Blue penguins (*Eudyptula minor*) at Taiaroa Head and the Otago Peninsula, 1993–95

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ABSTRACT

Blue penguin (*Eudyptula minor*) pairs at Taiaroa Head were monitored during the 1993–94 and the 1994–95 breeding seasons. Sixty-nine breeding pairs were monitored over the 1993–94 season. Egg laying began in June. Eighty-seven pairs were monitored during the 1994–95 season, and egg laying began in August. Two of the monitored pairs produced a third clutch after two unsuccessful clutches. The earlier start of egg laying in the 1993–94 season may have contributed to the higher number of pairs (than in the 1994–95 season) that produced a second clutch. A minimum of 284 breeding pairs were found along the outer coast of the Otago Peninsula during the 1994–95 breeding season. Predation was evident at some sites. At one location, only 5% of the breeding pairs estimated in the 1993–94 season bred in the 1994–95 season. At some sites the number of breeding pairs of blue penguins had increased since 1992.

1. INTRODUCTION

The species

Blue Penguins (*Eudyptula minor*) are the smallest of the world's penguins (Reilly and Balmford, 1975). Breeding blue penguins can be found around New Zealand's coast, on numerous offshore islands of New Zealand, and the coast of southern Australia and Tasmania (Reilly and Balmford 1975). Blue penguins form colonies of variable numbers. They generally favour nest sites below ground level, but in some locations will nest above ground, usually where there is dense ground cover (pers. obs., Green Island 45° 57' S, 170° 23' E; Klomp, *et al.* 1991).

2. THE STUDY AREA

The Otago Peninsula (45° 50' S, 170° 40' E) is situated on the south-east coast of the South Island of New Zealand and is approximately 23 kilometres in length (Figure 1). Its eastern coast is bordered by the Pacific Ocean. Several known blue penguin breeding sites exist on this moderately rugged coast. The western coast is bounded by Otago Harbour. Blue penguins also breed on this coastline, within 1.5 km of the Otago Harbour entrance.

A study of blue penguins at Taiaroa Head (45° 47' S, 170° 44' E) began in the 1992–1993 breeding season (Perriman and McKinlay 1995) and monitoring continued throughout the 1993–94 and the 1994–95 seasons. Three areas were regularly monitored at Taiaroa Head (Figure 2). A description of each is given below. (For a more detailed description of all areas (A–F) see Perriman and McKinlay (1995).).

Area A — A small (c. 0.2 ha), narrow, flat area that is bounded by steep cliffs and the Otago Harbour. For breeding, blue penguins use artificial nest boxes or burrows in soil.

Area C — A steep exposed site. Nests are confined to burrows in grass covered slopes, or under rocks on the beach front. This site is larger than area A (c. 0.3 ha) and penguin nests are exposed to flooding by sea swells during storms.

Area F — An area (c. 0.2 ha) situated west of the northern tip of the headland. It is backed by steep cliffs and bounded by the Otago Harbour. Blue penguin nests are located in rock crevices and under driftwood. Sites for burrows in soil are limited.

3. METHODS

3.1 Definitions

The following definitions have been used when interpreting the data:

Nest site: A burrow or hollow with evidence of use by birds having either excreta, fresh footprints or birds present.

Known nest: A nest site with eggs or chicks.

Possible breeding site: These were defined as those burrows that had no obvious breeding signs other than fresh nest material and an adult bird or copious amounts of adult excreta present. These sites had no egg shell fragments, chick excreta or feather keratin deposited in or outside the nest site.

Breeding pair: A pair that produced eggs.

One clutch pair: A pair that attempted to breed only once and laid only one clutch.

Two clutch pair: A pair that laid two clutches. This definition includes both replacement-clutch and double-breeding pairs. (see below).

Replacement-clutch pair: A pair whose first clutch was lost before the normal completion of incubation (approximately 36 days) resulting in re-nesting and laying a second clutch.

Double-breeding pair: A pair that re-nested after their first clutch of eggs was incubated past the normal incubation period. These pairs may or may not have successfully fledged a chick from their first clutch before re-nesting.

No. of nesting attempts: The total number of nests including both attempts from the two clutch pairs.

No. of eggs laid: The total number of eggs laid.

