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DISTRIBUTION AND STATUS OF COASTAL COLONIES OF SEABIRDS IN VICTORIA

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Abstract

Most of the known seabird colonies around the Victorian coast were surveyed between October and December 1978; others were examined in 1979 and early 1980. Data collected included colony area, nest-site density, associated vegetation and soil depth. There were some 1.45 million burrows of Short-tailed Shearwaters *Puffinus tenuirostris* in Victorian colonies and about 20 000 nest sites of Little Penguins *Eudyptula minor*, the two most abundant species encountered. Earlier estimates of colony numbers or size are reviewed together with survey estimates and the individual species' status is considered and compared with other Australian data. The threats to breeding areas and to the species in Victoria are considered.

Most Victorian seabird colonies are currently secure although some breeding sites are being reduced by land development. Man's increasing use of the coast, and the associated increased predation by dogs, may be locally severe but is of little importance to populations generally. Oil spills and other pollutants present potential threats and possible competition between seabirds and the local fishing industry requires investigation.

Introduction

In a changing environment conflict between the requirements of man and those of wildlife is inevitable. As well as killing or hunting wildlife of all types for food or sport, man affects wildlife indirectly by removing or modifying habitats and by introducing detrimental substances. Consequently populations of animal groups such as seabirds may alter dramatically. In Australia there have been a few attempts to assess the sizes of breeding colonies of seabirds comparable with those conducted in Britain and Ireland (e.g. Cramp, Bourne and Saunders, 1974) or Canada (e.g. Nettleship, 1977) but recently some accounts of island seabird colonies have been published (in the *Australian Bird Bander* and its successor the *Corella*). However, such details are generally lacking for Victorian colonies.

The present study was designed to produce data against which subsequent changes may be evaluated, and from which management procedures may be formulated to retain 'desirable' species at appropriate levels.

Methods

Between October and December 1978, attempts were made to visit the larger coastal islands of Victoria (Figure 1). Some islands were also revisited in 1979; Lady Julia Percy (January); Citadel (February); South Channel (June); Rabbit (December). Wattle Island was surveyed in December 1979 and Dannevig and Norman Islands were visited in January 1980. A few of the smaller islands for which recent details were available were not investigated, nor were the more inaccessible stacks in the Bay of Islands Coastal Park and the Port Campbell National Park. Mainland colonies of some species were also visited, but the data collected are incomplete. Data from published and unpublished sources have been incorporated below. In this survey we consider the following species in detail:

Little Penguin	*Eudyptula minor*
Fairy Prion	*Pachyptila turtur*
Short-tailed Shearwater	*Puffinus tenuirostris*
White-faced Storm Petrel	*Pelagodroma marina*
Common Diving-Petrel	*Pelecanoides urinatrix*
Australasian Gannet	*Morus serrator*
Black-faced Shag	*Leucocarbo fuscescens*
Silver Gull	*Larus novaehollandiae*
Pacific Gull	*Larus pacificus*
Kelp Gull	*Larus dominicanus*
Caspian Tern	*Hydroprogne caspia*
Crested Tern	*Sterna bergii*

Techniques for the estimation of seabird populations, and the accuracy of such estimates, depend largely on the species involved. Methods used tend to be group-specific and vary from direct counts (of nests, or pairs, or eggs, etc.) to sampling segments of colonies and extrapolation of areas occupied. For bur-

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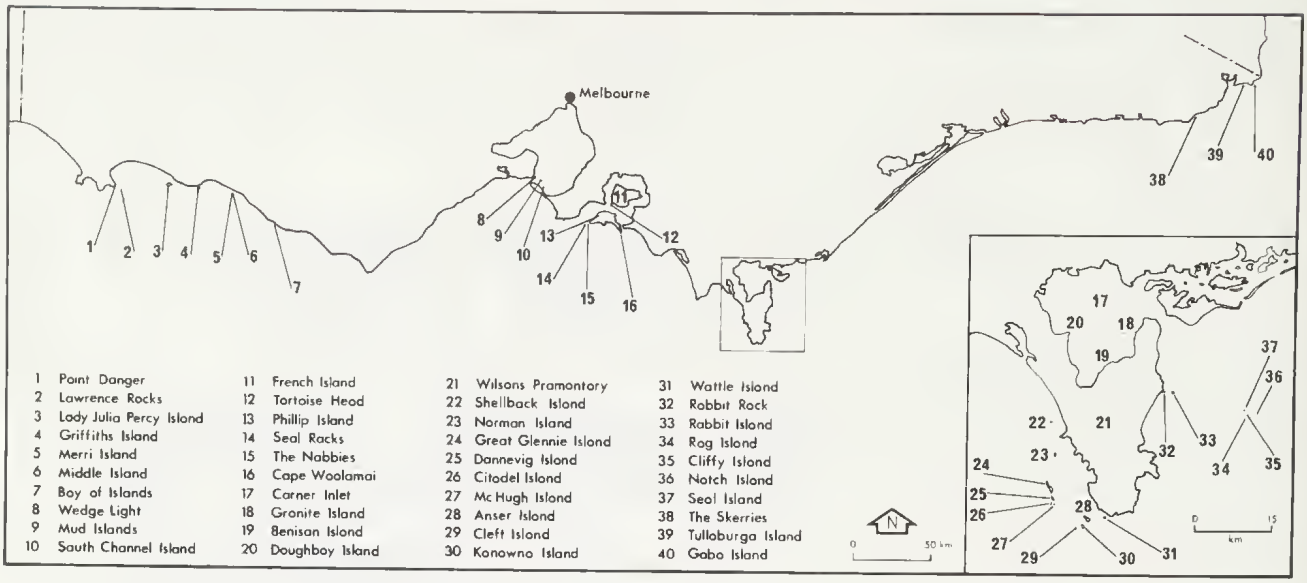

Figure 1. Main localities mentioned in text.

rowing species particular problems exist with temporal variation in occupancy, burrow density (which can be materially affected by substrate) and burrow or colony distribution. Additionally, the identification and numerical determination of nest sites themselves may be difficult or impossible in certain terrain (for further details see Nettleship, 1976). The techniques used in this survey are discussed below: time and weather constraints added to other practical problems. Survey information is summarised in Appendix 1, and further, more descriptive, details may be found in the series of articles on individual islands published mainly in *Corella* (and listed in the references) or in Harris (1979), as may earlier information on the islands.

Existing or potential threats to colonies were recorded. Whilst human disturbance may affect all seabird colonies only observed instances are listed below.

SHORT-TAILED SHEARWATER

The boundaries of colonies usually coincided with changes in vegetation and were marked on local maps or aerial photographs (black and white or colour) of largest available scale. Larger colonies were subdivided, where practicable, according to vegetation or physical features, and areas determined from the scale drawings. However, areas of small colonies were determined by ground measurement. Because no allowance was made for irregular topography the areas of many colonies were slightly under-estimated.

In small colonies, the numbers of burrows showing signs of current usage were counted directly. Elsewhere burrow density was determined by counting burrows in circular quadrats of 20 m². In the larger colonies (e.g. Cape Woolamai), and in those with prominent features (e.g. Griffiths Island, Corner Inlet islands), the quadrats were selected by means of a numbered grid, superimposed on a map or photograph of the colony, and tables of random numbers. In some colonies the quadrats sampled were at irregular intervals of 5-10 m, along a zig-zag path from one side of the colony to the other. The position of the quadrat was determined by throwing a metal rod about 5 m ahead. Quadrats which covered bare rock were always included. Total numbers of burrows in colonies were determined from the product of colony area and mean burrow density; 95% confidence limits are ± 2 SE of the mean density. Most nest sites had only one entrance but some had several; how this affects estimates of breeding pairs is not known. No allowance is made for possible error in delineation of colony boundaries.

