the nearest breeding location, Taiaroa Head.

Over the subsequent 20 years, annual nest numbers appear to have decreased by c. 30%. However, they are still about double the number recorded in the mid-1970s. It should also be noted that this apparent decrease may be an artefact because Kinakina Island is not included in analyses; breeding activity there remains unknown, but the island has the capacity to support up to 200–300 nests annually.

4.3 EFFECTS OF FAILED BREEDING YEARS

At Taiaroa Head, breeding failed five times at c. 10-year intervals from 1961 to 2007. These years were characterised by either no nesting or nests being abandoned before chicks fledged. Lack of data precluded a definitive conclusion about the geographical extent of breeding failures. Records included 4 years with breeding failure at one or more of the three largest Stewart Island shag colonies in Otago, including one that affected all three colonies: the 1990 breeding season (August 1990 – January 1991). The causes of breeding failures remain unknown, but this failed breeding season was preceded by a unique peak in the number of Stewart Island shags found dead by the Ornithological Society of New Zealand's Beach Patrol Scheme, which began in 1943: a total of 49 birds were found dead in 1990 (43 in Otago and six further south), and 37 (75%) of these were found in January–April. This 1990 total was five times the usual annual number and double the previous peak (Powlesland et al. 1993).

Failed breeding years have occurred both through periods of increase and periods of decrease in nest numbers, and so have not had a perceptible effect on longer term trends.

Failed breeding years may prompt the movement of breeders among existing colonies and the creation of new breeding locations (Lalas 1983, 1993). For example, the failed breeding year at Taiaroa Head in 1979 was followed in 1980 by the initiation of breeding at Wharekakahu and a tripling of nests at Green Island, from c. 60 to c. 185 nests. Nest numbers at Wharekakahu then increased rapidly from the initial c. 35 in 1980 to c. 210 in 1984. Stewart Island shags take 3 years to attain adult plumage (Lalas 1983; Marchant & Higgins 1990), so most of this increase must have come from immigration.

4.4 REVIEW OF THREATENED SPECIES STATUS

The latest assessment of the threatened species status of Stewart Island shags by the IUCN was made in 2006 (IUCN 2007). This assessment classified the species as Vulnerable, with the following 'justification': 'This species is classified as Vulnerable because it has a small range and is restricted to a small and decreasing number of colonies. Although it is known to abandon and reoccupy sites over decades, the loss of a comparatively large number of localities in recent years is of concern. It is not clear whether the number of birds is declining as a result'.

Otago has not lost any colonies of Stewart Island shags in recent years. The last loss of an established colony was at Gull Rocks in the mid-1980s, but this was more than compensated for by the initiation of breeding at Wharekakahu. Although the number of birds in Otago may be declining, these decreases are not attributable to a loss of colonies. However, the present threat status of Vulnerable remains applicable to the Otago population of Stewart Island shags, because it has a small distribution and breeding is restricted to a small number of colonies.

4.5 RECOMMENDATIONS

Based on the findings from this study, the authors make the following recommendations:

- Annual nest counts should be undertaken at all breeding colonies—This would be a continuation of the annual monitoring that was instigated by L. Perriman in 2005 for four of the five current breeding locations (Maukiekie Island, Taiaroa Head, Wharekakahu and Green Island). The only comprehensive dataset to date is for Taiaroa Head, which shows that analyses of annual data are able to highlight and quantify subtle trends in numbers that are likely to pass unnoticed with infrequent monitoring.
- An immediate assessment of nesting activity at Kinakina Island should be undertaken—Trends in the number of nests here remain unknown and could invalidate our assessment that nest numbers in Otago are decreasing. In addition, the ratio of the two colour morphs needs to be checked again, to verify that this breeding colony represents a southward spread of the Otago population rather than a northeastern spread of birds from Foveaux Strait.
- Population size should be assessed—In this study, we used the number of nests as the quantitative indicator of population size. To estimate the number of birds, more information is required, ideally including dawn or dusk counts of juveniles and unemployed adults ashore during the breeding season. Annual counts from at least one location would serve two functions: they would quantify the reservoir of potential breeders and provide values for parameters needed to create a model to estimate population size.
- Current conservation management should be continued—We conclude that there is no immediate need for species-specific conservation management. The only major threat perceived for the Otago population of Stewart Island shags is vulnerability to mammalian predators at Taiaroa Head, the only current mainland breeding location of the species; however, the Department of Conservation already implements year-round control of mammals at this site. All four current breeding colonies also have adequate legal protection—Maukiekie Island is on Maori Land, Kinakina Island is a Scenic Reserve and the other three are in Nature Reserves.