Dead in egg:	Deserted eggs which when broken open contained a dead embryo.
Eggs lost due to disappearance:	Eggs that disappeared from nests before the end of the normal completion of the incubation period, where no trace of the eggs could be found.
Eggs that failed to hatch due to flooding of nest:	Presumably did not hatch due to flooding of the nest by either heavy rain or encroaching seas.
Deserted eggs:	Eggs abandoned for unknown reasons prior to the completion of the normal incubation period.
Eggs not hatched due to unknown causes:	These eggs were incubated past the normal incubation period, but did not hatch. No distinction has been made here between death of an embryo and infertile eggs.
Reproductive success:	The number of chicks that fledged, divided by the number of eggs that were produced, expressed as a percentage.
Mean chicks fledged per nest:	The total number of chicks that fledged divided by the total number of nests.
Mean fledging success:	The number of chicks that fledgeddivided by the number of eggs that hatched.
Breeding season:	The length of time from after the moult of the previous season to the start of the moult in the following season.

3.2 Taiaroa Head monitoring

Breeding throughout the season was monitored by regularly checking nest sites, recording the breeding status at each nest, and banding and measuring birds. All nest sites at areas A and C were checked weekly between May and March of both the 1993–94 and the 1994–95 seasons. In the 1993–94 season, area F was monitored monthly from May to November. Weekly monitoring of area F began in June 1994 and continued through to February 1995. Known nests at areas B, D and E were counted once between October to November 1994 and 1995.

The recording of predation was based on observations of any known nest/nest site irregularities such as missing chicks, deserted eggs/young chicks, dead carcasses and/or other predator sign.

3.3 Otago Peninsula census

In addition to the monitoring described above, blue penguin breeding locations on the Otago Peninsula (Figure 1) were surveyed during the 1993–94 season. For each location visited, the number of known nests found was combined with the number of burrows that were thought to be possible breeding sites,

giving an estimated total. This survey was completed between August and October 1993.

FIGURE 1. DISTRIBUTION OF BLUE PENGUIN BREEDING SITES ON OTAGO PENINSULA, 1994.

During the 1994–95 season, known nests on the Otago Peninsula were counted between 24 October and 8 November 1994. Apart from sites regularly monitored at Taiaroa Head, only one day-time count was done at each location visited. Possible breeding sites were also counted.

FIGURE 2. LOCATION OF AREAS A–F AT TAIAROA HEAD AND SURROUNDING ENVIRONS.

4. RESULTS

4.1 Taiaroa Head known nest counts

Known nests were counted at the six defined areas at Taiaroa Head (Perriman and McKinlay 1995) during both the 1993–94 and the 1994–95 seasons. Results are summarised in Table 1.

There were no known nesting attempts at area E during either the 1993–94 or 1994–95 breeding season. The increase of monitoring visits to area F in the 1994–95 season resulted in the location of additional nests.

TABLE 1. DISTRIBUTION OF BLUE PENGUIN KNOWN NESTS AT TAIAROA HEAD DURING THE 1993-94 AND 1994-95 BREEDING SEASONS.

AREA:	A [*1]	B [*2]	C [*2]	D [*4]	E [*4]	F	TOTAL
1993-94 known nests	23	15	19	33	0	36 [*3]	126
1994-95 known nests	33	17	24	15	0	45 [*1]	134

Key

[*1] Area monitored weekly during the breeding season.
[*2] Area monitored fortnightly during the breeding season.
[*3] Area monitored monthly during the breeding season.
[*4] Area monitored once during October-November.

4.2 Recoveries of birds banded during the 1992-93 season

By the end of the monitoring period in 1995, 81% of all chicks banded in the 1992-93 season had not yet been recovered since fledging (Table 2). Of the known breeding adults banded at area A in the 1992-93 season, 65% were recovered alive in the 1994-95 season.

Of the birds banded at Taiaroa Head in the 1992-93 season and recaptured in the 1993-94 or the 1994-95 season, area fidelity was strongest for birds banded as known breeding adults. Table 3 shows that of the known breeding adults, only 4-7% of the those birds were recovered at a different area.

For the birds banded of an unknown age and breeding status, 14 of 76 birds recovered in the 1993-94 season were recovered at a different area to that where they were banded. In the 1994-95 season, only 6 of these 14 were recovered; 5 of these were recovered away from the area where they were banded.

Two adults that were banded of an unknown age and breeding status were recovered at Oamaru (80 km north of Taiaroa Head) in the 1993-94 season (D. Houston, pers. comm.). One chick from Taiaroa Head was recovered at Oamaru in the 1994-95 season (D. Houston, pers. comm.). Another chick banded at Taiaroa Head was recovered ashore at Rerewahine Point (Figure 1) in the 1994-95 season.

