

RESIGHTS, RECAPTURES AND RECOVERIES OF AUSTRALASIAN GANNETS *Morus serrator* BREEDING IN PORT PHILLIP BAY, VICTORIA

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Colonies of Australasian Gannet *Morus serrator* in Port Phillip Bay, Victoria, started with three nests at Wedge Light in 1966/1967, and have now expanded both in size and number; there are now about 1 000 gannets breeding at eight artificial sites in the Bay. Between 1967 and 2000, 1 116 gannet chicks were banded at sites in Port Phillip Bay, mostly at Pope's Eye (759) and Wedge Light (354), off Queenscliff. During subsequent studies, mainly at Pope's Eye and from 1988 onwards, band numbers were obtained from adults present at breeding sites as practicable. Resightings (or recaptures) of birds (172) banded as chicks are reviewed in relation to source, age and movement between sites in Port Phillip Bay. Recoveries (birds found dead) of 41 birds banded as chicks (3.7% of those banded) in Port Phillip Bay are discussed with respect to age post banding and location; the occurrence of live birds in rehabilitation centres is also noted. Resights and recaptures at breeding sites in Port Phillip Bay have, essentially, been of birds banded there. Few birds have been resighted from Lawrence Rocks, the major Victorian breeding site, which has itself also expanded (and a new site established on the nearby mainland). Although some may visit nesting colonies earlier, Australasian Gannets in Port Phillip Bay begin breeding at about four years of age and increasingly thereafter. Recoveries to date have been mainly in Port Phillip Bay (56%), often shortly after banding (e.g. 29% within five months), but occasional birds have been reported from coastal Tasmania, South Australia and New South Wales. Once recorded as a breeder, usually at natal colonies, birds seldom nested elsewhere; movement between sites generally involved younger, presumably non-breeding gannets. However, although philopatry may be strong, it is affected locally by available space on the artificial platforms. In consequence, as sites are filled, opportunities for younger birds to breed are reduced and the breeding population ages. Annual mortality of breeding adults (of mixed age) is about 6 per cent and, using locally determined breeding success, suggests that the species is capable of producing surplus birds which have expanded some colonies and initiated others. There is little evidence that immigration from distant sites has been responsible for colony growth in Port Phillip Bay, and it appears that local expansion has been internally driven.

INTRODUCTION

Australasian Gannets *Morus serrator* breed at relatively few sites in Australia and colonies are restricted to Tasmanian and Victorian waters (Marchant and Higgins 1990). In 1980/1981 Wodzicki *et al.* (1984) considered that the species' population was around 53 000, with 6 700 at Australian colonies and the remainder in New Zealand. Marchant and Higgins (1990) included reference to 2 463 pairs at the main Victorian colony (Lawrence Rocks, near Portland), but numbers there, at sites in Port Phillip Bay, Victoria and elsewhere in the species' range have increased since then (Waghorn 1983; Wodzicki *et al.* 1984; Hawkins 1988; Norman *et al.* 1998; Bunce *et al.*, in prep.). The colony at Wedge Light in Port Phillip Bay was initiated in 1966, perhaps including birds from Lawrence Rocks (Wheeler 1972), and that at Pope's Eye (also in Port Phillip Bay) in about 1985 (Norman and Menkhorst 1995). Nesting at these sites and at several newer, and smaller colonies elsewhere in Port Phillip Bay (all on artificial structures), has increased in recent years and the Victorian breeding population has been materially enhanced by the establishment of a mainland colony at Point Danger, opposite Lawrence Rocks (completely occupied by 1995, Norman *et al.* 1998). Norman and Menkhorst (1995) and Norman *et al.* (1998) indicated that colony growth at Pope's Eye involved birds fledged from Wedge Light; more recently established colonies elsewhere in Port Phillip Bay have also included birds produced at Wedge Light or Pope's Eye (Norman *et al.* 1998).

In this note, aspects of resightings, recaptures and recoveries of Australasian Gannets banded as chicks at sites in Port Phillip Bay from 1967 onwards, or fledged from Lawrence Rocks and resighted in Port Phillip Bay, are reviewed. Such observations are considered in relation to the expansion of the Victorian population generally. The general locations of the Victorian sites mentioned in the text are shown in Figure 1.