For most Short-tailed Shearwater colonies samples of burrow density were sufficient to provide reasonably restricted 95% confidence limits (given as ranges below). The accuracy of such estimates is unlikely to be greatly increased since some quadrats always contain no burrows. However, the largest source of error was in determining the areas of colonies: in low-density colonies with scattered, outlying burrows boundaries were particularly difficult to delineate.

On 1 November 1978, before laying, 56 burrows on Phillip Island were individually marked; on 22 December 46 (82%) held eggs. A further 150 burrows were examined on Great Glennie Island (7-11 December 1978); these held 98 eggs (e.g. 65%). Burrows were also examined on Wattle Island (12 December 1979; 50, 34 occupied).

LITTLE PENGUIN

The above procedure was generally adopted in penguin colonies, but only burrows with adults, young, eggs or accumulations of droppings were counted. Because burrow densities in colonies among rocks, or in thick vegetation (where there tended to be few), were difficult to estimate, the numbers of burrows in the more accessible areas of such colonies were determined and extrapolated to provide estimates of burrow densities. However, on some islands even this proved impossible and only the order of magnitude of burrow densities is proposed below.

Conversion of number of burrows to number of breeding pairs is unreliable in this species, since breeding seasons may be extended and some pairs may breed more than once in a season (Reilly and Balmford, 1975).

WHITE-FACED STORM PETREL

On Tullaberga and South Channel Islands the extent of the breeding colony was marked directly onto an aerial photograph and a map respectively; on the Mud Islands the area of the colony was measured with marked ropes. In all instances burrow densities were measured in circular quadrats of 1 m radius (3.14 m^2).

OTHER SPECIES

On most islands Fairy Prion and Common Diving-Petrel burrows were difficult to find and impossible to census, hence the population sizes of each colony are only general impressions. Nests of Australasian Gannets were counted, as were those of gulls and terns where practicable. When gull colonies were inaccessible the number of pairs holding territories was estimated and added to counts of nests. Replicate counts were not made, but inter-observer differences were minimised since all counts in 1978 were made by the senior author.

Results

1. ISLAND/COLONY DETAILS

Survey dates, methods and results (including population estimates) are summarised in Appendix 1 for the individual islands examined and totals for Little Penguins and Short-tailed Shearwaters given in Table 1. Details for other colonies (not surveyed) are as follows:

Skull (Cleft) Island

Black-faced Shags recently bred on the island (Lane, 1979b) and burrowing species may nest in the apparently sparse vegetation.

Killarney Reef

Some 500 pairs of Silver Gulls and about 200 pairs of Crested Terns have been recorded as nesting (Bowker, 1980a).

Bay of Islands

Hundreds of Short-tailed Shearwaters were seen on a stack off Boat Bay in about 1960 (W. Matheison, *pers. comm.*), and Black-faced Shags bred on one of the islands in the Bay (Reid, Shaw and Wheeler, 1971).

Twelve Apostles

Black-faced Shags were seen sitting on nests in November 1978.

Muttonbird Island

This is a dense but inaccessible Short-tailed Shearwater colony of many thousands of birds. There is a small shearwater colony on the mainland opposite, and the species probably breeds (but in small numbers, since there is little soil) on some of the other stacks in this area.

TABLE 1

Estimates of numbers of burrows of Little Penguins and Short-tailed Shearwaters at colonies in Victoria in 1978.

	Penguin	Shearwater Mean	Range
Lady Julia Percy Island	2000	15300	13100-17400
Lawrence Rocks	109*	0	–
Griffiths Island and Port Fairy mainland	0	52100	45500-58600
Middle Island	10*	0	–
Merri Island	199*	0	–
Other colonies west of Port Phillip Bay	500	10000 +	–
Mud Islands	< 5	0	–
South Channel Island	30-40	0	–
Phillip Island	6000	542300	439300-645300
French Island	?	3100	1800-4400
Granite Island	0	2100	1600-2400
Benison Island	0	7200	5900-8400
Doughboy Island	0	2000	1600-2300
Great Glennie Island	500	400300	334500-456300
McHugh Island	1000	6200	4500-7900
Citadel Island	45*	111*	–
Dannevig Island	hundreds	44600	37800-51300
Norman Island	400-500	145000	131350-158500
Anser Island	hundreds	251700	216200-287100
Kanowna Island	small numbers	52000	38300-65500
Shellback Island	hundreds	109500	87400-131600
Wattle Island	1000	83450	74650-92400
Rabbit Island	500	131000	115200-146600
Rabbit Rocks	100	3800	3200-4300
Seal Island	hundreds	54000	46800-60400
Notch Island	500	6000	4600-7300
Cliffy Island	0	6300	–
Rag Island	hundreds	18200	16100-20300
Skerries Rocks	< 10		–
Tullaberga Island	400-500		–
Gabo Island	5000-10000	7350	5000-9400
Victoria Total	c. 20,000	c. 1.45 million	

* Number counted

The Skerries Rocks

Barton (1978) recorded breeding Little Penguins (7 nesting pairs), Silver Gulls (14) and Crested Terns (28 nests and other runners).

OTHER COLONIES IN SOUTH-WEST VICTORIA

Small numbers of Short-tailed Shearwaters may try to breed regularly at Point Danger but the only definite breeding records are those of Learmonth (1965). Streeter (1979) found 272 freshly dead shearwaters, mostly killed by foxes, between 11 December 1978 and 13 January 1979. Shearwaters also breed at Crofts Bay (G. E. Cerini, *pers. comm.*) and possibly at Flaxman Hill (Dorward, 1976). Little Penguins breed in Port Campbell National Park (130 young banded there in 1979, P. N. Reilly *in litt.* to Fisheries and Wildlife Division), Gibson's Steps (about 300 burrows in two colonies, P. C. Kelly, *pers. comm.*), Three Mile Beach (L. McDonald, *pers. comm.*), Antares (D. McDowall, *pers. comm.*), Flaxman Hill (Dorward, 1976), and Portland Harbour Beach (a colony now much diminished due to changes in the nesting area, G. E. Cerini, *pers. comm.*). Many of these mainland breeding sites are damaged by vandals, and birds are killed by dogs and foxes. No attempt was made to census the mainland colonies of terns or gulls but

known breeding sites are listed in the species accounts.

During this survey we did not find Short-tailed Shearwaters or Black-faced Shags breeding on Lawrence Rocks though Mattingley (1908) recorded them in the past. Little Penguins occasionally breed on the Mud Islands (Kerry and Hall, *in press*), and French Island has been reported as a breeding site (Serventy *et al.*, 1971); we found no breeding birds, and nor were nest sites of penguins, Fairy Prions or Common Diving-Petrels found on Cliffy Island (cf. Campbell, 1900; Gillham, 1962). Common Diving-Petrels were not found on McHugh Island, where Gillham (1962) recorded several hundred burrows, or on Kanowna Island where Lane (1979b) found several burrows, probably of this species. No breeding Silver Gulls or Crested Terns were present on Rabbit Rocks when visited (cf. Gillham, 1961).

2. NUMBERS OF SEABIRDS IN VICTORIA

The following account includes a discussion of the estimated population sizes of some species of seabirds breeding in Victoria. An attempt is made to compare our data with earlier details, though those available give no indication either of accuracy or even of methods used. Victorian data are then considered within an Australian context.

Little Penguin

The total number of burrows in Victoria appears to be in the order of 20 000, of which about 30 per cent are on Phillip Island*, 30 per cent on Gabo Island, 30 per cent on islands off Wilsons Promontory, and 10 per cent elsewhere (mainly on Lady Julia Percy Island, see Table 1). Whilst a few mainland colonies (mainly in the Port Campbell area) may have been overlooked, such small colonies are insignificant compared with possible errors in estimates of birds in the larger colonies or the generalised estimates for some of the Wilsons Promontory islands.