TABLE 2. 1993-94, 1994-95 RECOVERIES OF CHICKS, KNOWN BREEDING ADULTS AND BIRDS OF UNKNOWN AGE AND BREEDING STATUS THAT WERE BANDED AT TAIAROA HEAD IN THE 1992-93 SEASON.

	BANDED 1992-93	RECOVERED 1993-94	RECOVERED 1994-95
Number of chicks banded at areas A-F	107	14 (13%)	20 (19%)
Number of known breeding adults banded at areas A-F	116	72 (62%)	41 (35%)
Number of known breeding adults banded at area A	20	15 (75%)	13 (65%)
Number of birds banded of unknown age and breeding status at areas A-F	153	76 (50%)	42 (27%)
Number of birds of unknown age and breeding status banded at area A	33	24 (73%)	13 (39%)

TABLE 3. 1993–94, 1994–95 RECOVERIES OF CHICKS, KNOWN BREEDING ADULTS AND BIRDS OF UNKNOWN AGE AND BREEDING STATUS; INCLUDING RECOVERIES FROM SITES OTHER THAN WHERE THEY WERE BANDED IN THE 1992–93 SEASON.

	RECOVERED 1993–94	RECOVERED AT ANOTHER SITE 1993–94	RECOVERED 1994–95	RECOVERED AT ANOTHER SITE 1994–95
Number of chicks recovered from those banded at areas A–F (1992–93)	14	7 (50%)	20	9 (45%)
Number of recoveries of known breeding adults banded at areas A–F (1992–93)	72	3 (4%)	41	3 (7%)
Number of recoveries of known breeding adults banded at area A (1992–93)	15	0	13	0
Number of recoveries of birds banded at areas A–F (1992–93), banded of unknown age and breeding status	76	14 (18%)	42	7 (16%)
Number of recoveries of birds banded at area A (1992–93), banded of unknown age and breeding status	24	9 (38%)	13	2 (15%)

4.3 Breeding success at Taiaroa Head

63 % of eggs produced at area F disappeared (Table 4). At area C, the greatest cause of egg failure was flooding of nests by sea or by rain (20%). The mean number of eggs produced per pair from area F was lower than either mean obtained from areas A or C. In contrast, area F had the highest mean for the 1994–95 season (Table 5).

TABLE 4. EGG PRODUCTION AT TAIAROA HEAD 1993–94.

	AREA A	AREA C	AREA F
Number of breeding pairs	23	19	27
Ratio of 1 : 2 : 3 clutch pairs	10:13:0	11:8:0	24:3:0
1st-clutch success of the two-clutch pairs	11 of 13	6 of 8	0 of 3
Number of eggs produced	70	50	52
Mean of number eggs laid per pair	3.0	2.6	1.9
Number of eggs not hatched due to: Dead in egg	0	3	0
Number of eggs not hatched due to: Broken	6	3	12
Number of eggs not hatched due to: Disappeared	0	0	33
Number of eggs not hatched due to: Nest flooded	0	10	0
Number of eggs not hatched due to: Nest deserted	9	3	0
Number of eggs not hatched due to: Unknown causes	7	5	5
Number of eggs hatched	48 (69%)	26 (52%)	2 (4%)

TABLE 5. EGG PRODUCTION AT TAIAROA HEAD 1994–95.

	AREA A	AREA C	AREA F	
Number of breeding pairs	32	17	38	
Ratio of 1 : 2 : 3 clutch pairs	23:9:0	13:4:0	15:21:2	
1st-clutch success of the two-clutch pairs	6 of 9	1 of 4	7 of 21	
Number of eggs produced	79	42	112	
Mean number of eggs laid per pair	2.5	2.5	2.9	
Number of eggs not hatched due to: Dead in egg	0	0	0	
Number of eggs not hatched due to: Broken	1	2	7	
Number of eggs not hatched due to: Disappeared	2	0	27	
Number of eggs not hatched due to: Nest flooded	0	5	0	
Number of eggs not hatched due to: Nest deserted	9	6	5	
Number of eggs not hatched due to: Unknown causes	5	2	28	
Number of eggs hatched	62 (78%)	27 (64%)	45 (40%)	

61 % of the pairs at area F produced a second clutch. Two pairs at area F, after two unsuccessful nesting attempts, laid a third clutch, a feat that has not been recorded at Taiaroa Head before, although it has occurred at Oamaru (D. Houston, pers. comm.) and in Victoria, Australia (Reilly and Balmford, 1975; Dann and Cullen, 1990).

Although hatching rates at area F were below those obtained from areas A or C, the success of hatching at area F during the 1994–95 season was ten times greater than it was during the 1993–94 season (Table 4).