METHODS

Study sites

BACKGROUND

Norman and Menkhorst (1995) provided details of the Wedge Light and Pope's Eye colonies, off Queenscliff, in southern Port Phillip Bay and Norman *et al.* (1998) gave some information regarding other Victorian sites (see also Bunce *et al.*, in prep.). The artificial, wooden platform at Wedge Light (about 25 m²) was fully occupied by around 1980/1981; removal of the central hut (in June or July 1992; G. Pearce, pers. comm.) temporarily increased nesting area. Some 58 nests were present in 1996/1997, including two on cross beams below the platform, and 62 were recorded in 1999 (A. Bunce, pers. comm.). The Pope's Eye colony, initially established on a wooden platform, expanded onto concrete structures and newer wooden platforms by 1992. Nearby, artificially-placed rocks (about ≤ 2 m above high water) were increasingly used: by 1994 about 140 nests were present, the total was over 160 by 1997 and reached 194 nests in the 1999/2000 breeding period (Norman and Menkhorst 1995; Norman *et al.* 1998; Gibbs *et al.* 2000; A. Bunce, pers. comm.).

Nesting at the number 6 navigation marker (a wooden triangular pile off Sorrento, 3–4 m above water, with a platform area of about 17 m²)

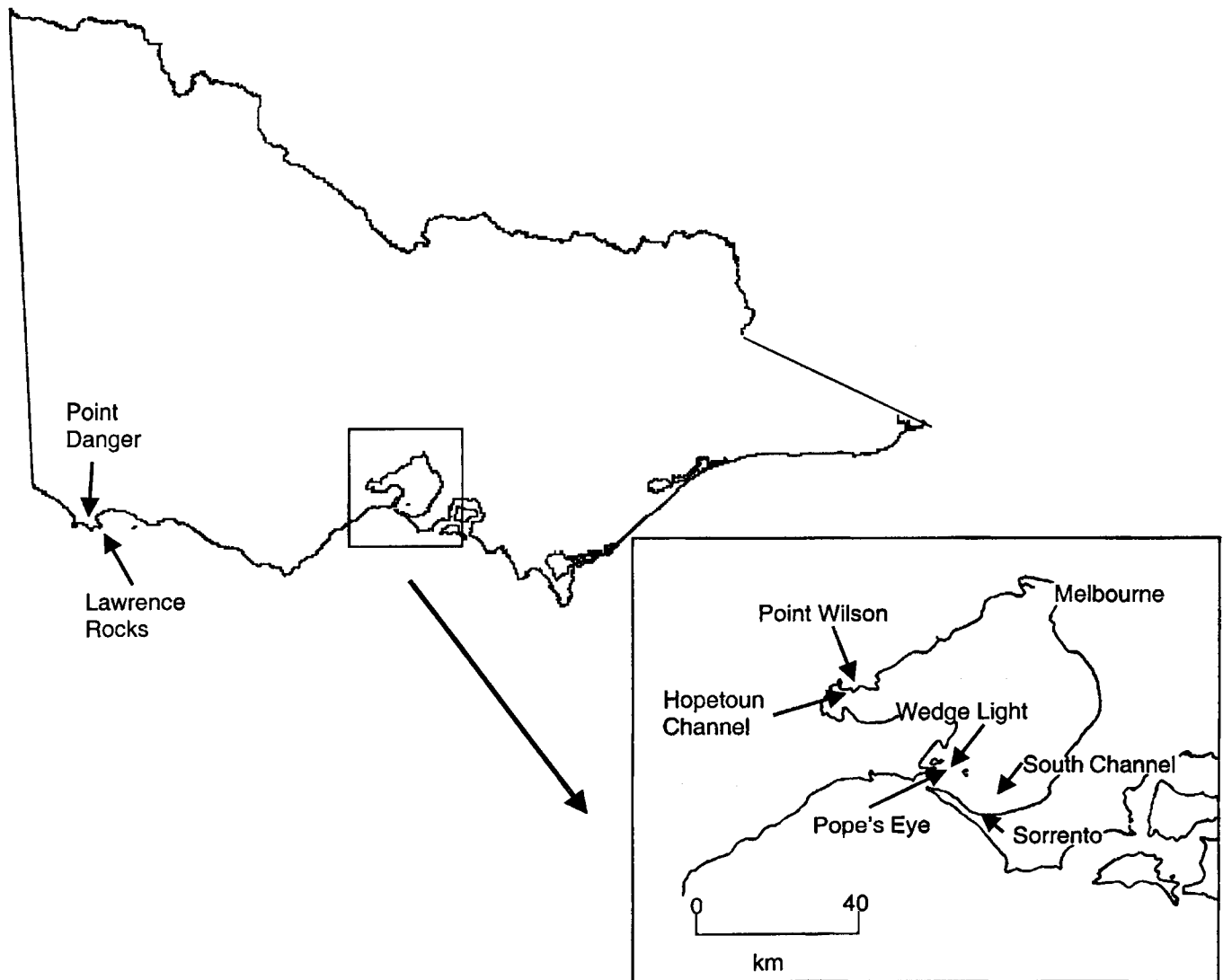


Figure 1. The locations of colonies of Australasian Gannets *Morus serrator* in Victoria.

was reported in 1993; 35 nests were counted in 1997 and 39 in October 1999. A similar pile nearby (number 10) had about 20 nests in 1997 and 36 in October 1999. The 'dolphin' (an artificial concrete caisson off the explosives jetty at Point Wilson, about 50 m² and about 3 m above high water mark) was first occupied as a nesting site in 1996 when 24 nests were present (Norman *et al.* 1998). In 1999 there were 82 nests; five active (and nine old) nests were also found at the Hopetoun Channel inner mark (platform area about 4 m²), and nine at the outer mark (about 4–5 m²). Removal of the superstructure at South Channel Pile, and its renovation in mid-1998, provided about 45 m² of potential nesting area which was rapidly occupied, holding about 30 nests in December 1998, and 79 in October 1999.