Variability in estimates (Table 2) relate in part to methods used. However, on Gabo Island there seems to have been a reduction in population size (cf. Gillham, 1961), and large variation in numbers breeding may also occur (Reilly and Kerte, 1978). On Phillip Island too, there has been a contraction in numbers of colonies and apparently numbers of birds (cf. Nicholls, 1918 with details in Harris and Bode, 1981).

The species commonly breeds around the southern Australian coast, and Serventy *et al.* (1971) listed some 116 known colonies of which 10 were in Victoria. We found them at 23 sites, and others have reported breeding at a further nine sites. Lane (1979a) summarised information from islands off New South Wales, and estimated some 16 800 breeding pairs, an estimate similar to that for Victoria.

Fairy Prion

The species was breeding on eight islands, and it may have nested on five others. Though an earlier breeding site was not confirmed (Cliffy), the increase in the numbers of Victorian sites is the result of a more comprehensive survey rather than increased range. Numbers were generally small, except on Lady Julia Percy Island where there were probably thousands of birds.

The species breeds on several islands around Tasmania but, again, numbers are generally small except for 'thousands' on Green Island and a 'very large population' on Albatross Island (Green and Mollison, 1961; MacDonald and Green, 1963; and references in Green, 1977). The Bass Strait region is the Australian stronghold of the species, and Victoria has a large proportion of the Australian population.

Short-tailed Shearwater

The number of burrows in Victoria (1978-1980) was estimated as about 1.45 million (see Table 1), many (some 30 per cent of total burrows) were on Phillip Island, and the Seal Group and islands off Wilsons Promontory held a further 63 per cent.

Earlier estimates (Table 2) for some colonies show considerable variation. The fortunes of colonies on Phillip Island are detailed elsewhere; whilst there has been a gradual increase in numbers of colonies it was concluded that the total population had not changed materially in recent times (Harris and Bode, 1981). Some previous estimates for Lady Julia Percy Island appear excessive (Norman *et al.*, 1980),

TABLE 2

Comparison of some earlier estimates of Little Penguin and Short-tailed Shearwater numbers with results obtained during this survey.

	Little Penguin	Short-tailed Shearwater
Lady Julia	5,000-10,000 pairs (McKean, 1962)	2 large colonies (Wood Jones and Tubb, 1937)
Percy Island	1,260 pairs (Seal Bay and Dinghy Cove, Reilly, 1977b)	90,000 burrows (Wheeler, 1965)
	2,000 burrows (Norman *et al.*, 1980)	50,000 burrows (Reid, Shaw and Wheeler, 1971)
		15,300 burrows (Norman *et al.*, 1980)
Phillip Island	20,000 birds (Nicholls, 1918)	colony area 251 ha (Sutton, 1933)
	50,000-100,000 (Reilly in Kay, 1978)	colony area 250 ha (1939, Seddon, 1975)
	c. 6000 burrows (Harris and Bode, 1981)	colony area 129 ha, 542,300 burrows (Harris and Bode, 1981)
	26,500 pairs (Cullen and Reilly, 1981)	
Gabo Island	many thousands (Gillham, 1961)	100 pairs (1959; Gillham, 1962)
	some 10,000 (Reid, Shaw and Wheeler, 1971)	1,000 pairs (Reid, Shaw and Wheeler, 1971)
	20,000-50,000 breeding pairs (Reilly, 1977a)	20,000-50,000 pairs (Reilly, 1977 a,b)
	5,000-9,400 burrows (this survey)	6,000 burrows (this survey)

but the population on Gabo Island has increased from 100 pairs in 1959 (Gillham, 1962). Other populations have also expanded: Griffiths Island (30 000 birds in 1971, Reid, Shaw and Wheeler, 1971; 43 400 burrows in 1978), French Island (colony founded in the early 1960s, 3 100 burrows in 1978), Citadel Island (none in 1959, Gillham, 1961; 111 in 1978), Cliffy Island (less than 100 pairs in 1959, Gillham, 1961; 6 000 burrows in 1978) and Rabbit Island (where there were 44 600 burrows in an area with few in 1965, Norman, 1967).

Victoria holds about 11 per cent of the colonies listed by Serventy *et al.* (1971), though the species increased in numbers and range during 1920-71 (Serventy *et al.*, 1971), and possibly since. The Tasmanian colonies are large and Naarding (1980) reported 133 colonies containing almost 11.5 million breeding birds. Serventy *et al.* (1971) gave Cat Island (c. 250 000 occupied burrows), Furneaux Group, as an example of a large and dense colony; several Victorian colonies are larger than this. In New South Wales, there are an estimated 25 700 breeding pairs, and the species may have increased both in range and numbers since its discovery in 1958 (see Lane, 1979a for details).

White-faced Storm Petrel

About 32 600 burrows were found on Tullaberga Island, Mud and Fort Islands; details of each colony are provided in Harris (1979). A dead bird was found on Kanowna, but if the species does breed there, the population is small. The species is widespread throughout Australia; Serventy *et al.* (1971) listed some 71 breeding colonies, and Lane (1979a) gave an estimate of 10 700 breeding pairs for ten sites in New South Wales.

No earlier details are available for Tullaberga Island but the Mud Islands colony has frequently been examined (for details see Harris, 1979; Kerry and Hall, *in press*). There seems little doubt that the once-extensive colony (10-11 acres in 1907, Mattingley, 1907) has declined: recent estimates have varied between 3 000 and 6 000 burrows (e.g. Wheeler, 1964a; Gayner, 1978).

The species probably colonized South Channel Island some time after 1919, and the colony was well established by 1932 (Gillham and Thomson, 1961). In 1947 the population was estimated at 2 000 birds, in 1964 2 000 burrows (Wheeler, 1964b) and burrows were estimated at 6 800 in 1978, but there is now little unused soil for additional burrows.

Common Diving-Petrel

During this survey the species was found breeding on five islands; it bred on McHugh and Cliffy Islands previously, and may breed on a further six islands (where dead birds were found). The total population was probably

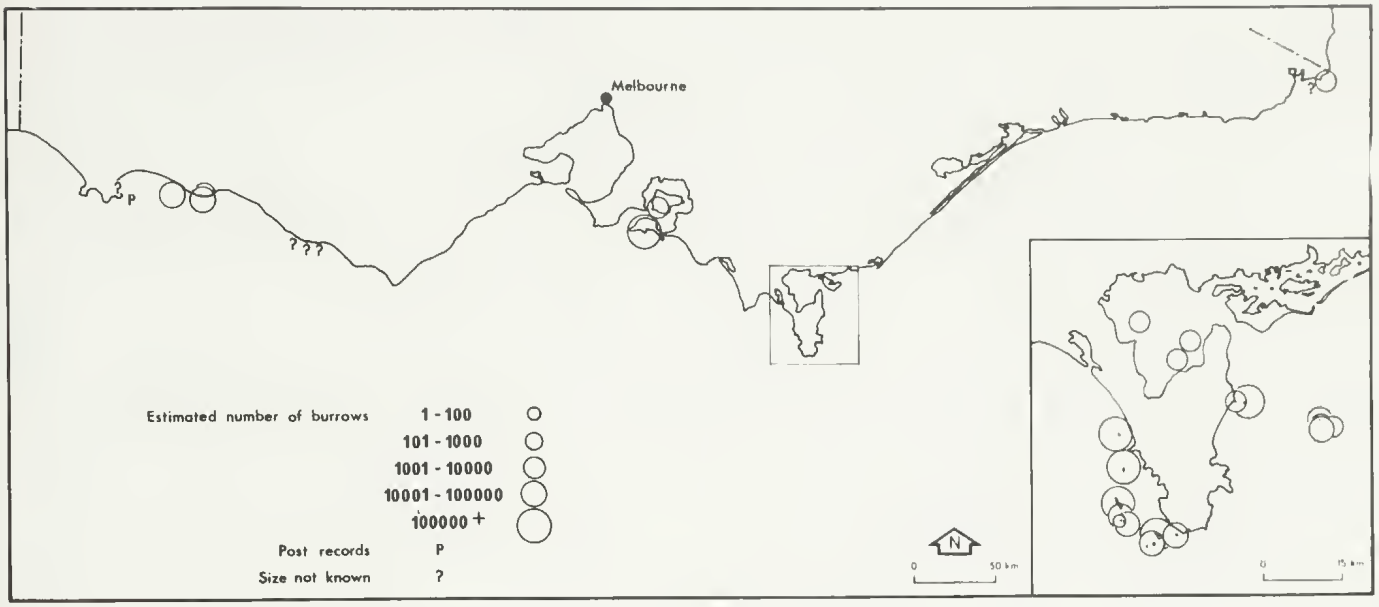

Figure 2. Orders of magnitude for burrow totals estimated in Short-tailed Shearwater colonies, Victoria, 1978-1980.