The Mann-Whitney U test showed significant variations in fledging success between the three areas for the 1993–94 breeding season (Table 6). A statistically significant difference occurred between area A and C ($p = 0.033$). As expected, a highly significant variation between areas A and F ($p < 0.001$) and C and F ($p < 0.001$) occurred. Both areas A and C attained a high fledging success, although slightly higher chick mortality occurred at area C. At area F, there were 30 nesting attempts by 27 breeding pairs (Table 4), but only two chicks hatched during the 1993–94 season. Neither chick fledged.

In contrast to the 1993–94 season, many chicks fledged from area F during the 1994–95 season (Table 7). The differences between the mean number of chicks fledged per pair for the three areas is significant ($p = 0.0001$ using the Kruskal-Wallis statistical test), and it is the high chick mortality (chicks missing from nests) from area F that has strongly influenced this difference.

TABLE 6. BLUE PENGUIN CHICK PRODUCTION AT TAIAROA HEAD 1993–94.

	AREA A	AREA C	AREA F	
Number of pairs	23	19	27	
Number of eggs laid	70	50	52	
Number of chicks hatched	48	26	2	
Number of chicks found dead	3	3	-	
Number of chicks missing	1	2	2	
Number of chicks fledged	44	21	0	
Fledging success	92%	81%	0%	
Reproductive success	63%	42%	0%	
Mean number of chicks fledged per nest	1.9	1.1	0	

TABLE 7. BLUE PENGUIN CHICK PRODUCTION AT TAIAROA HEAD 1994–95.

	AREA A	AREA C	AREA F	
Number of pairs	32	17	38	
Number of eggs laid	79	42	112	
Number of chicks hatched	62	27	45	
Number of chicks found dead	3	0	0	
Number of chicks missing	2	5	19	
Number of chicks fledged	57	22	26	
Fledging success	92%	81%	58%	
Reproductive success	72%	52%	23%	
Mean number of chicks fledged per nest	1.8	1.3	0.7	

4.4 Variations between the 1993-94 and the 1994-95 breeding seasons at Taiaroa Head.

The mean egg laying dates for pairs in the 1993–94 season was earlier than in the 1994–95 season (Table 8). Possible effects of this on the number of two-clutch pairs, which dropped from 50% of pairs (1993–94) to 27% of pairs (1994–95) are discussed later.

TABLE 8. COMPARISONS OF MEAN EGG LAYING DATES FOR ONE-CLUTCH PAIRS AND THE FIRST AND SECOND CLUTCH OF THE TWO-CLUTCH PAIRS USING NEST DATA FROM AREAS A AND C. 1993–94, 1994–95.

SEASON	ONE-CLUTCH PAIRS	1ST CLUTCH OF THE TWO-CLUTCH PAIRS	2ND CLUTCH OF THE TWO-CLUTCH PAIRS
1993-94	15 August (n=21)	8 August (n= 14)	16 November (n= 14)
1994-95	30 September (n=25)	24 August (n= 11)	27 November (n= 11)

4.5 Otago Peninsula survey

The numbers of nests in the various sites surveyed in the 1993–95 season are shown in Table 9. Of the nests found in the 1994–95 season, 95 % were within 2 kilometres of Taiaroa Head.

At the Hoopers Inlet site, only 1 nest was found during the 1994–95 season, considerably less than the 20 estimated for the 1993–94 season.

TABLE 9. NEST SITE ESTIMATES AND KNOWN NEST COUNTS OF BLUE PENGUINS ON THE OTAGO PENINSULA 1993–95.

SITES VISITED		SEASON		
		1993–94	1994–95	1994–95
	Approximate distance from Taiaroa Head (km)	Known nests and estimated possible nest sites	Number known nests	Possible nest sites
Taiaroa Head	-	150	134	nc
– Otekiho	0.8	0	0	0
– Harington Point	1.2	0	0	0
Rerewahine Point	1.9	20 *1	61	18
Penguin Beach	2	100	75	28
Pipikaretu Beach	3	2 *2 kn	2 *3	nc
Ryans Beach	4	0 *2	0 *3	nc
Victory Beach	5	4	2	2
Allans Beach	12	2 kn	5	2
Hoopers Inlet (South side)	13	20	1	0
Sandymount (sea cave)	14	20 *4	nc	nc
Sandfly Bay	16	0	4	1
TOTAL		318	284	51

nc = not counted
kn = number of known nests, no possible breeding sites are recorded in the figure given.