DATA COLLECTION

Initial observations were made at Wedge Light once or twice each breeding period between 1966 and 1981, when chicks were banded and (presumably all) banded adults resighted or recaptured (Wheeler 1972; Harris and Norman 1981; Blakers *et al.* 1984; Norman and Menkhorst 1995; Australian Bird and Bat Banding Scheme (ABBBS) records). Both Pope's Eye and Wedge Light were visited briefly in January 1987, when some banded adults were resighted and seven chicks banded. Between 1988 and 1992, visits to both sites were made at about 14 day intervals throughout breeding periods (Norman and Menkhorst 1995); chicks were banded whenever possible and frequent attempts made to identify banded adults (using binoculars; 8–10×40). During trips to colonies in

1993 and 1994, chicks were banded but only incidental records of banded adults were made.

There was an intensive study at Pope's Eye in 1994/1995, when chicks were banded and many band numbers of marked gannets obtained: banded birds were often distinguished as breeding (at a nest) or non-breeding (Gibbs *et al.* 2000). Four visits were made to Pope's Eye and Wedge Light in 1996/1997, three to the new colony at Point Wilson, and one to the navigation markers (numbers 6 and 10) off Sorrento. At Pope's Eye, Wedge Light and Point Wilson, chicks were banded and resights or recaptures of adults made whenever possible. Between 1997 and 2000 there was an extended study in which chicks were banded and numerous resightings (but not recaptures) made (Bunce 2000; A. Bunce, pers. comm.). The South Channel Pile colony was visited twice in 1998/1999 and all colonies were examined in 1999/2000, when two new sites were found off Point Wilson (inner and outer markers of the Hopetoun Channel). During visits, particularly those to Pope's Eye, band numbers of marked adults were obtained. Here, resightings or recaptures are accepted as taking place within nominated breeding periods, considered 12 months apart, although the intervening time may have been slightly less or more.

Recoveries (here = found dead) of banded birds are routinely reported to the ABBBS. In this review, details available and processed up to 30 June 2000 are considered: where known, recovery locations are considered to be within Port Phillip Bay, near its entrance, or more distant.

RESULTS

Banding totals

Summaries of the banding of gannet chicks at the Port Phillip Bay colonies are presented for breeding periods between 1966/1967 and 1999/2000 in Table 1. Of 1 116 chicks banded, most were marked at Pope's Eye (759, 68.0%) or Wedge Light (354, 31.7%). To an extent, particularly at Wedge Light in earlier periods, banding totals may reflect annual productivity as the breeding population increased. Later totals, however, also indicate both changing emphases of particular studies conducted primarily at Pope's Eye, and the numerically greater productivity there.

TABLE 1

Totals of chicks banded at colonies of Australasian Gannets *Morus serrator* in Port Phillip Bay, Victoria, in the 1967–2000 breeding periods.

Breeding period	Site		
	Wedge Light	Pope's Eye	South Channel
1967–1968	7		
1968–1969	10		
1969–1970	7		
1970–1971	9		
1971–1972	5		
1972–1973	5		
1973–1974	11		
1974–1975	10		
1975–1976	10		
1976–1977	14		
1977–1978	13		
1978–1979	19		
1980–1981	5		
1986–1987		7	
1988–1989	20	33	
1989–1990	34	51	
1990–1991	29	46	
1991–1992	15	29	
1992–1993	30	73	
1993–1994	25	61	
1994–1995	1	86	
1996–1997	39	115	
1997–1998	13	81	
1998–1999		61	3
1999–2000	23	116	
Totals	354	759	3

Resights

In the study period, 172 individual gannets originally banded as chicks (mostly at Port Phillip Bay colonies) were resighted or recaptured (all termed resights below) on 280 occasions at sites in Port Phillip Bay. Numbers of resights reported here for each breeding period are minimal since it was impossible to read all bands completely and attempts to capture banded adults were constrained by potential egg damage or displacement, or chick loss off breeding platforms. In the resightings of individuals discussed below, 11 birds (6.4%) were originally banded at Lawrence Rocks, 57 (33.1%) were banded at Wedge Light and 104 (60.5%) at Pope's Eye. Of 1 116 chicks banded at sites in Port Phillip Bay between 1967 and 2000, 123 (11.0%) were resighted at Pope's Eye, at Wedge Light (14, 1.2%), or at the newer sites at Point Wilson (14, 1.2%), South Channel (8, 0.7%) and channel marker 10 (2, 0.2%). Of the 11 gannets originally banded at Lawrence Rocks, seven were

recorded at Pope's Eye, two at Wedge Light, and four elsewhere.