below a few thousand pairs. The only other recorded Australian colonies are 20 pairs on Councillor Island (Milledge, 1972), and large numbers on Craggy Island (Whinray, 1975), all in Tasmania. Victoria may have, therefore, more than half the Australian colonies but the extension of range reported here must only represent more intensive examination of islands.

Australasian Gannet

The colony on Wedge Platform is of recent origin, six pairs were recorded in 1972 (Nelson, 1978) and 28 nests were found in 1978, but expansion is restricted by available space. In contrast, the colony at the Lawrence Rocks has expanded from 200 nests in 1900 and 1933 (Nelson, 1978), to 605 pairs in 1960-1961 (McKean, 1966) and 1 456 occupied nests in 1978.

The other Australian colonies occur around Tasmania, on Cat Island, Pedra Branca, Eddystone Rocks and Black Pyramid (Brothers, 1979; MacDonald and Green, 1963; Warham and Serventy, 1978); estimates appear to resemble the Victorian total and the species' population is about 35 000-36 000, mostly in New Zealand (Nelson, 1978).

Silver Gull

Though many thousands of pairs nest on the Mud Islands, other colonies hold less than a thousand pairs, e.g. at Skerries Rocks (c. 20 pairs, Barton, 1978), Killarney Reef (500 pairs, Bowker, 1980a). Colonies have also been recorded at Crags, Altona Saltworks, Shoal Inlet and near St Margaret Island in Corner Inlet (Kay, 1978), and there are doubtless others. Opportunistic nesting may take place on the Promontory islands, since breeding has now been recorded on 13 islands in the past 20 years.

Breeding was first recorded on the Mud Islands in 1952, 120 young were recorded in 1961 and 3 000-4 000 pairs now breed there (Kerry and Hall, *in press*). This rapid increase may have resulted from residential development on Mornington Peninsula (Kerry and Hall, *in press*) but is probably also associated with the ability of the species to breed into autumn and winter (thousands were breeding in July 1973, F. 1. Norman, unpublished data), which may represent extended nesting, or double-brooded birds (cf. Nicholls, 1964).

There are some 30 000 breeding pairs on coastal islands off New South Wales (Lane, 1979a), and the species is widespread throughout the continent with some breeding colonies well inland (Serventy *et al.*, 1971).

Pacific Gull

We found over 400 pairs of Pacific Gulls on the islands off Wilsons Promontory, and a pair at Cape Woolamai, Phillip Island. Serventy *et al.* (1971) list no Victorian breeding sites (probably the result of a lack of observers) and they suggested an apparent decrease in numbers and reduction in range in eastern Australia.

Kelp Gull

The Kelp Gull has invaded Victoria within the last decade; R. M. Warneke (*pers. comm.*) noted them first breeding on Seal Rocks in 1969. There are 12-15 breeding pairs on New South Wales islands (Lane, 1979a), and this species may be displacing the Pacific Gull in Tasmania (J. H. Calaby in Green, 1977).

Caspian Tern

The species was found breeding only on the Mud Islands (8 pairs), though numbers and colony location fluctuate annually (Kerry and Hall, *in press*). The species has also bred on Ram Island (in 1976, RAOU Nest Records), Bird Island, Lakes Entrance, Wingan Inlet, Mallacoota Inlet (Dorward, 1976), Cape Bridgewater, Stingray Bay and Bird Island (Kay, 1978) but these sites were not surveyed in 1978. No colonies are known in New South Wales and Serventy *et al.* (1971) showed most occurring in Western Australia. The Victorian population can only be small by comparison.

Crested Tern

There were 800-1 000 pairs of Crested Terns breeding on the Mud Islands in 1978, and six pairs on Seal Island. Some 40 pairs bred on Seal Rocks in 1966, but only six pairs in 1978 (R. M. Warneke, *pers. comm.*). The species has also bred on Killarney Reef (200 pairs, Bowker, 1980a), the Skerries (up to 500 pairs, Barton, 1978, 1980), on a shoal near St Margarets Island (A. H. Corrick, *pers. comm.*), and on Rabbit Rocks (Gillham, 1961). Thus the state has considerably less than the 13 000 breeding pairs estimated for New South Wales (Lane, 1979a).

Other species

Only two breeding colonies of the Black-faced Shag were found in 1978, at Notch Island and on one of the Twelve Apostles. Breeding has also been reported in the Bay of Islands (Serventy, *et al.*, 1971), and on Dannevig Island in 1979 and Skull Rock (Lane, 1979b, 1980). The species is restricted to southern Australia, where Serventy *et al.* (1971) listed only 34 breeding sites (and noted that fishermen were destroying birds and nests). However, the absence of recorded breeding sites in Victoria may reflect only a lack of observations at appropriate times.

No nesting Little Terns *Sterna albifrons* or Fairy Terns *Sterna nereis* were found, but the species have been recorded nesting around the coast in small numbers (Kay, 1978). Kay (1978) listed 11 Victorian breeding sites for the Fairy Tern and two birds were seen on the Mud Islands where 10-20 pairs are usually recorded (Kerry and Hall, *in press*).

3. BREEDING HABITAT OF VICTORIAN SEABIRDS

At most sites details of the vegetation within colonies were collected and burrow densities were determined within quadrats placed in different types of vegetation. The areas of such vegetation types occupied by colonies of Little Penguins, Short-tailed Shearwaters, and White-faced Storm Petrels were also frequently obtained. Some details are summarised below (Tables 3-5) and others given in Harris (1979). Differences in totals given below are due to differing levels of data collection and to the inclusion of subdominant plant species within communities dominated by other species.

