

NUMBERS OF NON-BURROWING BREEDING SEABIRDS OF THE HOUTMAN ABROLHOS: 1991–1993 AND 1999

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Counts of non-burrowing seabirds were conducted on 146 islands, islets and rocks in the Houtman Abrolhos, Western Australia over 14 days in early summer 1999, using a jet boat. Comparisons with similar counts made in 1991–1993 showed that numbers of breeding pairs increased from 450 000 to 701 000. This difference was due largely to the Sooty Tern *Sterna fuscata* (272 700 to 455 200) and Common Noddy *Anous stolidus* (132 000 to 161 400), although numbers of Crested *Sterna bergii*, Roseate *Sterna dougallii* and Fairy Terns *Sterna nereis* and Lesser Noddy *Anous tenuirostris* also increased. Fluctuations between 1991–93 and 1999 may be explained by increased numbers of pairs breeding in years when food is abundant, with years with a strong Leeuwin Current having lower participation rates and delayed breeding in many species. Interpretation of data collected during rapid monitoring of seabirds at the Houtman Abrolhos, such as reported here, must take account of oceanic conditions.

INTRODUCTION

The Houtman Abrolhos comprises three groups of islands, totalling about 150 islets and rocks. They lie between 28°18'S and 29°00'S, about 70 km west of Geraldton, Western Australia. The Abrolhos is renowned for its rich and abundant seabird fauna, having more breeding species and individuals than any other locality in the eastern Indian Ocean. Some of these species breed further south than on equivalent west coasts elsewhere in the world. A description of the islands, their marine environment and seabirds can be found in Fuller *et al.* (1994), who provided counts and estimates of abundance for all breeding species during early summer in 1991–1993. They visited all islands in the Abrolhos, but not in the same year: Easter Group was examined in 1991, Wallabi Group in 1992 and Pelsaert Group in 1993.

Fuller *et al.* (1994) suggested that future counts would enable trends to be documented and allow evaluation of the effects of environmental change and human impacts. This paper provides counts or estimates of all breeding species present in November 1999 (except for burrow-breeders), and compares these counts and estimates with those made in 1991–1993. It also provides comments on the effectiveness of rapid survey techniques for documenting seabird populations at the Abrolhos. The work in 1999 was the first that examined all islands in the archipelago over a few days.

METHODS

Work was conducted from the jet boat P.V. *Piper* operated by the Western Australian Department of Fisheries. All islands, islets and rocks that could support breeding seabirds were visited as follows: Wallabi Group 17 to 21 November 1999 inclusive, Easter Group 22 to 25 November inclusive and Pelsaert Group 26 to 30 November inclusive. The number of above high water features examined in each group was: 44 in the Wallabi Group, 50 in the Easter Group and 52 in the Pelsaert

Group. On each island one person (two on a few larger islands) walked over the whole of the island on foot searching for nests and nesting colonies. Counts or estimates were made as described by Fuller *et al.* (1994), except that time did not permit counts or estimates of the burrow-nesters (Wedge-tailed Shearwater *Puffinus pacificus*, Little Shearwater *P. assimilis* and White-faced Storm-petrel *Pelagodroma marina*). Some information from briefer visits in other years is presented where appropriate.

RESULTS

Table 1 provides a list of all Islands in the Houtman Abrolhos where seabirds were recorded breeding in 1991–1993 and 1999. As well as the burrowing species, we have excluded information on oystercatchers, which breed earlier than our visits.

Comments on differences between 1991–1993 and 1999 are provided below, along with notes on records for other years. Note that in Fuller *et al.* (1994), while the numbers of breeding pairs are correct in their Appendix 1, in their Appendix 2 additional islands were inadvertently inserted. Thus, total numbers of pairs were sometimes too high.

Red-tailed Tropicbird *Phaethon rubricauda*. While we did not record this species breeding in 1993, it has bred on both Pelsaert and Rat Islands (Serventy *et al.* 1971; Fuller *et al.* 1994). It was not recorded breeding on Pelsaert Island between 1954 and 1988 and was not present in 1993, but three pairs were nesting there in 1999 and four in 2000.