While no birds banded as chicks at Lawrence Rocks were resighted at Wedge Light between 1967 and 1987, two (one banded in 1965/1966, the other in 1966/1967) were found dead (shot) there in February 1972, together with three other adults (one banded as a chick at Wedge Light in 1967/1968, one in 1968/1969). Subsequently, another nine have been recorded in Port Phillip Bay, seven at Pope's Eye and one each at South Channel and Point Wilson. Two were less than or equal to three years post banding, one four years old, and six were six or seven years old on first resighting. Between 1966 and 1975, 1 811 chicks were banded at Lawrence Rocks (Pescott 1980), and only the two birds (0.1%) killed at Wedge Light were recorded from this cohort in Port Phillip Bay. From 1986 to 1995, another 6 999 chicks were marked at Lawrence Rocks (Fisher and Cooper n.d.), and of these nine (0.1%) were subsequently resighted in Port Phillip Bay. This limited, later intrusion of such birds into the Port Phillip population occurred well after the unmodified Wedge Light platform was fully occupied, when the Pope's Eye colony was expanding or full and other sites were being developed. No new recruits from Lawrence Rocks have been recorded in Port Phillip Bay since the establishment of the mainland colony at Point Danger in 1995. In some contrast, three birds from Wedge Light were reported at Lawrence Rocks, one 26 years post banding (from the 1969 cohort, by which time only 24 chicks had been banded at Wedge Light), one from the 1974 cohort (64 chicks banded to that time) in 1988 and another from the 1988/1989 cohort (145 banded).

Details of resightings made at Wedge Light and Pope's Eye colonies in breeding periods between 1971 and 2000 are summarised in Table 2. Apart from the inclusion of two breeding adults from Lawrence Rocks, and one bird (two resights) from Pope's Eye, the colony at Wedge Light has developed by returning young fledged there. Indeed, of 18 resightings (involving 15 individual birds), 16 (88.9%, 12) were of chicks produced at Wedge Light. By comparison, Pope's Eye contained numerous breeding adults (banded as chicks) from Wedge Light (37 individual birds, 27.8% of resightings) or, more obviously, from Pope's Eye itself (171 resights, 61.1%; 85 birds). Notably, birds from Wedge Light, first observed in 1986, increased from about 1991. However, in breeding periods when larger numbers of resightings were made, the proportion of birds from Pope's Eye increased from 60 per cent (1991, 20 resights) to 70.8 per cent (1994, 65) and was over 60 per cent in other periods (1997, 66 resights; 1998, 46). At Pope's Eye, 129 individuals were involved in resight totals; of these, 37 (28.7%) were originally banded at Wedge Light and 85 (65.9%) at Pope's Eye. For the resighted birds banded at Wedge Light (58), most (38, 65.5%) were seen at Pope's Eye and fewer at Wedge Light (12) or elsewhere. In contrast, of 104 resighted birds banded at Pope's Eye, 85 (81.7%) were at Pope's Eye itself, and 11 at the newer Point Wilson colony (Table 2).

At Point Wilson, visited in 1996, 1997 and 1999, initial resights were of birds banded at Pope's Eye (5) or Wedge Light (4); the proportion from Pope's Eye was higher in

TABLE 2
Resights and recaptures of banded Australasian Gannets *Morus serrator* at Wedge Light and Pope's Eye colonies, Port Phillip Bay, Victoria in breeding periods between 1971 and 2000.

Breeding period	Recorded at					
	Wedge Light from			Pope's Eye from		
	Wedge Light	Pope's Eye	Other sites	Wedge Light	Pope's Eye	Other sites
1971-1972	2*		2**			
1973-1974	1					
1975-1976	1					
1976-1977	1					
1977-1978	1					
1978-1979	1					
1986-1987				3		
1988-1989				1		
1989-1990		1		4	1	
1990-1991				4	4	
1991-1992		1		7	12	1*
1992-1993					2	1*
1993-1994				1	1	1*
1994-1995				15	46	4*
1996-1997	7			8	27	2*
1997-1998				19	44	3*
1998-1999				16	29	1*
1999-2000					5	
Totals	14	2	2	78	171	13

a = from Lawrence Rocks. * = dead.

the last visit (7 of 9 resights), when a bird from Lawrence Rocks was also recorded. At South Channel Pile too, there was a bird from Lawrence Rocks seen in 1999, as were others from Pope's Eye (4) and Wedge Light (3).