Little Penguin

Most of the Victorian colonies visited during this survey, or listed elsewhere, are on islands. Mainland colonies (Portland, Warrnambool-Port Campbell area) were small and located in inaccessible bays usually at the base of cliffs, places which provide sheltered landing and, presumably, few terrestrial predators. Nest sites were most commonly found under granite boulders or *Poa poiformis* tussocks. On 24 of the islands, breeding was recorded under or among rocks on 14 and under *Poa* on 11 islands. The distribution of breeding sites reflects the distribution of appropriate habitat. There are, for example, few islands or promontories between Wilsons Promontory and Gabo Island, and colonies to the west are similarly restricted. It seems likely that the distribution

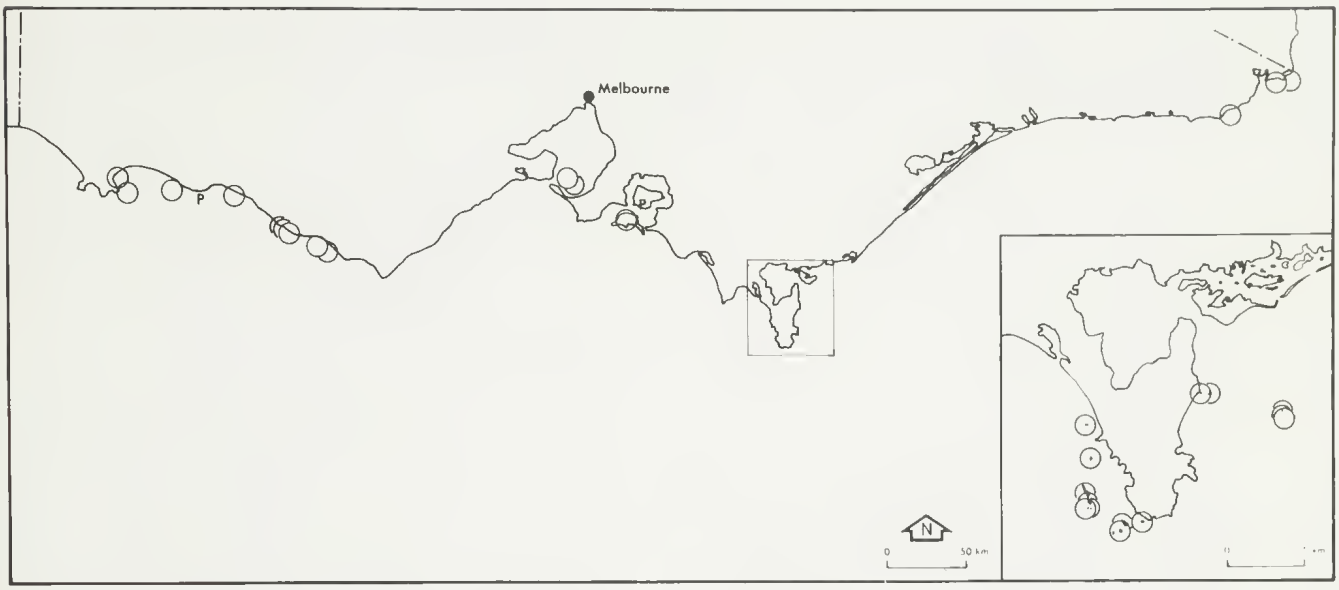

Figure 3. Location of breeding colonies of Little Penguins in Victoria.

TABLE 3

Major vegetation or 'habitat' types in colonies of Short-tailed Shearwaters on 21 Victorian islands (excepting Phillip and French Islands) visited in 1978; mean burrow density, burrow totals and soil depths are also shown.

Vegetation dominated by	Area (ha)	Number of islands	Mean burrow totals
Poa poiformis	211.2	16	1066157
Lavatera	35.1	2	93118
Ammophila	15.8	1	40100
Casuarina	12.2	1	7976
P. poiformis + rocks	11.6	1	29259
Mixed scrub[a]	9.4	1	27927
Tetragonia + *Rhagodia*	5.1	1	15759
Senecio lautus	4.6	1	6677
Carpobrotus	4.4	2	2027
P. poiformis + *S. lautus*	3.6	2	18578
Grassland[b]	3.1	2	2219
Tetragonia	2.9	1	5287
Carduus tenuiflorus	2.9	1	1752
Poa + *Tetragonia*	2.2	1	8550
Senecio + other spp.	1.8	1	5522
Heath[c]	1.2	1	751
Poa + other spp.	0.9	1	2503
Lepidium	0.7	1	6069
Scirpus	0.6	1	519
Bromus + other spp.	0.6	1	1915
Other spp.	0.3	1	518

[a] = Great Glennie.
[b] = Lady Julia Percy Island (see Norman *et al.*, 1980); Gabo Island.
[c] = Great Glennie.

TABLE 4

Major vegetation categories in quadrat samples within colonies of Short-tailed Shearwaters on Phillip Island, 1978. Mean burrow densities/m² are also shown.

Vegetation dominated by	Number of colonies	Mean burrow density/m²	Number of quadrats
Tetragonia inplexicoma	12	0.16	48
Ammophila arenaria	10	0.13	132
Hordeum + other sp.	7	0.32	15
Juncus sp.	7	0.16	28
Bromus + other sp.	7	0.21	28
Carduus + *Silybum*	7	0.17	8
Arctotheca calendula	6	0.33	60
Leptosperma gladiatum	6	0.21	32
Rhagodia baccata	6	0.13	18
Silybum marianum	6	0.18	19
Stipa elatior	5	0.26	76
Other species	16	0.19	747

of islands or similar nesting areas limits the population rather than availability of nesting sites, since apparently suitable areas were not being utilised.

Short-tailed Shearwater

Naarding (1980) reported that only 25 of the 133 Tasmanian colonies known to him were on

TABLE 5

Life-forms and habits of plant species found in sample quadrats in Short-tailed Shearwater colonies. (Following Black, 1960-1965; Gillham, 1960; Willis, 1970, 1972).

	Total	No. alien	Annuals	Bi-ennials	Perennial	Woody
Phillip Island	24	13	6*	6	16	3
Other Colonies	28	4	4*	3	24	7

*Included here are species which may be annual or biennial.

the mainland, and in Victoria most shearwater colonies visited during this survey were on islands (including Phillip and French Islands); the few mainland colonies on headlands or promontories were small. On 21 of these islands, 21 vegetation types were recognised in the colonies (Table 3) but most colonies included areas of *Poa poiformis* (Naarding, 1980 also found that most Tasmanian colonies had tussock grass, and this provided the most abundant cover). Of the c. 330 ha of colony area considered here, 211 ha (64%) was covered by *Poa*, and held 1 066 000 burrows (79% of total in Table 3). The only other plants to dominate large areas of colonies were *Lavatera* (on Great Glennie and Anser Islands), *Ammophila* (Griffiths Island) and *Casuarina* (Great Glennie Island). Dominance by other plant species was generally restricted to small areas of colonies on the islands. On Phillip Island (Table 4), an area probably more affected by human activities than others, a different range and greater variation in dominant species was found, but in all colonies there the vegetation was characteristically of alien species (13 of 25 dominant in quadrats), and perennials (16); few woody plants (3) were present, and no heath species were recorded (Table 5). In contrast, species found on island colonies were generally native, and perennial; more woody species were also recorded.

The relationship between the shearwaters and vegetation in the nesting areas is complex and presumably dynamic (see Gillham 1960, 1961, 1962 for further details). Only plants tolerant of the birds' trampling, burrowing and excretion can exist in dense colonies. However, the vegetation may itself restrict distribution of burrows as the birds are limited, generally, to areas dominated by fine and short-rooted species. Burrowing beneath trees and shrubs was restricted to areas of sandy loams.

Successful burrowing is also limited to areas of soil sufficient for maintenance of nest sites. Within colonies burrow distribution was related to soil depth, the shearwaters requiring about 30 cm of soil in which to establish burrows. Soil depth was greater under *Lavatera* (on Glennie Island), *Poa* and *Lepidium*, and burrow density tended to increase with increased soil depth. Inclusion of surface or sub-surface rocks and boulders modified this tendency. Increased burrow density itself may lead to erosion, as a result of increased soil instability and destruction of plant cover and binding. Such destruction may also allow the invasion of ephemerals which become established in the non-breeding season only to die off in the drier seasons, during the birds' occupancy of the area. Extensive eroded areas (for example on Great Glennie, previously dominated by *Poa*) which have burrow densities similar to neighbouring uneroded areas may only be temporary stages before burrows collapse, thus reducing breeding success and subsequently burrow density.

Most of the island colonies (apart from those on Phillip Island) appear to have reached a maximum size and density, and in some areas unsuitable open nest sites are used. Any major expansion of the Victorian population can only be by colonisation of suitable mainland areas which are generally restricted and where they may be subject to increased predation by dogs, cats and foxes (e.g. Point Danger, Learmonth, 1965).