Little Pied Cormorant *Phalacrocorax melanoleucos*. Although not usually considered a seabird, this species breeds in mangroves on the fringe of a landlocked lagoon on Wooded Island. While we did not record any breeding in 1991 or 1999, we recorded 11 nests on 5 December 1993, five on 4 December 1995 and three on 8 December 2000.

TABLE 1
Islands of the Houtman Abrolhos and numbers of seabird pairs recorded breeding on them in November 1991–93 and November 1999.

Species	Group	Island	1991–1993	1999	Species	Group	Island	1991–1993	1999
Red-tailed Tropicbird	Pelsaert	Pelsaert	0	3	Osprey	Pelsaert	Newbold	1	0
					(continued)	(continued)	One	1	0
		TOTAL	0	3			Pelsaert	3	3
Pied Cormorant	Wallabi	First Sister	11	0			Rotondella (2nd islet to S)	0	1
		(3rd Islet to N)					Sandy	1	0
		Traitors (Islet 1)	23	8			Ship Rock	0	1
		Traitors (Islet 3)	28	0			Six	1	1
	Easter	Wooded	700	450			Square	0	1
	Pelsaert	Eight	35	65			Stick	1	1
		One	25	0			Sweet	2	1
		Seven (islet to W)	9	0			The Coral Patches	1	1
		Shag Rock	12	38			TOTAL	36	31
		Sweet	33	0	White-bellied Sea-Eagle	Wallabi	Akerstrom	1	1
		TOTAL	876	561			East Wallabi (islet near jetty)	0	1
Eastern Reef Egret	Wallabi	Little Pigeon	1	0			Eastern	0	1
		Long (Abrolhos)	1	0			First Sister (2nd islet N)	0	1
		Seagull	0	1			Long	1	1
		Wann	1	0			North	0	1
	Easter	Bynoe	1	0			Oystercatcher	1	1
		Helms (islet 1-SW)	1	0			Pelican	1	1
		Little Rat	1	1			Tattler	1	1
		Serventy	1	0			West Wallabi	0	2
		Soumi	1	1			Crake	0	1
	Pelsaert	Davis	0	1		Easter	Dry	0	1
		Gregory	1	0			Gilbert	1	0
		One	1	0			Sandy	1	0
		TOTAL	10	4			Suomi	1	1
Osprey	Wallabi	Dicks	1	1			Wooded	0	1
		East Wallabi	1	1			Davis	1	0
		First Sister	1	0			Pelsaert	2	1
		(3rd islet N)					Square	1	0
		Little Pigeon	0	1			TOTAL	12	16
		Long (islet to N)	1	0	Pacific Gull	Wallabi	Dakin	1	1
		North	1	1			First Sister	0	1
		Pigeon	1	0			First Sister (3rd islet N)	1	1
		Plover	1	0			Little Pigeon	0	1
		Saville-Kent	1	0			Long	1	2
		Second Sister	1	1			Marinula (islet to NE)	0	1
		Shag Rock	0	1			Pelican	0	1
		Third Sister	0	1			Pigeon	0	1
		Traitors (Islet 1)	0	1			Plover	1	1
		Wann	1	0			Shag Rock	0	1
		West Wallabi	1	0			Saville-Kent	1	0
	Easter	Bushby	0	1			Seal	1	0
		Bynoe (2nd islet to W)	0	1			Seal (islet to N)	0	1
		Helms (islet 4 to SW)	1	0			Second Sister	0	1
		Keru	0	1			Third Sister	0	1
		Leo	1	0			Traitors	1	2
		Leo (islet to N)	0	1			Traitors (Islet 5)	1	0
		Little Rat	1	2			Wann	0	1
		Rat	2	1			Bushby	1	1
		Serventy	1	0			Bynoe	0	1
		Shearwater	1	0		Easter	Campbell	0	2
		Stokes (islet to NE)	0	1			Gibson (islet to S)	0	1
		Suomi	1	1			Gilbert	1	1
		Tapani	0	1			Gilbert (islet to NW)	1	0
		White Bank	1	0			Helms	1	1
	Pelsaert	Wooded	0	1			Joe Smith	1	1
		Arthur	0	1			Keru	1	1
		Fairbridge	1	0			Leo	0	1
		Gaze (islet to S)	1	0			Leo (islet to E)	0	1
		Gun	0	1			Little North	1	1
		Gun (islet adjacent-SE)	1	0			Morley	1	1
		Jon Jim	1	0			Rat	0	2
		Lagoon	1	0					