For all breeding sites in Port Phillip Bay, the influence of birds from Pope's Eye in resight totals is apparent (Table 3). Philopatry of resighted birds was high, but differed between the two major colonies. Between 1986, when Pope's Eye was first visited, and 2000, 759 chicks were banded there: 104 of these (13.5%) have subsequently been resighted. Of these resights, 85 (81.7%) were seen again at Pope's Eye (including one first seen at Wedge Light); 12 others (including two seen at Pope's Eye in the second and fourth years) were later at Point Wilson, and six elsewhere. In some contrast, for Wedge Light, where 229 chicks were banded in the same period, resights (57, 24.9% of those banded) were mainly at Pope's Eye (37, 64.9%); only 12 (21.0%) were resighted at Wedge Light and eight elsewhere. Founding birds at newer sites were, nevertheless, from Wedge Light or Pope's Eye. Thus, of 22 resights at Point Wilson, 13 (13 birds) were from Pope's

Eye and 8 (4) from Wedge Light, with only one resight of a bird banded at Lawrence Rocks.

Resighted birds, once recorded at a particular colony generally bred there in later periods; those involved in interchanges between sites were usually younger (probably non-breeding) birds. For example, one bird, banded at Wedge Light, was seen at Point Wilson in its fourth year and then at Pope's Eye in its sixth. Another bird (from Wedge Light) was resighted at navigation marker 10 in its fourth year post banding, and at Pope's Eye when six years old. Other birds (banded at Pope's Eye) were either reported at Pope's Eye in the fourth year post banding, and seen at Point Wilson later, or moved from Wedge Light (third year) and then seen at Pope's Eye from the fourth year onwards.

Age at first resight

The ages (in breeding periods, here taken as years) of the 172 banded chicks on first resighting in Port Phillip Bay (at any colony) are summarised in Table 4. While small numbers were seen one or two years post banding,

TABLE 3
Summary of resightings (and recaptures) of individual Australasian Gannets *Morus serrator* at breeding colonies in Port Phillip Bay, Victoria. Shown in parentheses are numbers of birds found dead.

Source	Resight/recapture at					
	Wedge Light	Pope's Eye	Point Wilson	Channel mark No. 6	Channel mark No. 10	South Channel
Wedge Light	12 (2)	37	4		1	3
Pope's Eye	1	85 (1)	12	1	1	4
Lawrence Rocks	2 (2)	7	1			1
Totals	15 (4)	129 (1)	17	1	2	8

resights increased subsequently, particularly 3–7 years after marking and the mean age at first resight was 5.6 years (± 3.04 , 1–21). However, this average includes breeding birds at nests, or non-breeders attending or visiting colonies.

Between 1988 and 1994 resighted birds were not necessarily assigned to individual nests, but in 1994/1995 and 1996/1997 they were more positively associated with them. Although some birds (18, 20% of the 90 birds recorded at nests) were present when three or four years old, most were older (Table 4). The average age for 45 birds at nests in 1994/1995 was 6.8 years (± 3.25 , 4–17) and in 1996/1997 the mean was 7.2 years (± 4.68 , 3–23, $n = 45$). In 1994/1995, no bird considered to be breeding was under 4 years old, but some others present at the colony were two–three years post banding. Similarly, in 1996/1997, of 29 birds breeding at Pope's Eye, only one three year old and three two-year old birds were present. At Wedge Light, none of those seen was less than four years post banding and at the three new colonies, all resighted birds were 4–5 years post banding.

Resights at Pope's Eye generally increased in the study period (Table 2). In earlier breeding periods (1986–1989) there were no records of birds fledged from Pope's Eye itself (supporting the view that the colony was not developed much before 1985), and resights were of birds fledged previously from Wedge Light (or occasionally from Lawrence Rocks). There were no young or pre-breeders banded at Pope's Eye seen there until 1989/1990, when one bird fledged in 1986/1987 was resighted. But in time, the proportion of birds of pre-breeding or young breeder age (here taken as ≤ 5) increased and then declined (Table 5), reflecting colony growth towards completion (around 1994/1995), apart from subsequent use of neighbouring, generally unsuitable, rocks). Numbers of younger birds increased to a maximum between 1990 and 1993 and then declined as founding birds maintained sites and continued to age. At Pope's Eye, the incoming younger cohort was predominantly comprised of birds fledged from Pope's Eye, although birds from Wedge Light, and occasionally from Lawrence Rocks, were reported.