White-faced Storm Petrel

Storm petrels were found breeding only on three islands. On the Mud Islands the main breeding colony, in sandy soil admixed with coarse shell fragments and aeolianite, was dominated generally by *Glaucium flavum*, and the smaller colony was under *Atriplex cinerea*, whereas on South Channel Island the species was nesting in sandy loam dominated by *A. cinerea, Rhagodia baccata*, and *Tetragonia implexicoma*. On Tullaberga Island most burrows

were in areas of *R. baccata* and *A. cinerea*. Burrow density was highest in *Rhagodia* (1.4/m²), where soil depth averaged 0.16 m (n = 31).

Shearwaters were not present in any storm petrel colony, a feature noted on others in Bass Strait islands (Gillham, 1963), though elsewhere in Australia the species are sympatric (Serventy *et al.*, 1971). The species may be restricted to more low-lying islands of which there are few around the Victorian coast.

Fairy Prion and Common Diving-Petrel

Nests of both species were found among basalt and granite boulders and rocks but some burrows were excavated under *Carpobrotus*, and Gillham (1961) recorded diving-petrels under *Poa* and *Scirpus* on Dannevig and McHugh Islands. On most islands these species nested in very shallow soil or among boulders, areas quite unsuited for shearwaters. However, scarcity of nest sites is unlikely to limit the species' populations in Victoria.

Other species

All Pacific Gull nests were on isolated islands, as were breeding pairs of Kelp Gulls, and colonies of Black-faced Shags. Terns found during the survey were on sandy beaches or rocks on islands, but elsewhere in mainland Victoria some terns nest on more isolated sand or shingle beaches. Habitat does not appear to restrict the breeding of terns, or the Silver Gull (which breeds in various locations around the coast), in Victoria.

4. THREATS TO THE BREEDING HABITAT

For successful breeding, seabirds require a secure nesting site and an adequate and assured food supply. Most Victorian colonies are on offshore islands where, until European man arrived, there were few if any mammalian predators. The larger marsupial carnivores (*Dasyurus, Sarcophilus*) have not been recorded from the smaller Bass Strait islands (Hope, 1973), but they do co-exist with colonies of shearwaters on the Tasmanian mainland where their role as predators of colonial-nesting seabirds seems to be minimal and Naarding (1980) considers feral cats to pose a greater threat. Indeed Serventy *et al.* (1971) suggested that seabirds select islands only if they provide sufficient visual expanse of surrounding sea. For whatever reason most species select islands for nesting and, for some species, distribution may be limited by their availability.

The main threats to the seabirds' requirements are as follows:

Destruction of habitat

At more accessible shearwater colonies nesting habitat has either been eliminated (e.g. Warrnambool area) or is being modified (e.g. Phillip Island), but as yet effects on the total populations have been minimal. Whilst some colonies have disappeared (e.g. penguins and shearwaters on Phillip Island), other areas have, apparently, been colonised recently (e.g. French Island). However, further change in land use may seriously affect the viability of other colonies. About 60 and 20 per cent of the breeding burrows of shearwaters and penguins are in National Parks. Faunal Reserves controlled by the Fisheries and Wildlife Division contain virtually all Victorian breeding gannets, about 33 per cent of the storm petrels, 25 per cent of shearwater burrows and 10 per cent of the estimated penguin burrows. Land administered by the Commonwealth Department of Transport contains about 40 per cent of Victoria's penguins. Most of the other colonies are on Crown Land, in foreshore reserves controlled by local authorities, or on islands where isolation gives protection from some forms of habitat disturbance. Though most colonies are on 'reserves', and theoretically enjoy official protection, the security of such colonies is often neglected.

Habitat degradation is also caused by the birds themselves burrowing in unstable soil; fires, grazing (by rabbits or cattle), or trampling (by cattle, and by humans) increase the risk of soil erosion.

Predation

The decline of the Cat Island (Furneaux Group) gannetry has been attributed primarily to human predation and vandalism (Nelson, 1978; Warham and Serventy, 1978), and Lawrence Rocks now appears to be the main Australian colony. Whilst penguins (and perhaps shearwaters) are taken for use as craypot bait in Bass Strait, and young shearwaters for food (legally in Tasmania but ille-

gally from Victorian islands), there is no evidence to suggest that such predation is now influencing populations.

Feral or pet dogs have caused locally severe mortalities in penguin and shearwater colonies (e.g. Middle and Merri Islands; Grossard Point and Cape Woolamai, Phillip Island) as do foxes (Point Danger, Benison Island). Though foxes have little impact on the breeding population (Norman, 1971), the numbers should be controlled and the effects of feral cats warrants investigation.

Disturbance

Human disturbance in colonies may be inadvertent, but as recreational activities increase, with increased leisure time, inevitably more accessible colonies will be affected. For instance at the Mud Islands in 1976 and 1977 a total of 843 visitors from 176 boats were recorded on 16 days and, although few people deliberately walked through storm petrel colonies, all could affect nesting terns or gulls (Venn, 1979) as could bird watchers, banders or amateur photographers. At more sensitive colonies, visitors should have limited access during breeding seasons and instructive displays should be available. Indeed at one site, Penguin Parade on Phillip Island, visitors have been controlled, and the penguins have become a tourist attraction with some 62 000 visitors in 1963-64; 88 000 in 1970-71, and 144 400 in 1976-77 (per B. West).

Some 'mainland' colonies suffer from a range of adverse factors, which may have varying effect on breeding success and breeding habitat. Thus the colonies (penguin and shearwater) at and near Griffiths Island have been or are being influenced by human disturbance and destruction of birds and burrows, predation (dogs and foxes) and modification of habitat (including physical elimination of breeding areas) (for some details see Bowker, 1980b). Similar factors affect colonies on Phillip Island (Harris and Bode, 1981).

5. THREATS TO THE MARINE ENVIRONMENT

Little is known of the interrelationships existing between seabirds and the marine environment. Whilst there is some agreement that food itself may limit population size, there is still dispute as to whether it is most influential near the breeding colonies (e.g. Ashmole, 1963), or when birds are not breeding (Lack, 1966; Diamond, 1978). However, some factors which might influence Victorian seabirds, both those breeding within the state and those using off-shore waters as non-breeding habitat, are readily apparent.

Food availability

Bass Strait and adjoining waters are amongst the more productive marine waters around Australia (Serventy *et al.*, 1971) and support large numbers of fish, crustacea and cephalopods on which seabirds feed (Blackburn, 1950; Roughley, 1961). The existing commercial fishery probably does not yet affect stocks of most fish species. And even if it had, the initial results might be to increase the number of small fish and thus benefit the seabirds. However, intensification of the industry or the development of markets based on smaller fish could influence populations of seabirds in Victorian waters as it has elsewhere (e.g. Crawford and Shelton, 1978; Frost *et al.*, 1976; Idyll, 1973; Nelson, 1978). In Victoria the Little Penguin appears to suffer from food shortages in some years (Reilly, 1977b; Reilly and Kerte, 1978), and there is a need to understand the interrelationships between the birds and prey species before any larger-scale fishery is developed.

In addition, the influence of modification to freshwater discharges into coastal areas of Victoria should be examined since localised hydrographic variations may alter the distribution of prey species taken by seabirds.

Oil and toxic chemical pollutants

Oil or toxic chemical pollution may represent the largest threats to seabirds (Bourne, 1976; Nettleship, 1977). The Bass Strait oil-field has developed markedly during recent years: production of crude oil has increased from about 7.8 million kilolitres in 1970 to 25.8 million in 1977 (Doran, 1979). Although this is piped ashore (with low probability of spillage), increasingly oil will be shipped into Victoria from other fields and contingency plans should allow for possible major spillages. Whilst the ocean currents around Victoria and Tasmania are generally west to east during winter and sum-

mer (Serventy *et al.*, 1971) the system is complex. Indeed Pollock (1971) has suggested that the interchange between oceanic and Bass Strait waters may be restricted for periods, and this could present serious consequences for pollution control. Additionally, surface oil can be moved by prevailing winds which need not act in concert with water movement.