Table 1 — *continued*

Species	Group	Island	1991–1993	1999	Species	Group	Island	1991–1993	1999
Pacific Gull (<i>continued</i>)	Easter (<i>continued</i>)	Serventy (islet to N)	0	1	Caspian Tern (<i>continued</i>)	Pelsaert (<i>continued</i>)	One	0	1
		Shearwater	0	1			Pelsaert	2	9
		Stokes	0	1			TOTAL	76	51
		Suomi	1	1	Crested Tern	Wallabi	Long	60	0
		Tapani	1	1			North	343	0
		White (islet to S)	1	1			Second Sister	4	0
		White Bank	0	1			Third Sister	0	3
		Wooded	2	3			West Wallabi	0	764
	Pelsaert	Arthur	0	1		Easter	Bynoe	0	790
		Burnett	0	1			Leo	600	7
		Diver	1	0			Shearwater	35	143
		Eight	1	0			White Bank	4	0
		Fairbridge	1	0			Wooded	0	3
		Hummock	0	1		Pelsaert	Pelsaert	1 013	1 480
		Iris Refuge	1	0			Six	0	9
		Murray	1	0			Sweet	0	14
		Newman	0	1			The Coral Patches	95	0
		One	1	1			TOTAL	2 154	3 213
		Pelsaert	8	2	Roseate Tern	Wallabi	Dicks	0	18
		Post Office	0	1			Far	297	0
		Robertson	0	1			Hall	0	120
		Sandy	0	1			Long	0	171
		Seven	1	1			Marinula	10	0
		Ship Rock	1	0			Marinula (islet to NE)	490	341
		Six	0	1			North	0	4
		Square	1	1			Seal	0	73
		Stick	1	1			Second Sister	0	139
		Sweet	0	1			Third Sister	139	8
		The Coral Patches	1	1			Traitors	81	0
		Three	2	2			Traitors (Islet 5)	2	0
		Uncle Margie	1	0		Easter	Campbell (islet to S)	386	0
		TOTAL	43	60			Gibson	20	0
Silver Gull	Wallabi	Dakin	0	1			Gilbert (islet to NW)	98	0
		Dicks	0	1			Leo	0	627
		First Sister	0	1			Little North	552	0
		Long	0	1			Serventy	3	0
		Plover	2	1			Shearwater	0	647
		Shag Rock	0	1			White	0	700
	Easter	Dry	7	0		Pelsaert	White (islet to S)	42	0
		Gibson	2	0			Gregory	30	0
		Gilbert	8	0			Jon Jim	105	964
		Helms (islet 1 to SW)	1	0			Pelsaert	365	1 700
		Joe Smith	8	0			Robertson	0	8
		Leo	0	2			Square	497	0
		Serventy	4	0			Sweet	11	0
		Shearwater	5	0			The Coral Patches	311	10
		Suomi	0	1			TOTAL	3 439	5 530
		Wooded	0	1	Fairy Tern	Wallabi	East Wallabi	58	0
	Pelsaert	Eight	0	3			North	0	28
		Fairbridge	4	1			Third Sister	0	19
		Jackson	4	0		Easter	Bynoe	25	0
		Jon Jim	4	0			Helms	8	0
		Murray	4	0			Little North	128	0
		Newman	15	0			Rat	0	21
		One	0	2			Tapani	32	0
		Pelsaert	80	0			White	0	87
		Ship Rock	1	0		Pelsaert	Wooded	0	19
Caspian Tern	Wallabi	Stick	0	8			Burnett	0	24
		Sweet	4	8			Fairbridge	9	0
		East Wallabi	1	0			Gregory	10	15
		Long (islet to N)	0	1			Murray	57	0
		North	0	1			Newman	20	17
	Easter	Seal	0	1			Pelsaert	38	265
		Traitors (Islet 1)	0	1			Post Office	5	0
		Gilbert	0	1			Sandy	0	6
		Joe Smith	0	1			The Coral Patches	12	0
		Keru	1	0			Uncle Margie	3	0
	Pelsaert	Leo	70	32			TOTAL	405	501
		Shearwater	1	0	Bridled Tern	Wallabi	Akerstrom	40	7
		Coronation (2nd islet NE)	1	0			Alcatraz	8	1
		Eight	0	1			Beacon	700	600
		Gun	0	1					
		Lagoon	0	1					