Recoveries, resights and mortality rates

Of the 125 birds banded as chicks at Wedge Light up to 1981, eight (6.4%) were subsequently recovered. Two

recoveries were at Wedge Light itself (shot, in February 1972), and another (band only) was reported at Wahgunyah, north-east Victoria, some 250 kilometres inland of the banding site. Other birds were recovered in Port Phillip Bay (3) or just outside it. In later breeding periods, a further 33 recoveries (3.3% of 991 banded as chicks at all sites in Port Phillip since 1986) were made. Of the 41 recoveries, about 29 per cent (12) occurred within five months of banding, and another five were reported up to 20 months post banding. A similar number (16) were recovered 21–60 months post banding, suggesting that the majority of losses occurred around or soon after fledging and that the rate thereafter drops considerably. The mean age of recoveries was 32.5 months (± 29.76 , <1–120) post banding, reflecting the inclusion of older (and more distant) recoveries. While few recoveries have been made away from Port Phillip Bay, one bird was found at Marshall Bay, Tasmania (41 months after banding), one at Port Stephens, New South Wales (2), and one each at Coobowie (5), Wool Bay (41), Bollapandda (4) and Kandina (6), in South Australia; another bird was released off Kangaroo Island after being caught on a fishing line. Most recoveries (23) were, however, within Port Phillip Bay, or just beyond the Heads. Apart from the early records of dead adults at Wedge Light, only five have been found dead at breeding sites subsequently, although one chick was found dead before fledging.

Other banded gannets have been reported to the ABBBS as live recaptures away from breeding sites, generally in or just outside Port Phillip Bay. Some of these recaptures (pre-fledging or just-fledged birds) were replaced at Pope's Eye or Wedge Light, others were held in rehabilitation centres (where they were released or died), or sent to the Melbourne Zoo. Considerable confusion surrounds such records, a consequence of multiple handling and/or reporting. It is, however, clear that in some breeding periods a small number of young leave the colonies, before or just after fledging, and may be washed ashore to be rehabilitated and released, or be moved to the Zoo, or die. Of 18 'rehabilitated' birds ten were from Wedge Light, all before 1991/1992, whereas those from Pope's Eye were reported up to 1997/1998. Of 15 of known age when recaptured, nine were made within three months after banding. At least three birds replaced at the colonies were subsequently resighted there.

TABLE 4
Age at first resighting or recapture of Australasian Gannets *Morus serrator* at Port Phillip Bay, Victoria, colonies.

Banded at / group	Resight/recapture in years post-banding																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	23	
All birds																							
Lawrence Rocks		1	1	1	1	5	2																
Wedge Light	1	2	4	8	8	6	9	8	3		2	1					1	1		1	2		
Pope's Eye		6	16	23	28	23	4	3	1														
Totals	1	9	21	32	37	34	15	11	4		2	1					1	1		1	2		
Per cent	0.6	5.2	12.2	18.6	21.5	19.8	8.7	6.4	2.3		1.2	0.6					0.6	0.6		0.6	1.2		
Known breeders																							
1994–1995 ^a				4	11	19	1	6								2	2						
1996–1997 ^b			1	13	5	4	10	7		1									1		2	1	

a = birds at Pope's Eye. b = birds at several sites in Port Phillip Bay, including Pope's Eye.

TABLE 5

Age of resightings and recaptures of Australasian Gannets *Morus serrator* at Pope's Eye, Port Phillip Bay, Victoria 1986–2000, showing the proportion less than or equal to 5 (i.e. taken to be pre-breeders or young breeding birds) compared with the total resighted in each breeding period.

Breeding period	Total resights	Total ≤5	Total 5+	Per cent ≤5	Total banded at Pope's Eye ≤5	Total banded at Pope's Eye as % of ≤5
1986–1987	3		3			
1988–1989	1		1			
1989–1990	5	1	4	20.0	1	100.0
1990–1991	8	5	3	62.5	4	80.0
1991–1992	20	15	5	75.0	11	73.3
1992–1993	3	3		100.0	2	66.7
1993–1994	3	1	2	33.3	1	100.0
1994–1995	65	32	33	49.2	25	78.1
1996–1997	36	17	19	47.2	15	88.2
1997–1998	66	11	55	16.7	7	63.6
1998–1999	46	4	42	8.7	4	100.0
1999–2000	5		5			