*1 C. Lalas, pers. comm. (nests estimated: Feb 1994)
*2 H. McGrouther, pers. comm. (known nests counted: Sep 1994)
*3 H. McGrouther, pers. comm. (known nests counted: Jan 1995)
*4 G. Loh, pers. comm. (nests estimated: Aug. 1994)

4.6 Predation

Between the 1991–92 and the 1993–94 seasons, H. McGrouther (pers. comm.) reported a number of dead blue penguins in nest sites at Pipikaretu Beach and he caught ferrets (*Mustela furo*) at blue penguin nest sites.

In April 1994 at area B, five dead blue penguins with puncture wounds to their neck regions were found. An additional 3 adults were recovered alive at this

time, with open wounds to their necks (pers. obs.). Stoats (*Mustela erminea*) were seen in this area at this time (pers. obs.).

In the 1994–95 season, 6 dead birds were found in or nearby previously used nest sites at the Hoopers inlet location. There was no known predation of adults or chicks at Taiaroa Head during the 1994–95 season.

5. DISCUSSION

5.1 Number of known nests at Taiaroa Head

The number of known nests found at areas B, C, and D during the 1993–94 and the 1994–95 breeding seasons was less than was recorded for the 1992–93 season (Perriman and McKinlay 1995). This probably reflects fewer monitoring visits to these areas in the 1993–95 seasons. Both areas A and F have had an increase of known nests since 1992. The availability of more nest sites (nest boxes) at area A has possibly helped to increase the number of pairs breeding at that area (Table 1). There were 57% more known nests at area A in the 1994–95 season than in the 1992–93 season (Perriman and McKinlay 1995). Increased visits throughout the 1994–95 season to area F confirmed additional breeding pairs.

Access difficulties to area F during the 1993–94 season resulted in fewer monitoring visits than at area A or C. During the last monitoring visit at area F, some new pairs of penguins were found on eggs and other pairs were found on their second clutch. Because the fate of these eggs could not be determined, these eggs and the new pairs were excluded from all tables. Therefore, pair and productivity numbers used for area F during the 1993–94 season are minima.

Because of the length of time between monitoring rounds at area F in the 1993–94 season, many failed eggs (63%) had to be categorised as disappeared from nests. Egg failure due to other causes possibly occurred between the monthly monitoring visits.

It is possible that egg and chick loss at area F may have been caused by either flooding of nests or predation by norway rats (*Rattus norvegicus*), as discussed by Stahel and Gales (1987).

Most blue penguins that breed at area B do so in long rabbit burrows, making confirmation of breeding difficult. It is possible that other pairs have bred there but were not found during the 1993–94 or the 1994–95 seasons' survey. At area D, a shift in the nesting site of Stewart Island shags (*Leucocarbo chalconotus*) meant excluding at least 25 blue penguin nest sites from the counts to prevent disturbance of the shags.

5.2 Egg laying and breeding success

The mean egg laying dates of pairs from the 1993–94 and the 1994–95 seasons were compared in Table 8. These data are reproduced in Table 10 along with mean egg laying dates from the 1992–93 season (Perriman and McKinlay 1995).

TABLE 10. COMPARISONS OF MEAN EGG LAYING DATES FOR THE ONE-CLUTCH PAIRS AND THE FIRST AND SECOND CLUTCH OF THE TWO-CLUTCH PAIRS USING NEST DATA FROM AREAS A AND C. 1992–93, 1993–94 AND 1994–95 SEASONS.

SEASON	ONE-CLUTCH PAIRS	1ST CLUTCH OF THE TWO-CLUTCH PAIRS	2ND CLUTCH OF THE TWO-CLUTCH PAIRS
1992–93	19 October (n=25)	15 September (n=13)	9 November (n= 13)
1993–94	15 August (n=21)	8 August (n= 14)	16 November (n= 14)
1994–95	30 September (n=25)	24 August (n= 11)	27 November (n= 11)

For the 1993–94 season, the one-clutch pairs had a mean laying date 6–8 weeks earlier than for the 1992–93 or the 1994–95 season (Table 10). This is a significant difference ($p < 0.001$ using Kruskal-Wallis statistical test) in the commencement of breeding for one-clutch pairs.

There was also a significant difference in the mean laying date of the first clutch of the two-clutch pairs ($p< 0.03$, Kruskal-Wallis). The second clutch of the two-clutch pairs had no significant difference between the mean lay dates.