Table 1 — *continued*

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Species	Group	Island	1991–1993	1999	Species	Group	Island	1991–1993	1999
Bridled Tern (continued)	Wallabi (continued)	Dakin	0	35	Bridled Tern (continued)	Pelsaert (continued)	Burnett	6	35
		Dicks	300	200			Burnett (1st islet to N)	1	2
		First Sister (3rd islet N)	0	1			Burton	0	6
		Eastern	5	7			Coronation	0	65
		Little Pigeon	50	3			Coronation (1st islet NE)	0	1
		Long	700	350			Davis	20	6
		Marinula	20	2			Diver	3	8
		Marinula (islet to NE)	0	2			Eight	70	40
		Pelican	30	40			Fairbridge	0	20
		Pigeon	200	120			Foale	0	3
		Plover	4	8			Gaze	0	6
		Saville-Kent	0	9			Gaze (islet to S)	0	2
		Shag Rock	5	3			Gregory	0	5
		Tattler	2	3			Gun	1 000	2 500
		Traitors	5	0			Gun, islet adjacent (south end)	0	2
		Traitors (Islet 1)	1	1			Iris Refuge	0	2
		Traitors (Islet 2)	2	1			Jackson	0	40
		Traitors (Islet 4)	0	1			Lagoon	0	6
		Traitors (Islet 5)	2	2			Newbold	0	1
		Alexander	0	100			Newman	0	55
		Alexander (islet to S)	4	0			Nook	0	1
		Bushby	1	3			One	50	40
		Bynoe	200	150			Pelsaert	1 000	90
		Bynoe (1st islet to W)	0	3			Post Office	15	150
		Bynoe (2nd islet to W)	0	3			Robertson	1	3
		Bynoe (3rd islet to W)	0	2			Rotondella	0	2
		Campbell	40	45			Rotondella (1st islet to S)	0	4
		Crake	3	3			Rotondella (2nd islet to S)	0	3
		Dry	10	40			Seven	4	30
		Gibson	1	2			Seven (islet to W)	0	2
		Gibson (islet to S)	0	2			Six	0	9
		Gilbert	12	20			Square	0	10
		Gilbert (islet to SW)	0	1			Stick	50	35
	Gilbert (islet to NW)	1	0	Sweet		15	25		
	Helms	8	15	The Coral Patches		0	6		
	Helms (islet 1 to SW)	6	2	Three		4	8		
	Helms (islet 2 to SW)	2	3	Travia		0	1		
	Helms (islet 3 to SW)	2	1	Travia (1st islet SE)		0	2		
	Joe Smith	3	0	Travia (2nd islet SE)		0	1		
	Keru	250	55	Two		5	8		
	Leo	200	500	Uncle Margie		6	30		
	Leo (islet to E)	0	1	TOTAL		7 061	6 368		
	Leo (islet to N)	1	4	Sooty Tern		Easter	Alexander	50 000	83 000
	Little North	300	0				Gilbert	0	1 100
	Little Rat	25	70				Keru	2 500	0
	Little Roma	2	1				Leo	20	0
	Morley	50	60				Little North	200	14 000
	Roma	5	5				Serventy	0	800
	Serventy	40	150				Stokes	1 250	0
	Serventy (islet to N)	0	3				Suomi	4 000	0
	Serventy (islet to W)	0	1				White	5 500	0
	Shearwater (islet to S)	10	2				Wooded	500	120 000
Stokes	40	2	Common Noddy	Pelsaert	Pelsaert	208 700	236 300		
Stokes (islet to NE)	0	3			TOTAL	272 670	455 200		
Suomi	1 000	0			Wooded	0	200		
Tapani	5	0			Pelsaert	132 000	161 200		
White	10	80			TOTAL	132 000	161 400		
Pelsaert		Wooded	500	350	Lesser Noddy	Easter	Morley	11 750	12 800
		Arthur	2	8			Wooded	5 345	14 485
		Basile	4	25			Pelsaert	34 870	40 700
							TOTAL	51 965	67 985

Pied Cormorant *P. varius*. A large colony breeds in mangroves on Wooded Island; about 700 pairs in 1991 and 450 in 1999. We recorded about 450 pairs in 1993 and 1995, about 400 in 1997, and 500 in 2000. Several small colonies are present elsewhere in the archipelago, where nests are on the ground, but none over 100 pairs.