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Appendix 1

MAUKIEKIE ISLAND, MOERAKI PENINSULA

Location: 45°22'S, 170°52'E; 100 m offshore between Moeraki Point and Tikoraki Point

Land status: Maori Land (c. 0.5 ha)

Description: Flat-topped, cliff-fringed island; c. 90 m × 60 m

Nests: On c. 80 m × 30 m plateau of island (c. 0.25 ha)

TABLE A1.1. RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS AT MAUKIEKIE ISLAND.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1962	Nesting			1962	Watt (1975)
1965	Nesting			2 Nov 1965	McKenzie (1972)
1967	Failed*			24 Oct 1967	McKenzie (1972)
1970	Nesting			1970	A. Wright, Taiaroa Head notebook
1974	110			Oct 1974	Watt (1975)
1979	310	290	340	Nov 1979	C. Lalas photo from mainland
1980	440	400	472	9 Jan 1981	J. Zeldis aerial photo
1983	800			1983	C. Lalas notes
1984	800	771	801	23 Oct 1984	C. Lalas aerial photo
1987	920			13 Nov 1987	Lalas (1993)
1990	Failed*			5 Dec 1990	C. Lalas count from mainland
2005	600	550	650	Oct 2005	L. Perriman count from mainland
2006	760	737	770	Oct 2006	L. Perriman count from mainland
2007	650	643	662	Oct 2007	L. Perriman count from mainland

* Failed breeding recorded in 2 years: no nests in 1967; and ten adults sitting on nest mounds in 1990, but no chicks or fledglings.

Appendix 2

TAIAROA HEAD, OTAGO PENINSULA

Location: 45°47'S, 170°43'E; at and southeast of Howlett Point, at the mouth of Otago Harbour

Land status: Wildlife Sanctuary and Nature Reserve (5.3 ha)

Description: At tip of Otago Peninsula

Nests: Sites spread across 150 m of west-facing and southwest-facing slopes

TABLE A2.1 RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS AT TAIAROA HEAD.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1940	0			19 Oct 1940	Richdale (1953)
1943	8			-	S. Sharpe notebook, Sept 1958
1957	80			-	S. Sharpe notebook, Sept 1958
1958	40			-	S. Sharpe notebook, Sept 1958
1960	53			-	S. Sharpe notebook, 1960
1961	Failed*			-	S. Sharpe notebook, 1961
1967	200			28 Oct 1967	McKenzie (1972)
1969	380	341	418	25 Aug 1969	A. Wright, photo from sea
1972	Failed*			3 Oct 1972	A. Wright, Taiaroa Head notebook
1973	310			Sept 1973	Watt (1975)
1975	430	415	440	Jan 1976	A. Wright, photo from sea
1976	410	392	429	Feb 1977	A. Wright, photo from sea
1977	390			15 Nov 1977	Lalas (1993)
1978	400			Oct 1978	Lalas (1993)
1979	Failed*			-	C. Lalas notes and photos
1980	70	70	85	Nov 1980	C. Lalas (1993) and photos
1981	480	425	481	Oct 1981	C. Lalas notes and photos
1982	420	401	444	Nov 1982	C. Lalas photo from sea
1983	470	443	480	19 Nov 1983	C. Lalas photo from sea
1984	540	519	550	8 Nov 1984	C. Lalas aerial photo
1987	620			1987	Lalas (1993)
1990	Failed*			26 Oct 1990	L. Perriman, Taiaroa Head notebook
1991	350	315	380	Nov 1991	C. Lalas photo from sea
1992	540	525	544	Nov 1992	C. Lalas photo from sea
1993	510	490	526	Dec 1993	C. Lalas photo from sea
1994	330	312	354	2 Dec 1994	C. Lalas photo from sea
1995	250	239	264	30 Nov 1995	C. Lalas photo from sea
1996	570	526	607	Nov 1996	C. Lalas photo from sea
1997	510	463	558	15 Oct 1997	C. Lalas photo from sea

Continued on next page

Table A2.1—continued

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1998	490	465	522	Nov 1998	C. L alas photo from sea
2000	Failed*			31 Oct 2000	I. Burns, Taiaroa Head notebook
2001	470			Sept 2001	L. Perriman count from sea and land
2002	440			Oct 2002	L. Perriman count from sea and land
2003	395			Oct 2003	L. Perriman count from sea and land
2004	400			Oct 2004	L. Perriman count from sea and land
2005	385			Oct 2005	L. Perriman count from sea and land
2006	335			Oct 2006	L. Perriman count from sea and land
2007	315			Oct 2007	L. Perriman count from sea and land

* Failed breeding recorded in 5 years: no nests in 1961 and 1972; c. 400 nests in 1979; c. 23 nests in 1990; and no records for nest numbers in 2000.

Appendix 3

WHAREKAKAHU, OTAGO PENINSULA

Location: 45°53'S, 170°42'E; 300 m offshore between Cape Saunders and Allans Beach

Land status: Nature Reserve (2 ha)

Description: Flat-topped, cliff-fringed island; about 200 m × 150 m

Nests: Sites at edge of plateau

TABLE A3.1. RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS AT WHAREKAKAHU.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1978	0	-	-	-	C. Lalas notes
1979	0	-	-	-	C. Lalas notes
1980*	35	35	45	1980	C. Lalas aerial photo
1982	95	90	103	24 Feb 1983	C. Lalas count of mounds [†]
1983	130			1983	Lalas (1993)
1984	210	206	229	23 Oct 1984	C. Lalas aerial photo
1987	150	138	165	13 Nov 1987	C. Lalas aerial photo
2005	130	120	140	Oct 2005	L. Perriman count from mainland
2006	105			Oct 2006	L. Perriman count from mainland
2007	46			3 Nov 2007	L. Perriman count from mainland

* Earliest known record for nesting.