Observations at Pope's Eye from 1994 onwards allow a preliminary estimation of mortality rates. Thus 65 resightings were made of known age birds in 1994/1995; of these, 52 (80%) were resighted in 1996/1997 or later, and 46 (70.8%) in 1997/1998 or subsequently. These resights suggest an average mortality of around 10.9 per cent over the three-year period (though the rate is reduced by inclusion of only one resight of known pairs, and the fact that only one of a pair was present). However, if birds not known to be associated with a nest, together with those less than four years old, an unaged adult and one bird from each known pair (16, using random number tables), are removed then the total of known breeders for 1994/1995 is reduced to 39. Of these birds, 34 were resighted in 1996/1997, or later and 32 in 1997 or subsequently. For this mixed-age cohort, the average annual adult mortality was 6.4 per cent. Following Nelson (1978a), and using the simple formula for calculating mean adult life expectancy ($l_{ex} = 2 - m/2m$, where m = annual adult mortality), average life expectancy of adult Australasian gannets in Port Phillip Bay is some 15.1 years. Since pairs routinely fledge 0.57 young per pair (Norman and Menkhorst 1995), then each pair would produce some 8.6 young on average, i.e. a surplus of 6.6 which, in a stable population, would allow a 76.7 per cent mortality in the prebreeding cohort. If young birds enter the breeding population at age four years then, with an adult mortality rate of 6.4 per cent, the original population could replace itself in 5–6 years, a time when 77 per cent of the original cohort would still be alive and capable of adding to the population for another 10 years. Young birds produced in early breeding periods would also enter the breeding population and produce additional numbers. Hence, if a colony was established by 100 pairs of breeding age and subject to mortalities and productivity as indicated, then four years later the population would have increased by 62 per cent (or 12.8% p.a.).

DISCUSSION

In the period considered here, populations of Australasian gannets have increased substantially in Port Phillip Bay, Victoria as they have elsewhere (Wodzicki *et al.* 1984;

Hawkins 1988; Norman *et al.* 1998), apart from the Cat Island (Furieux Group) colony which is now extinct (I. Skira, pers. comm.). The Wedge Light colony, begun in 1966/1967, expanded well before Pope's Eye was occupied (about 1985); both were essentially full before other breeding sites in Port Phillip Bay were initiated (e.g. navigation markers 6 and 10 in about 1993, Point Wilson (about 1996), South Channel Pile (1998), and the Hopetoun Channel markers in 1998 or 1999). Sites such as Wedge Light, Pope's Eye, and the navigation markers 6 and 10 all developed while the Lawrence Rocks colony was expanding; others (e.g. Point Wilson, Hopetoun Channel markers) were formed as gannets at Lawrence Rocks occupied available nesting area and, presumably, became the source of birds which breed at nearby Point Danger (Norman *et al.* 1998; Bunce *et al.*, in prep.).

Wedge Light was fully occupied about 1980/1981 (although the breeding area was slightly increased between 1992 and 1993). Expansion at Wedge Light was about 21 per cent annually between 1966 and 1981, but the longer term increase was 10 per cent p.a. (between 1966 and 1997). The Pope's Eye colony also grew at 18 per cent p.a. from 1985/1986 to 1996/1997 (Norman *et al.* 1998), rates well above those suggested as being generated from natal colonies (Nelson 1978a). While initial colonizers at Wedge Light presumably included birds from Lawrence Rocks, subsequent growth at Port Phillip Bay colonies has depended almost exclusively on internal productivity. At Wedge Light, most resights were birds returning to the natal colony whereas at Pope's Eye resighted birds, fledged from Wedge Light, were initially numerous (Table 5) but ultimately expansion was due to the return of young produced there. Elsewhere in Port Phillip Bay, colonisation of new sites (reflected by resights) was predominantly by birds fledged from Pope's Eye and Wedge Light. Throughout, birds from Lawrence Rocks have not formed a large, or increasing, proportion of resighted birds; indeed, no new individual has been resighted since 1994/1995, when the Point Danger colony was founded. And for the Lawrence Rocks colony too, where the rate of population increase was 7 per cent (per annum) from 1960 onwards, there have been few resights of birds from Port Phillip Bay

colonies (Fisher and Cooper n.d.; ABBBS records). Despite Nelson's (1978a) view that Australian gannet colonies were unlikely to be as 'autonomous' as those elsewhere, there is no evidence that New Zealand birds (or even remnants from the Cat Island colony) have infiltrated Victorian colonies. (Indeed, there has been some infusion of Cape Gannets *M. capensis* into colonies at Lawrence Rocks and Wedge Light; e.g. Norman *et al.* 1998). Immigration has, therefore, not played a major role in the expansion of Victorian colonies, rather strong philopatry has, and the local increase has taken place while others were also underway in New Zealand (Wodzicki *et al.* 1984). Further, the founding of, and increases at, the various sites in Port Phillip Bay have taken place at different times and intervals.