Eastern Reef Egret *Egretta sacra*. Ten nests were recorded in 1991–1993, but only four in 1999. However, as nests of the Eastern Reef Egret are probably significantly underestimated due to difficulty in locating them in mangle or under limestone ledges, the difference is not considered to be significant.

Osprey *Pandion haliaetus*. Thirty-six active nests were recorded on 32 islands in 1991–1993, while 31 active nests were recorded on 28 islands in 1999. Although few active nests would have been missed, this difference is unlikely to be significant.

White-bellied Sea-eagle *Haliaeetus leucogaster*. Twelve active nests on 11 islands were located in 1991–1993, while 16 occupied nests were found on 15 islands in 1999. Sea-eagles are very common in the Wallabi Group (12 islands with active nests over the two survey periods) where Wedge-tailed and Little Shearwaters are available as prey the year round. Tammar Wallabies *Macropus eugenii* are also being taken.

Pacific Gull *Larus pacificus*. Forty-three nests were found on 34 islands in 1991–1993, while 60 nests were found on 54 islands in 1999. This species had finished or almost finished breeding at the time of our visits (flying young or large runners) and the counts were based largely on locating recently-used nests. The number located was, therefore, less than the number of pairs actually breeding. The increase between visits is unlikely to be significant.

Silver Gull *L. novaehollandiae*. In 1991–1993, 153 nests were located on 16 islands, and in 1999 32 nests were found on 14 islands. Most of this difference is due to a count of 80 on Pelsaert Island in 1993. Breeding was generally finished by the time of our visits and additional breeding takes place in autumn; thus actual breeding numbers would be higher than revealed by our work.

Caspian Tern *Sterna caspia*. A colony of Caspian Terns occurs on Leo Island, where 70 pairs were breeding in 1991 and 32 in 1999. A colony on Pelsaert Island seems to be growing in size. Elsewhere, single nests occur, mainly on small islets.

Crested Tern *S. bergii*. Breeding colonies of between 100 and 1 000 pairs are scattered throughout the archipelago, although smaller colonies of a few pairs are sometimes present. Only on Pelsaert Island can a major colony be found every year. Numbers increased from 2 154 nests in 1991–1993 to 3 213 in 1999.

Roseate Tern *S. dougallii*. Some 3 439 pairs were recorded in 1991–1993 and 5 530 in 1999. While we would not have missed any breeding colonies, breeding starts at different times each year and is often commencing or about to commence during our visits. Therefore our counts cannot be compared. This species also breeds in late-summer–autumn at the Abrolhos (Fuller *et al.* 1994).

Fairy Tern *S. nereis*. About 400 nests were located in 1991–1993 and 500 in 1999. This species was also starting to breed at the time of our visits; therefore the dates of the visits and the commencement of breeding would vary the count. Some colonies intermingled with those of Roseate Terns.

Bridled Tern *S. anaethetus*. This species breeds both in large colonies (e.g. 700 and 600 on Beacon Island and 1 000 and 2 500 on Gun Island) and in ones and twos on small islets. It is present on most islands being recorded on 104 islands out of 146 visited. The totals of 6 300 and 7 000 would not be significantly different, noting that numbers in the larger colonies are estimates, not counts.

Sooty Tern *S. fuscata*. This species was recorded on 10 islands in the Easter Group and one (Pelsaert Island) in the Pelsaert Group. Numbers on Pelsaert Island have been estimated most years since 1986 by measuring the extent of the colony from ground mapping on to an air photograph and multiplying by a constant of $14\,400 \pm 1780$ nests per hectare calculated from ground transects at a time when birds were sitting on eggs (Fuller *et al.* 1994). Table 2 shows that the size of the colony has fluctuated from 179 000 in 1989 and 180 000 in 2000 to 247 000 in 1991.

TABLE 2

Sooty Tern colony size on Pelsaert Island during visits from 1986 to 2000.