[†] Count of nest mounds after the end of the 1982 breeding season was considered accurate because all nest mounds were occupied.

Appendix 4

GULL ROCKS, OTAGO PENINSULA

Location: 45°54'S, 170°39'E; 500 m offshore between Seal Point and Harakeke Point

Land status: Wildlife Sanctuary

Description: Four islets; the largest a pyramid about 90 m × 60 m

Nests: On north-facing slope of largest islet

TABLE A4.1. RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS AT GULL ROCKS.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1966	60			24 Sept 1966	Poppelwell (1972) and Watt (1975)
1969	50	Unknown	53	1969	Lands and Survey notes*
1971	Nesting			1971	A. Wright, Taiaroa Head notebook
1973	Nesting			1973	Lands and Survey notes*
1975	Nesting			1975	A. Wright, Taiaroa Head notebook
1978	0				C. Lalas notes
1979	0				C. Lalas notes
1980	0				C. Lalas notes
1981	0				C. Lalas notes
1982	8			20 Dec 1982	C. Lalas count ashore
1983	20			1983	C. Lalas notes
1984	0			23 Oct 1984	C. Lalas aerial photo
1987	0			13 Nov 1987	C. Lalas aerial photo
1994	0			10 Feb 1995	C. Lalas from boat
1995	0			30 Nov 1995	C. Lalas from boat
1996	0			18 Feb 1997	C. Lalas from boat
1997	0			4 Feb 1998	C. Lalas from boat
2000	0			8 Jan 2001	C. Lalas from boat
2001	0			16 Nov 2001	C. Lalas from boat
2004	0			15 Mar 2005	C. Lalas from boat
2006	0			20 Feb 2007	C. Lalas from boat
2007	0			19 Nov 2007	C. Lalas from boat

* Entries for 1969 and 1973 were sourced by Rakesh Pandey on 20 October 1983 from files held by the Department of Lands and Survey, Dunedin. The notes for 1969 stated '53 birds on nests'.

Appendix 5

GREEN ISLAND, OFF BRIGHTON

Location: 45°58'S, 170°23'E; 2 km offshore from mouth of Kaikorai Stream

Land status: Nature Reserve (4.5 ha)

Description: Island with a western platform and eastern cone; about 300 m × 200 m

Nests: On north-facing slope

TABLE A5.1. RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS AT GREEN ISLAND.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1957	Nesting			1957*	Gillham (1960)
1968	75	50	100	1968	Watt (1975)
1970	Nesting				Alan Wright notebook
1977	60	50	60	Nov 1977	C. Lalas notes
1978	Failed†				C. Lalas photo from sea
1979	60	59	69	11 Nov 1979	C. Lalas photo from sea
1980	185	179	194	12 Nov 1980	C. Lalas aerial photo
1981	154			2 Sept 1981	C. Lalas count from sea
1982	199			6 Aug 1982	C. Lalas aerial photo
1983	190	189	198	31 Oct 1983	C. Lalas photo
1984	260	252	268	23 Oct 1984	C. Lalas aerial photo
1987	210	199	223	13 Nov 1987	C. Lalas aerial photo
1990	Failed†			8 Nov 1990	C. Lalas count from sea
1991	100	86	110	Nov 1991	C. Lalas photo from sea
1992	125	121	128	8 Aug 1992	C. Lalas photo from sea
1993	170	160	182	2 Nov 1993	C. Lalas photo from sea
1995	180	165	197	25 Nov 1995	C. Lalas photo from sea
2005	189	177	200	Oct 2005	L. Perriman count from mainland
2006	124			1 Oct 2006	L. Perriman count from mainland
2007	143			1 Oct 2007	L. Perriman count from mainland

* Year of survey provided by Captain A.J. Black, MV *Alert* (pers. comm. to C. Lalas, 1980).

† Failed breeding recorded in 2 years: no records for nest numbers in either year.

Appendix 6

KINAKINA ISLAND, THE CATLINS

Location: 46°41'S, 169°22'E; 1 km offshore from Waipati Beach, north of Chaslands Mistake

Land status: Scenic Reserve (c. 0.4 ha)

Description: Slope-topped, partially cliff-fringed island; about 150 m × 50 m

Nests: On east-facing slope

TABLE A6.1. RECORDS FOR NUMBER OF STEWART ISLAND SHAG (*Leucocarbo chalconotus*) NESTS ON KINAKINA ISLAND.

YEAR	NEST COUNT			DATE OF COUNT	SOURCE
	BEST ESTIMATE	MIN.	MAX.		
1985	0	-	-	Jan 1986	C. L alas count ashore*
1993	9	8	10	8 Jan 1994 [†]	C. L alas count ashore*

* Both counts were made with Department of Conservation staff: Greg Lind in 1986 and Brian Murphy in 1994.

[†] 11 chicks, all near fledging; no fledged chicks.

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