The Pope's Eye colony was, in 1986/1987, developed essentially by birds produced at Wedge Light; such birds tended to be young breeders which gradually aged with the colony. The first record of a chick banded at Pope's Eye and breeding there was in 1989/1990 but by 1991/1992, most resights were birds from Pope's Eye. While there was an input of young breeders for some years, in time numbers of new birds entering the population declined (Table 5). To an extent the potentially strong philopatry was compromised by nest site availability and occupation of suitable sites by increasingly older breeders. The opportunity for younger breeders to enter the population was essentially reduced to replacing mortalities, to nesting in less satisfactory sites or, alternatively, to occupying new areas (sometimes rapidly, e.g. South Channel Pile). By around 1981, when Wedge Light was full, new breeders there depended on the mortality of older adults (or limited use of supporting cross members, Norman *et al.* 1998). At Pope's Eye, full about 1992, expansion occurred by increased nesting attempts on the lower lying rocks adjacent to the original platforms. Such sites were usually unsuccessful (e.g. Gibbs *et al.* 2000). However, once established at a breeding site birds tended to return there later and recorded interchange between sites was limited, as in other gannets (e.g. Klages 1994).

While birds were resighted from one or two to over 23 years post banding, only one individual was present at a nest when three years old. In general, average ages of individuals at nests at Pope's Eye suggested that breeding by some individuals began four years post fledging, with others entering the breeding population somewhat later. However, resight data suggest that some newer colonies were begun essentially by younger (4 year old) rather than older birds (see also Wodzicki and Stein 1958; Nelson 1978a,b; Brun 1972). In Port Phillip Bay, there are now few appropriate platforms available for further breeding; in some contrast, at Point Danger, a mainland colony was founded and continues to expand (Bunce *et al.*, in prep.; A. Govanstone, pers. comm.).

Data summarized here were obtained from an amalgam of observations at colonies of Australasian Gannets in Port Phillip Bay. It is accepted that studies have been concentrated at Pope's Eye where, since the occupied (and available) area is greater than elsewhere in Port Phillip Bay, the larger numbers of chicks banded there have dominated

resight totals. It is also possible that the absence of resights of birds banded at Wedge Light between 1967 and 1971 may reflect problems associated with band durability (ABBBS). Further restrictions of the study were imposed by the nature of the sites. Not only are potential breeding areas now limited, but opportunities to record banded birds are moderated by the size of the sites themselves, and the need to minimize disturbance. Nevertheless, the results support earlier studies, both in Victoria (Norman and Menkhorst 1995) and New Zealand (e.g. Wodzicki and Stein 1958; Wodzicki *et al.* 1984) and suggest, to a varying extent, that the Australasian Gannet has a breeding routine similar to those of other sulids. Thus, younger birds are generally absent from colonies, breeding is initiated around four years of age, and birds usually return to natal colonies (if possible) and remain there (see also Nelson 1978a,b; Klages 1994). Mortalities of any age group rarely occur at nest sites; rather there is an increased, often local, mortality near or shortly after fledging. Once established at a breeding site; adult gannets in Port Phillip Bay usually have a relatively high breeding success. Estimated annual mortality in adults is similar to that reported for the northern gannet *Morus bassana* (about 6%, Nelson 1978a) or the Australasian Gannet at New Zealand colonies (4–5%, Nelson 1978b), as is that for the pre-breeding cohort (about 77% compared with around 70% in *M. bassana*, Nelson 1978a). Dispersal is extensive in this species, with birds banded in New Zealand being recovered along the east Australian coast (Wodzicki and Stein 1958; Marchant and Higgins 1990). Certainly birds from Lawrence Rocks have been recovered in and around Port Phillip Bay, and further east, and along the Western Australian coast (Fisher and Cooper n.d.; ABBBS records). To date, however, recoveries of birds from Port Phillip Bay have only been made in South Australia, Tasmania and New South Wales, waters in which birds from Lawrence Rocks, and New Zealand also occur (Marchant and Higgins 1990). That colonies have increased rapidly and essentially from internal productivity rather than immigration is contrary to some expectations. However, simple extrapolations using current, averaged data suggest the opportunity for large population increases, increases quite independent of immigration from other colonies.

In Victoria, the breeding population of the Australasian Gannet has expanded considerably since the 1950s, and continues to do so. Gannets now occupy areas where breeding was not previously recorded (or even possible, as with artificial sites in Port Phillip Bay), and numbers now presumably exceed those previously involved. This expansion has resulted in a surplus population of potential breeders which must occupy new sites if they are to breed: in such instances strong philopatry is compromised. As local colonies filled, the opportunity for younger birds to obtain nest sites declined and the increasingly experienced (and perhaps more successful) breeding population has tended to age. In considerable contrast to the views of Klages (1994), who considered that fringe sites were 'not physically inferior' to central sites since gannet colonies were established 'invariably at places that provide space for everyone', colonies in Port Phillip Bay have been established at sites with very limited nesting area (e.g. Wedge Light, navigation piles or channel markers) or with

limited prospects for expansion (e.g. Pope's Eye, where fringe sites are inferior, and central nesting may confer some enhanced breeding success (Gibbs *et al.* 2000)). Some factors potentially involved in enabling local gannet populations to increase are currently being investigated.

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