Year	Area of colony (ha)	Estimated number of breeding pairs (mean \pm SE)
1986	12.89	185 600 \pm 22 900
1989	12.43	179 000 \pm 22 100
1990	16.10	233 500 \pm 28 700
1991	17.08	247 700 \pm 30 400
1993	14.50	210 300 \pm 25 800
1995	13.44	194 900 \pm 23 900
1996	14.38	207 000 \pm 25 400
1999	16.41	236 300 \pm 29 000
2000	12.51	180 100 \pm 22 300

In the Easter Group, colonies have appeared and disappeared on various islands in recent years. In 1991 we estimated 63 970 pairs on eight islands and in 1999 we found an estimated 218 900 pairs on five islands. Data from our visits to the Easter Group where all islands were visited are provided in Table 3. Total numbers of pairs differed little in 1991, 1995 and 1996, but were much larger in 1999. Most of the increase was due to the Wooded Island colony increasing from 350 pairs in 1996 to about 120 000 pairs in 1999. In 2000 there were only 400 pairs present on Wooded Island, but we did not visit other islands in the group that year. Breeding was well advanced at the time of our visits, so it is most unlikely that we missed recording breeding birds.

Common Noddy *Anous stolidus*. Until recently Common Noddies bred only on Pelsaert Island (a very large colony on Rat Island was wiped out by the early part of the 20th Century (Fuller *et al.* 1994)). Estimates are shown in Table 4. The density of nests within the colony varies by more than two orders of magnitude, with very high densities (>50 000 nests/ha) in low *Sarcocornia* around shallow

TABLE 3
Sooty Tern colony sizes in the Easter Group from 1991 to 1999.

Island	Estimated No. of active nests 1991	Estimated No. of active nests 1995	Estimated No. of active nests 1996	Estimated No. of active nests 1999
Alexander	ca 50 000	ca 30 000	ca 1 500	ca 80 000
Bynoe	Nil	100–500	ca 300	Nil
Campbell	Nil	Nil	ca 30 000	Nil
Gilbert	Nil	Nil	Nil	ca 1 100
Keru	2 000–3 000	Nil	ca 40	Nil
Leo	20	500–1 000	ca 20 000	Nil
Little North	ca 200	ca 15 000	300–400	ca 15 000
Serventy	Nil	Nil	Nil	ca 800
Stokes	1 000–1 500	500–1 000	Nil	Nil
Suomi	3 000–5 000	ca 400	Nil	Nil
White	5 000–6 000	Nil	Nil	Nil
Wooded	100–500	500–1 000	ca 350	ca 120 000
Total	61 320–66 220	47 000–49 000	ca 52 540	ca 217 000

muddy lakes and low densities (<500 nests/ha) in areas of *Atriplex* shrubs. In 1999 a colony of about 200 pairs was located on Wooded Island, the first record there since 1913, when Alexander saw a small colony breeding among Sooty Terns (Johnstone and Coate 1992).

TABLE 4

Common Noddy colony size on Pelsaert Island from 1989 to 1999.

Year	Area of colony (ha)	Estimated number of breeding pairs (mean \pm SE)	No. of points sampled
1989	17.91	116 500 ¹	38
1991	14.44	129 800 \pm 28 200	55
1993	13.21	132 000 \pm 22 750	75
1995	16.23	147 700 \pm 43 700	50
1996	16.73	157 900 \pm 20 000	0 ²
1999	18.42	173 900 \pm 22 000	0 ²

Notes

1. Point data not retained by computer program in use at the time, standard error not possible to calculate.
2. Estimate based on all triangular tessellation data from 1991, 1993 and 1995 (180 samples, 9 940 \pm 1 195 nests/ha).

This species has been extending its range in Western Australia. A colony established on Lancelin Island about 250 kilometres south-south-east of Pelsaert Island in 1992. By 1996 it consisted of 300 breeding pairs and by 1998 had more than 900 pairs (Dunlop and Mitchell 2001). We located single nests under construction on Little North Island on 5 December 1995 and Alexander Island a day later, but no colonies resulted.

Lesser Noddy *A. tenuirostris*. Endemic to the Abrolhos at the subspecies level, this species breeds on Pelsaert, Wooded and Morley Islands. In 1991–1993 we estimated a total of 40 195 pairs and in 1999 we estimated 67 985 pairs. Estimates are based on quadrat counts along fixed transects. All estimates made are provided in Table 5, and areas of colonies are given in Table 6.