50% of all pairs from areas A and C produced a second clutch in the 1993–94 season (Table 4). This compares with 29% for the 1992–93 season (Perriman and McKinlay 1995) and 27% for the 1994–95 season (Table 5). The greatest production of second clutches was probably a result of the earlier start of breeding during the 1993–94 season (Table 10).

The definition of two-clutch pairs includes both double-breeding pairs and replacement-clutch pairs. In the 1992–93 season there were more replacement-clutch pairs than double-breeding pairs. By definition, replacement-clutch pairs have a failed first clutch and can, therefore, re-lay much earlier than those double-breeding pairs that have a successful first clutch. Therefore, it is the failure of the replacement-clutch pairs in the 1992–93 season and the success of the double-breeding pairs in the 1993–94 season that has separated the median commencement date of the second clutch of eggs for these two seasons by just one week (Table 10).

Rogers *et al.* (1995) showed that mean laying dates for the first clutch of eggs for little penguins on Lion Island, New South Wales, varied between 9–10 September for the 1992–94 seasons. The 1993–94 mean laying date at Lion Island was one month later than the mean laying date for the first clutch produced by pairs at Taiaroa Head.

In the 1993–94 season, many (81%) of the two-clutch pairs from areas A and C had a successful first clutch (Table 4). This differed from the 1994–95 season, where only 7 of the 13 (54%) two-clutch pairs from areas A and C had successfully fledged chicks from their first clutch (Table 5). It is possible that the production of second clutches of eggs for the 1994–95 season was influenced more by the failure of the first clutch than by the timing of egg production of the first clutch. At area F, 61 % of the breeding pairs produced a second clutch during the 1994–95 season. Many (66%) of the two-clutch pairs at area F had failed to fledge chicks from their first clutch during that season. It is likely that this was the why there were more two-clutch pairs at area F than at areas A and C. Two pairs at area F produced a third clutch, both pairs were

unsuccessful with their first two nesting attempts. Reilly and Balmford (1975) also recorded triple laying by two pairs after two unsuccessful clutches.

Figures 3, 4 and 5 represent the production of eggs laid by blue penguin pairs at areas A and C during the three seasons from 1992 to 1995. Egg production was recorded for each month from June to January of each season. These figures clearly show the differences in egg laying between the three seasons. Breeding started much earlier in the 1993–94 season. For figures 3, 4 and 5, only nesting data from areas A and C was used, as these are the only sites where egg laying dates are known for all three seasons.

5.3 Recoveries of banded birds

Of 20 breeding adults that were banded at area A in the 1992–93 season, 13 were recovered alive in the 1994–95 season (Table 2). The estimated annual mortality for these birds was 19%. Similarly, Reilly and Cullen (1979) gave an estimate of 18.5% annual mortality for birds banded as breeding adults in Australia. Of 116 breeding adults banded at areas A–F in the 1992–93 season, 41 birds were recovered alive in the 1994–95 season. This is substantially fewer than Reilly and Cullen's applied estimate of 77. It should be noted that some areas of Taiaroa Head are monitored less regularly than others; therefore it is probable that other birds are alive and yet to be recovered at Taiaroa Head or elsewhere.

5.4 Otago Peninsula nest counts

Dann (1994) surveyed many sites on the Otago coast in the 1991–92 season, and counted known nests. Dann's estimates, along with data reproduced from Table 9, are shown in Table 11.

A reduction of known nests was recorded for 4 of the Otago Peninsula breeding areas visited between the 1991–92 and the 1993–94 seasons. Since Dann's 1991–92 survey, the number of blue penguin pairs at Sandymount sea cave appears to have increased threefold (Table 11). Estimating and searching for blue penguin nests in this cave can be impeded by a lack of daylight and territorial breeding fur seals (*Arctocephalus forsteri*).

From observations made at Taiaroa Head over the 1992–94 breeding seasons, it seemed that the best time for an estimation of numbers of breeding pairs at other locations on the Otago Peninsula would be in late October or early November. By this time, most birds that are going to breed should have commenced nesting. This period is, unfortunately, also the time when breeding fur seals establish territories. For that reason and because of access difficulties, the Sandymount sea-cave was not surveyed during the 1994–95 season.

Blue penguins occasionally occupy several sites before choosing one in which to breed (Dann 1994). It is important to note that possible breeding sites may have been occupied before or after a breeding pair nested at a known nest.

Some pairs that produce a second clutch do not always re-lay in the nest where their first clutch was laid (pers. obs.). At Taiaroa Head, pairs that laid their second clutch in another nest may have done so because of disturbance to their first nest site e.g., burrow collapsed or flooded (pers. obs.).