In the event of such spillages Little Penguins would probably be most at risk; indeed already some oiled penguins have been found at Gabo Island (Reilly and Kerte, 1978). In recognition of this, Kay (1978) has suggested that dispersants should be used to protect penguins' breeding colonies, despite their detrimental effects to other marine organisms. Feeding flocks of shearwaters, often extremely large, may also be susceptible during their breeding seasons.

Pollution caused by toxic chemicals is usually detectable only after massive mortalities. Data on the occurrence and the effects of such chemicals (PCBs, DDT, heavy metals) in the marine environment are fragmentary and often conflicting (e.g. Bourne, 1976), and their sublethal effects are generally unknown. Concentrations of such pollutants in local seabirds have not been examined, and monitoring programs to rectify this situation should be initiated.

Conclusion

Most colonies of seabirds around the Victorian coast appear secure at present but in some areas breeding habitat is being either reduced or restricted by land use practices. No seabird population is under immediate pressure but colonies near centres of population, and having a tourist and educational value, require further management to enhance these values. Factors which might influence either the size of breeding populations or their productivity, such as pollutants, food availability and fisheries, require further examination.

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APPENDIX 1

Survey methods and summary of field data collected, from individual islands. (Publications presenting details are also indicated).

Lady Julia Percy Island (visited 27-30 Nov. 1978; 23-25 Jan. 1979). Little Penguin: dense colonies in talus, Dinghy Cove and Seal Bay (total counted 351 burrows); scattered colony above Seal Bay (burrow density × area, 1600 burrows); some 2000 burrows in total. Fairy Prion: not surveyed, widely distributed and perhaps thousands of pairs. Short-tailed Shearwater: numerous colonies, numbers estimated by direct counts, by the product of burrow densities and areas (using quadrats), and by subsampling and counting; estimated 15 300 burrows. Common Diving-Petrel: not estimated, but nesting in at least five areas. For further details see Norman *et al.* (1980), and Pescott (1976).

Lawrence Rocks (1 Dec. 1978)
Little Penguin: direct count of 109 burrows.

Fairy Prion: estimate only, of less than 200 breeding burrows. Common Diving-Petrel: dead young found. Australasian Gannet: direct count of 1 456 nests. See Pescott (1980) for further information.

Griffiths Island (25-26 Nov. 1978).
Short-tailed Shearwater: burrow densities from 59 quadrats (3.14m²), estimate of c. 43 400 burrows using density × area; a further 8 700 burrows at the Southcombe and Peasoup colonies on the adjacent mainland. Further details in Bowker (1980b) and Harris (1979).

Middle and Merri Islands (1 Dec. 1978).
Little Penguin: direct count of 199 and 10 burrows.

Mud Islands (22-23 Nov. 1978).
White-faced Storm Petrel: main colony estimated using lines to determine area, subsampling in quadrats (123 of 20m²; 32 of 3.14 m²) to find burrow density which varied between 0.1-1.3/m²; population estimated at 5 600 burrows (95% confidence limits 4 400-6 900), a further 198 burrows counted elsewhere. Silver Gull: some thousands of pairs; Kerry and Hall (*in press*) suggested 3 000-4 000 pairs. Caspian Tern: 8-10 pairs counted. Crested Tern: estimate of 800-1 000. See Harris (1979) and Kerry and Hall (*in press*).

South Channel Island (10 Nov. 1978; 21 June 1979).
Little Penguin: D. R. Venn (*pers. comm.*) found 30-40 pairs.
White-faced Storm Petrel: occupied 3300m², burrow density 2.05/m² in 40 quadrats (3.14m²); estimated 6 800 (6 000-7 600) burrows. Silver Gull: 7 nests counted. Details in Harris, Deerson and Brown (1980a).

Harbour Light (Wedge) Platform (10 Nov. 1978).
Australasian Gannet: count of 28 nests.

French Island (30 Oct. 1978).
Short-tailed Shearwater: dense colony in *Tetragonia, Carduus* and grasses, small colonies elsewhere on Tortoise Head, counts and quadrats (17,20m²) used to produce estimate of 3 100 burrows.

Phillip Island (24 Oct.-3 Nov. 1978).
Little Penguin: burrows counted in small colonies, otherwise 20m² quadrats or 2m-wide transects used; number of used burrows of the order of 6 000, mainly at the western end of the island. Short-tailed Shearwater: colonies distributed along some 26 km of southern and western coast, boundaries drawn on aerial photographs and areas determined; burrows counted in small colonies but elsewhere burrow densities determined from 20m² quadrats (735); estimate 542 300 (439 300-645 300) with 356 000 at Cape Woolamai. Silver Gull: nests counted or estimated at Seal Rocks (250-300 pairs), the Nobbies (c. 200 pairs), Purple Rock (150-200 pairs), and Cape Woolamai (80-130 pairs). Pacific and Kelp Gulls: count of one pair (Cape Woolamai) and three pairs (Seal Rocks) respectively: Crested Tern: six pairs on Seal Rocks. Further details in Harris and Bode (1981).

Granite Island (17 Oct., 6 Nov. 1978).
Short-tailed Shearwater: Burrow density in 0.75 ha *Poa poiformis* 0.3/m² (3.14m² quadrats), estimate of 2 020 (1 610-2 430) and a further 100 burrows in bare ground. Further details in Norman (1977a).

Benison Island (17 Oct., 7 Nov. 1978).
Short-tailed Shearwater: most burrows in *Poa-Senecio lautus* (1.01 ha), density 0.46/m² (28 quadrats, 3.14m²); others in mixed *Poa, Pteridium esculentum, Lomandra longifolia* and *Pelargonium australe* (0.94 ha), density 0.27/m²; estimate of 7 200 (5 930-8 400). Norman (1977b) provided some earlier details.

Doughboy Island (17 Oct., 7 Nov. 1978).
Short-tailed Shearwater: most burrows north of central ridge, population in 0.6 ha estimated at 2 000 (1 600-2 400) using burrow density 0.3/m² (22,20m² quadrats), few elsewhere. Silver Gull: 84 nests counted, others estimated. Earlier details in Norman (1977c).

Shellback Island (13 Dec. 1978).
Little Penguin: not counted, perhaps several hundred burrows. Fairy Prion: dead birds found. Short-tailed Shearwater: burrow density on slopes (21,20m² quadrats) 0.2/m² (24.5 ha) and 0.48/m² (30 quadrats) on flatter top (12.3 ha); estimate of 109 500 (87 400-131 600). Common Diving-Petrel: a dead bird found. Pacific Gull: not counted, about 100 pairs

thought to be breeding. Further details in Harris, Deerson and Brown (1980b).

Norman Island (17 Jan. 1980).
Little Penguin: not counted but Lane and Battam (1980) estimated 400-500 pairs. Fairy Prion: dead birds found. Short-tailed Shearwater: burrow density in *Poa* (20.75 ha) 0.7/m² (28 quadrats, 20m²), population estimated at 145 000 burrows (131 350-158 500). Common Diving-Petrel: three nests found. Silver Gulls: 85 pairs considered present. Pacific Gull: estimated 35 pairs present. Further information in Lane and Battam (1980) and Norman *et al.* (1980 b,d).