The same species of seabirds were breeding in 1991–1993 and 1999, except for the Red-tailed Tropicbird, which was present in small numbers only in 1999. The total number of pairs of all species breeding was 459 000 in 1991–1993 and 701 000 in 1999 (Table 7). This difference

was due largely to the Sooty Tern (272 700 to 455 200) and Common Noddy (132 000 to 161 400), although numbers of Crested, Roseate and Fairy Terns and Lesser Noddy also increased.

DISCUSSION

The use of a jet boat allowed a rapid survey of 146 islands, islets and rocks in the Houtman Abrolhos in 14 days. Our experience in using outboard-drive boats in some earlier years demonstrates that any other type of vessel would have been unsuitable for a rapid survey in this area where coral and limestone reefs abound.

One concern with the 1991–1993 survey was that each major island group was surveyed in a different year, leaving the possibility of major movements of breeding colonies between island groups between years. However, in 1999 we counted more breeding pairs than in the 1991–1993 survey, suggesting that we did not over-estimate numbers in the first survey.

The rapid survey technique we used is useful for quickly monitoring numbers of those species where breeding is well underway in early summer — Osprey, White-bellied Sea-Eagle, Caspian Tern, Crested Tern, Bridled Tern, Sooty Tern, Common Noddy and Lesser Noddy. It is of limited value for monitoring species that have largely finished nesting such as oystercatchers and Pacific Gull (although recently-used Pacific Gull nests can often be located), species that are commencing breeding and which in some years may delay breeding onset such as Fairy Tern, and species that have protracted breeding seasons such as Pied Cormorant, Silver Gull and Roseate Tern.

Fluctuations in the total number of pairs of all species breeding between 1991 and 1993 and 1999 may be explained by the increased numbers of pairs breeding in years when food is abundant. Dunlop and Wooller (1990) and Wooller *et al.* (1991) suggested that variations in the strength of the Leeuwin Current off the south-west coast of Western Australia can affect seabird breeding timing and success, with Little Penguins *Eudyptula minor* at Penguin Island (32°18'S) being in poorer condition and having lower reproductive success in years when the current was stronger.

TABLE 5
Estimated number of Lesser Noddies found on Pelsaert, Wooded and Morley Islands.

Island	Year	Colony Number	Estimated number of breeding pairs (mean \pm SE)	Island	Year	Colony Number	Estimated number of breeding pairs (mean \pm SE)
Pelsaert	1989	1	28 900 \pm 2 325	Pelsaert (continued)	1999	1	26 196 \pm 2 525
		2	21 615 \pm 2 660			2	14 490 \pm 1 352
		5	3 480 \pm 1 090			3	0
		6	115 \pm 80			4	0
		Total 1989	54 110			south end	25
	1991	1	26 420 \pm 3 000	Wooded	1989	Total 1999	40 700
		2	14 015 \pm 8 580			1	6 875 \pm 1 555
		4	16			1991	5 345 \pm 835
		5	1 220 \pm 660			1993	6 325 \pm 1 120
		6	86 \pm 40			1995	8 890 \pm 1 340
	1993	Total 1991	41 760			2	300
		1	20 110 \pm 2 040			3 (lagoon)	380
		2	14 760 \pm 1 385			Total 1995	9 570
		5	0			1996	6 750 \pm 1 150
		6	0			2	1 055 \pm 430
	1995	Total 1993	34 870			3 (lagoon)	95
		1	19 700 \pm 2 260			Total 1996	7 920
		2	19 100 \pm 1 635			1997	5 330 \pm 980
		5	0			2	650 \pm 280
		6	0			3 (lagoon)	95
	1996	Total 1995	38 700			Total 1997	6 075
		1	21 020 \pm 2 290			1999	12 694 \pm 1 880
		2	18 440 \pm 1 590			2	1 281 \pm 397
		5	0			3 (lagoon)	510
		6	0			Total 1999	14 485
	1997	south end	40	Morley	1989		16 375 \pm 2 455
		Total 1996	39 500			1991	11 750 \pm 2 440
		1	24 030 \pm 2 500			1993	7 665 \pm 1 535
		2	18 300 \pm 1 900			1995	9 600 \pm 1 800
		5	0			1996	8 930 \pm 1 470
	1997	6	0			1997	12 300 \pm 1 600
		south end	25			1999	12 800 \pm 1 805
		Total 1997	42 355				

TABLE 6

Area of mangal used by Lesser Noddy colonies, Houtman Abrolhos.