FIGURE 3. TIMING OF EGG LAYING FOR THE ONE-CLUTCH PAIRS AT AREAS A AND C, TAIAROA HEAD 1992–95.

FIGURE 4. TIMING OF EGG LAYING FOR THE FIRST CLUTCH OF THE TWO-CLUTCH PAIRS AT AREAS A AND C, TAIAROA HEAD 1992–95.

FIGURE 5. TIMING OF EGG LAYING FOR THE SECOND CLUTCH OF THE TWO-CLUTCH PAIRS AT AREAS A AND C, TAIAROA HEAD 1992–95.

Perriman and McKinlay (1995) recorded 3 double-breeding pairs that produced eggs 1 week after the successful fledging of chicks from their first clutch. This differs from Kinsky (1960) who observed replacement eggs, but only after a period of three weeks or more after the first eggs were lost. Reilly and Balmford (1975) reported the shortest interval between clutches was 2 weeks. Reilly and Balmford (1975) recorded a minimum period of 7 weeks between clutches of double-breeding pairs that had fledged chicks from their first clutch. Rogers *et al.* (1995) noted that there was a range of 0–46 days between clutches.

TABLE 11. NEST SITE ESTIMATES AND KNOWN NEST COUNTS OF BLUE PENGUINS ON THE OTAGO PENINSULA 1991–95.

SITE	1991–92 *	1993–94	1994–95	1994–95
	Estimated Number of nests	Known nests and estimated possible nest sites	Number known nests	Possible nest sites
Taiaroa Head	128	150	134	nc
– Otekiho	1 kn	0	0	0
– Harington Point	6 kn	0	0	0
Rerewahine Point	nc	20 *1	61	18
Penguin Beach	75	100	75	28
Pipikaretu Beach	12	2 *2 kn	2 *3	nc
Ryans Beach	1 kn	0 *2	0 *3	nc
Victory Beach	2	4	2	2
Allans Beach	1 kn	2 kn	5	2
Hoopers Inlet (South side)	nc	20	1	0
Sandymount (sea cave)	6	20 *4	nc	nc
Sandfly Bay	nc	0	4	1
TOTAL	232	318	284	51

* 1991-92 from Dann (1994)
nc = not counted
kn = number of known nests, no possible breeding sites are recorded in the figure given.

*1 C. Lalas, pers. comm. (nests estimated: Feb 1994)
*2 H. McGrouther, pers. comm. (known nests counted: Sep 1994)
*3 H. McGrouther, pers. comm. (known nests counted: Jan 1995)
*4 G. Loh, pers. comm. (nests estimated: Aug. 1994)

Assuming that blue penguins on other Otago Peninsula sites bred at the same time as birds at Taiaroa Head and that some pairs produce two or more clutches in the same season, it is possible that some double counting of pairs was made at other surveyed sites on the Otago Peninsula. This is especially likely if a pair produced eggs in two separate nests and evidence of both clutches was found. Breeding blue penguins at other Otago Peninsula sites did not seem to show significant variations in the breeding season from that of the Taiaroa Head birds. However, this will need to be tested with regular monitoring of other sites distinct from Taiaroa Head before the assumption made here can be validated.

At Penguin Beach, it is possible that an additional 15–25 nests (at least) were not found during the 1994–95 season's count. This estimate is based on the possible number of nests under a large area of tree nettle (*Urtica ferox*). Tall mature tree nettle was searchable and nests were counted. However, adjacent to the larger nettle was an area of younger, smaller tree nettle. It was in this

area that the estimate was applied. This estimate has been excluded from the numbers shown in the result section of this paper. Pairs of blue penguins were also found breeding under tree nettle at Victory Beach. Therefore, other pairs could have been present under the younger tree nettle at this location.

At the Sandfly Bay site, only moulting sites were recorded during the 1993–94 season survey. At the end of the 1993–94 season, employees of the Department of Conservation placed nest boxes along this beach. In the 1994–95 season, some of these boxes were occupied and at least four pairs attempted to breed.

Other people provided valuable information on the distribution of blue penguins on the Otago Peninsula. Different counting techniques, searches, months and years will influence the estimate accuracy. Because of these variables, it is possible that the figures recorded at Rerewahine Point, Penguin Beach and at the Sandymount sea-cave could have higher estimation errors that other sites listed in Table 9.

Two other blue penguin breeding locations have been recorded on the Otago Peninsula (a bay west of Harakehe Point and the coast below Onekapua Cliff, pers. obs., see figure 1). Counts were not done at these locations or at the Sandymount sea-cave as access to each is difficult.