Great Glennie Island (7-10 Dec. 1978).
Little Penguin: not counted but considered to be of the order of 500 pairs. Fairy Prion: one found dead. Short-tailed Shearwater: 518, 20m² quadrats taken over island in varying vegetation, estimate 400 300 burrows (334 500-456 300). Silver Gull: estimated as 100 pairs breeding. Pacific Gull: three nests found, about 10 pairs with territories; B. Robertson saw 30 birds in November 1979, and found 3 nests. Harris (1979) and Harris, Brown and Wainer (1980) give further details.

Dannevig Island (17 Jan. 1980).
Little Penguin: not estimated but few burrows found. Fairy Prion: birds found dead and Lane (1979b) found nests. Short-tailed Shearwater: burrow density in *Poa* (6.49 ha) 0.7/m² (15 202 quadrats), estimate 44 600 (37 800-51 300). Common Diving-Petrel: breeding, recorded by Lane (1979b). Black-faced Shag: Lane and Battam (1980) recorded 30 birds on nests in November 1979, and young were present in January 1980. Silver Gull: 10-12 pairs counted. Pacific Gull: c. 20 pairs estimated. See Norman *et al.* (1980 a,d).

McHugh Island (11 Dec. 1978).
Little Penguin: 11 burrows found in quadrats (50, 20m²) used to provide estimate of about 1 000 burrows. Fairy Prion: nests found by Lane (1979b). Short-tailed Shearwater: burrow density 0.16/m² in *Poa* (3.9 ha; 50, 20m² quadrats) providing estimate of 6 200 burrows (4 500-7 900). Pacific Gull: one pair present; B. Robertson found 4 nests in November 1979. See Harris and Deerson (1980a).

Citadel Island (11 Dec. 1978; 13 Feb. 1979).
Little Penguin: 45 burrows counted. Fairy Prion: about 50 burrows counted. Short-tailed Shearwater: 111 burrows counted. Common Diving-Petrel: a dead bird found. Pacific Gull: old sites recorded by Lane (1979b) in 1978 and flying young seen in 1979. See Norman and Brown (1979, 1980).

Anser Island (11 Dec. 1978).
Little Penguin: estimate of several hundred pairs. Fairy Prion: burrows found but no estimate made. Short-tailed Shearwater: 122, 20m² quadrats taken in various vegetation types; burrow densities (highest in *Poa*, 0.6/m²; lowest in *Lavatera* 0.2/m²) multiplied by areas gave 251 700 burrows (216 200-287 100) (but here the extreme slope of parts of the island would markedly increase areal measurement). Silver Gull: one pair counted. Pacific Gull: 20 breeding pairs estimated. See Harris (1979), Lane (1979b) and Harris *et al.* (1980).

Kanowna Island (13 Dec. 1978).
Little Penguin: not surveyed. Fairy Prion: ten dead birds found. Short-tailed Shearwater: 30,20m² quadrats in *Poa* (4 ha) held 0.56 burrows/m² or 22 700 (19 300-26 000) in total; 29,20m² quadrats (in 11.6 ha) had 0.28 burrows/m² giving a mean of 29 300 (19 000-39 500). White-faced Storm Petrel: one dead bird found. Silver Gull: one pair with young counted. Pacific Gull: nests and estimate giving total of about 100 pairs. See Harris and Deerson (1980b).

Wattle Island (12 Dec. 1979).
Little Penguin: not counted but may be of the order of 1 000 pairs. Fairy Prion: corpses found. Short-tailed Shearwater: burrow density in *Poa* (9.6 ha) 0.81/m² in 30,20m² quadrats, 0.5/m² in 5,20m² quadrats in *Disphyma australe* (1.1 ha); estimates of 77 750 (72 000-83 500) and 5 700 (2 650-8 900) burrows respectively. Common Diving-Petrel: corpses found (see also Lane and Battam 1980). Silver Gull: count of 68 nests. Pacific Gull: nests 30 found. See Lane and Battam (1980) and Norman, Brown and Deerson (1980 c,d).

Rabbit Island (5, 10 Dec. 1978; 10 Dec. 1979).
Little Penguin: estimate of 500 burrows. Short-tailed Shearwater: 136,20m² quadrats provided

average burrow density 0.48/m² and island total of 131 000 (115 200-146 600) burrows. Silver Gull: 27 nests counted in 1979. Pacific Gull: five nests found in December 1979. See Norman and Harris (1981), and Norman *et al.* (1980).

Rabbit Rocks (21 Dec. 1978).
Little Penguin: estimate of about 100 pairs. Short-tailed Shearwater: occupied 0.55 ha; burrow density 0.68/m² in 25,20m² quadrats giving burrow total of 3 800 (3 200-4 300). Pacific Gull: 2 pairs present. See Harris and Deerson (1980g) for further details.

Seal Island (21 Dec. 1978).
Little Penguin: not counted but some hundreds of burrows. Fairy Prion: not counted, perhaps several hundred pairs. Short-tailed Shearwater: 0.47 burrows/m² in 11.33 ha *Poa* (30,20m² quadrats), burrow total 54 000 (46 800-60 400). Common Diving-Petrel: dead adults and young found. Silver Gull: 20 pairs estimated. Pacific Gull: 100 pairs estimated. Crested Tern: count of six pairs nesting. See Harris and Deerson (1980d).

Notch Island (21 Dec. 1978).
Little Penguin: estimate of about 500 burrows. Fairy Prion: small colony, burrows not counted. Short-tailed Shearwater: burrow density in 23,20m² quadrats was 0.2/m² in northern colony (1.6 ha), burrow total 3 300 (2 700-3 900); density 0.28/m² in 22,20m² quadrats in southern area (0.97 ha) and total 2 700 (1 900-3 400) burrows. Common Diving-Petrel: live young found. Black-faced Shag: some 20 unfledged, and about 100 juvenile, birds present. Silver Gull: count of five pairs breeding. Pacific Gull: estimate of ten breeding pairs. Further details given in Harris and Deerson (1980c).

Cliffy Island (21 Dec. 1978).
Short-tailed Shearwater: main colony in 0.9 ha *Poa*, burrow density 0.61/m² in 20,20m² quadrats or 5 300 burrows (3 800-6 700); 508 burrows counted in about half remaining *Poa* area, island burrow estimate about 6 300. Silver Gull: one pair counted. See Harris and Deerson (1980e).

Rag Island (21 Dec. 1978).
Little Penguin: not counted but hundreds of burrows present. Short-tailed Shearwater: 31,20m² quadrats in *Poa* (2.67 ha) gave a burrow density of 0.68/m² and thus 18 200 (16 100-20 300) burrows. Common Diving-Petrel: one dead young found. Silver Gull: estimate of 20 pairs. Pacific Gull: estimate of at least 5 pairs breeding. See Harris and Deerson (1980f).

Tullaberga Island (16 Nov. 1978).
Little Penguin: 0.04 burrows/m² in 25,20m² quadrats taken in *Poa* (0.5 ha) where burrows totalled 180 (100-260); single burrow in 18,3.14 m² quadrats in *Rhagodia* (1.3 ha) added 230 to total. White-faced Storm Petrel: most burrows in *Rhagodia*, density 1.37/m² in 18,3.14m² quadrats; in *Atriplex* (0.1 ha) 0.76 burrows/m² (5,3.14m² quadrats) and in *Poa* (0.5 ha) 0.24/m² (25,20m² quadrats); estimate of 20 000 (14 304-25 850). See Harris, Brown and Deerson (1980).

Gabo Island (13-15 Nov. 1978).
Little Penguin: generally 20m² quadrats used, but also strip transects through scrub areas; c. 5 620 (3 720-7 330) burrows estimated in 438 quadrats (19.37 ha sampled) and 820 in 46.87 ha of scrub; small numbers counted; island may hold 5 000-10 000 burrows. Short-tailed Shearwater: one area counted, remaining colonies sampled by 20m² quadrats (248, in 5.84 ha); burrow total 7350 (5 000-9 400). Further details in Harris (1979), and Reilly (1977a).