Island and colony number	Area (ha)
Pelsaert 1	1.696
Pelsaert 2	1.034
Wooded 1	0.475*
Wooded 2	0.063
Morley	0.890

*Area used varies depending on size of Pied Cormorant colony.

TABLE 7

Total pairs of non-burrowing breeding seabirds recorded in the Houtman Abrolhos 1991–1993 and 1999.

Species	1991–1993	1999
Red-tailed Tropicbird, <i>Phaethon rubricauda</i>	0	3
Pied Cormorant, <i>Phalacrocorax varius</i>	876	561
Eastern Reef Egret, <i>Egretta sacra</i>	10	4
Osprey, <i>Pandion haliaetus</i>	36	31
White-bellied Sea-eagle, <i>Haliaeetus leucogaster</i>	12	16
Pacific Gull, <i>Larus pacificus</i>	43	60
Silver Gull, <i>L. novaehollandiae</i>	153	32
Caspian Tern, <i>Sterna caspia</i>	76	51
Crested Tern, <i>S. bergii</i>	2 154	3 213
Roseate Tern, <i>S. dougallii</i>	3 439	5 530
Fairy Tern, <i>S. nereis</i>	405	501
Bridled Tern, <i>S. anaethetus</i>	7 061	6 368
Sooty Tern, <i>S. fuscata</i>	272 670	455 200
Common Noddy, <i>Anous stolidus</i>	132 000	161 400
Lesser Noddy, <i>A. tenuirostris</i>	40 195	67 985
TOTAL	459 130	700 955

The Leeuwin Current is a body of warm, low-salinity, low-nutrient, tropical water that flows southward along the west coast of Australia (Pearce and Walker 1991) and it greatly affects the Houtman Abrolhos (Pearce 1997). The strength of the Leeuwin Current varies from year to year and its strength is correlated to some extent with the Southern Oscillation Index (SOI), the Leeuwin Current being stronger in years with negative SOI values. The SOI was negative and declining during 1991–1993, returning to positive in 1995 and 1996, but declined dramatically with the severe El Niño of 1997–early 1998. The index returned to positive in mid-1998 and remained there during 1999 (refer to Commonwealth Bureau of Meteorology website — see References).

Detailed studies (Surman 1998; Gaughan *et al.* 2002; Surman and Wooller 2003) at the Houtman Abrolhos provided information on food and foraging range of the five abundant terns — Crested, Roseate and Sooty Terns and the Common (Brown) and Lesser Noddy — and on seabird breeding timing and success during the 1990s. Their results suggested that some species were greatly affected by the strength of the Leeuwin Current. In 1997 there was a total breeding failure in Wedge-tailed Shearwaters and Common Noddies, and very low breeding participation in Lesser Noddies. Sooty Terns were also affected. The timing of breeding was also delayed in negative SOI years. These species forage well away from the islands and depend on prey items that are affected by the Leeuwin Current. Species that forage closer inshore (e.g. Crested Tern) were not affected.

The significant increase in the number of breeding pairs of Common Noddy and Sooty Tern in 1999 compared with 1991–1993 is most likely due to different oceanic conditions affecting food supply. The differing numbers of breeding Sooty Terns, Common and Lesser Noddies revealed by our studies are also likely to be due to changing Leeuwin Current strength.

As the number of breeding pairs of some seabirds in different years appears to be related to the strength of the Leeuwin Current, very different figures might be obtained when comparing years with strong and weak currents, due to early versus delayed commencement of breeding and high versus low breeding participation rates. Therefore, interpretation of data collected during rapid monitoring of seabirds at the Houtman Abrolhos, such as reported here, must take into account prevailing oceanic conditions. More frequent rapid surveys, as well as further studies into seabird breeding participation and success and research into the relationship between oceanographic conditions and seabird breeding at the Abrolhos are required.

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