Table 9 showed that 95 % of the Otago Peninsula known nests were found within 2 kilometres of Taiaroa Head. It is expected that this percentage will change when 3 other known breeding sites on the Peninsula are surveyed in subsequent seasons.

5.5 Predation

Blue penguins at 6 of 18 known breeding sites on the Otago Peninsula have disappeared within the last 20 years (A. Wright, pers. comm.). Four other sites listed in Table 9 have reduced populations. Predation is thought to have had some role in many of these reductions. Dann (1992) concluded that at Phillip Island, Australia, predation was the main cause of mortality for banded penguins on land.

The 3 dead birds found at area E at the end of the 1992–93 season were thought to have been predated by a mustelid, but this was not confirmed because of decomposition. In the 1993–94 season there were 14 fewer blue penguin pairs recorded at area B than in the previous season. Mustelids were possibly responsible for predation of five dead blue penguins found at Pilots Beach early in 1994 (pers. obs.). Other blue penguins could have been predated at this time in long burrows where they were unable to be recovered. Further birds may not have bred at all, especially if a pair bond was broken by the loss of a partner.

It is believed that some of the Hoopers Inlet site birds were predated during the 1994–95 season (pers. obs.). If so, it is possible that the reduction of breeding pairs in this area can be at least partly attributed to predators.

At area E in the 1992–93 season, two dead birds were found in separate burrows and one other was found near a previously used nest site (pers. obs.).

6. CONCLUSIONS

Egg laying began earlier in the 1993–94 season than the 1994–95 season. This earlier start is believed to have increased the number of two-clutch pairs in the 1993–94 season. Breeding failure by pairs at area F during the 1994–95 season probably influenced the high percentage (61%) of pairs in this area that produced a second or third clutch. The disappearance of birds at one-third of known breeding sites on the Otago Peninsula in the last two decades and the reduction of pair numbers at 4 of the 12 surveyed Otago Peninsula sites, raises questions about the continued survival of blue penguins on the peninsula. As with many existing colonies on the Otago Peninsula and elsewhere, the extent to which populations have changed is unknown. Small increases of pair numbers have occurred at some studied sites e.g., Sandfly Bay, Allans Beach (Table 11). Further annual surveys are required to determine if recolonization is possible at sites where predation or other factors have severely reduced the colony size and where the only management technique at many of these sites has been to provide nesting boxes. Nesting boxes may, in the short term, boost small colony numbers, but with continued predation pressures it is expected that the smaller populations will perish unless there is protection from predation by introduced mammals.

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8. REFERENCES

Dann, P., Cullen, J.M. 1990. Survival patterns of reproduction and lifetime reproductive output of little penguins *Eudyptula minor* on Phillip Island, Victoria, Australia. Pp. 63–84 *In* Davis L.S. and Darby J.T. (Eds), *Biology of Penguins.* Academic Press, San Diego.

Dann, P. 1992. Distribution, population trends and factors influencing the population size of little penguins (*Eudyptula minor*) on Phillip Island, Victoria. *Emu* 91, 263–272.

Dann, P. 1994. The breeding distribution and abundance of blue penguins in Otago. *Notornis* 41, 157–166.

Kinsky, F.C. 1960. The yearly cycle of the northern blue penguin (*Eudyptula minor novaehollandiae*) in the Wellington harbour area. Records of the Dominion museum 3, 145–218

Klomp, N.I., Meathrel, C.E., Wienecke, B.C., Wooller, R.D. 1991. Surface nesting by little penguins on Penguin Island, Western Australia. *Emu* 91, 190–193.

Perriman, L., McKinlay, B. 1995. The blue penguin (*Eudyptula minor*) at Taiaroa Head, Otago 1992–93. *Science and Research series No. 86*, Department of Conservation, Wellington.

Reilly, P., Balmford, P. (1975) A breeding study of the little penguin (*Eudyptula minor*) in Australia. Pp 161–187 *In* Stonehouse, B. (Ed) *The biology of penguins.* Macmillan: London.

Reilly, P.N., Cullen, J.M. (1979) The little penguin *Eudyptula minor* in Victoria, I: Mortality of adults. *Emu* 79, 97–102.

Rogers, T., Eldershaw, G., Walraven, E. 1995. Reproductive success of little penguins, *Eudyptula minor*, on Lion Island, New South Wales. *Wildlife Research* 22, 709–715.

Stahel, C.D., Gales, R.P., 1987. Little Penguin (:) Fairy Penguins in Australia. New South Wales University Press: Kensington.