# SOUTHERN RIGHT WHALE AERIAL SURVEY AND PHOTOIDENTIFICATION, SOUTHERN AUSTRALIA, 2006

Final Report, to 28 February 2007, on work done under the Agreement between the Commonwealth of Australia and the Western Australian Museum signed on 14 March 2006

# J L Bannister

Project Manager, Western Australian Museum, Locked Bag 49, Welshpool DC, Western Australia 6986

# Contents

Summary	ige 3
1. Background	3
<ul> <li>2. Major activities undertaken.</li> <li>2.1 Aerial survey.</li> <li>2.2 Photoidentification.</li> <li>2.2.1 Aerial photography.</li> <li>2.2.2 Photographic analysis.</li> </ul>	<b>6</b> 7 7 7
3. Outcomes.         3.1 Long term assessment.         3.2 Aerial survey, C Leeuwin WA- Ceduna SA.         3.2.1 Assessment of numbers.         3.2.2 Distribution.         3.2.3 Population size.         3.3 Photoidentification.         3.4 Photographic catalogue.	7 7 8 9 9 10
4. Other species	11
5. Acknowledgements	11
6. References	11

# Tables 1-4

Figures 1-3

#### Summary

An annual programme of aerial survey for southern right whales continued off the southern Australian coast in 2006. As in past years flights took place close inshore between C Leeuwin, Western Australia, and Ceduna, South Australia, where the majority of the 'Australian' population seems to approach the coast in winter/spring: cows about to give birth appearing at an average of three years, others less predictably. Two 'short' flights, on 3-5 August and 27-29 September, between C Leeuwin and Twilight Cove, WA, maintained the series of flights on the southern WA coast since 1976. A 'long' flight, between C Leeuwin, WA and Ceduna, SA on 26-29 August and 2 September, continued the series extended along the coast into South Australia from 1993; an additional leg, on the west coast between Perth and C Leeuwin, was flown on 2 September. Counts and identifying photographs were obtained, with, as usual, emphasis where possible on the latter on the 'short' flights and on the former on the 'long' flight. Usual concentrations, mainly but not exclusively of cows accompanied by calves of the year, were encountered in and near Doubtful I Bay (WA), in and east of Israelite Bay (WA), and at Head of the Bight (SA). Cow/calf pairs were more common than usual just east of Albany, WA and a higher proportion than usual of 'unaccompanied' animals was recorded on the final flight, at the end of September. The number recorded on the 'long' flight in 2006 (447 animals including 152 cow/calf pairs) was fewer than in 2005 (itself a record year) but higher than in any other year since those flights began in 1993. Significant positive increase rates continue to be obtained for the three classes, 'all' animals, 'unaccompanied' animals and cow/calf pairs in the 'long' flight data series, excluding data for 1996 and 1997 where there seems to have been some undercounting. For cow/calf pairs the increase rate for the period 1993-2006 is 7.56 (p=0.000), close to that recorded for other Southern Hemisphere populations (South Africa, eastern South America, at ca 7%). The 95% CI (4.61, 10.51) remains rather wide, although a 1997 power analysis indicated the need for a time series to 2007 to provide a reliable result. Identifying photographs were again obtained using a digital-camera system. Computerised photographic matching, introduced comprehensively in late 2003, has continued, allied with a computerised database. Of 4571 images available from 1976-2006, mainly from the aerial surveys, 2611 have so far been digitised; comparison has been completed for 2065 images, resulting in 858 separately identified individuals, mainly from 1980-2000. The sightings database currently contains 2265 separate sighting events mainly for 1976-2002. Current population size for animals visiting the area surveyed is estimated to be ca 2100, with a total Australian population of ca 2400.

#### 1. Background

Southern right whales (*Eubalaena australis*) approach southern hemisphere continental, and some island, coasts in the austral winter-spring, particularly for adult females (cows) to give birth. Other classes, including cows, adult males and juveniles of either sex, also approach coasts at that time, but cows about to give birth do so relatively regularly, at an average of every three years. Animals remain within 1-2 km (*ca* 1 nm) of the shore at such times, and are then amenable to survey from the air, or to more prolonged study from suitable coastal vantage points.

Southern Hemisphere right whale numbers were very severely reduced in the early part of the nineteenth century by unrestricted whaling, so much so that in Australian waters by the early 1900's they were believed to be virtually extinct. But increasing numbers of sightings from the early 1960's, together with reports of significant increases off South America and South Africa, resulted in a coastal research programme beginning in 1976 off southern Western Australia, based on aerial survey (Bannister, 2001).

#### Aerial Survey

Aerial surveys for right whales off the southern Australian coast have been undertaken annually since 1976. At first funded by the Commonwealth Department of Primary Industry, from 1979 the programme has been funded by the Australian National Parks and Wildlife Service and its successors (Australian Nature Conservation Agency; Biodiversity Group, Environment Australia and Department of the Environment and Heritage). Recent funding has been made available from the Natural Heritage Trust through the Department. Comparable data series for animals recorded off the Western Australian south coast are available from 1977, in various combinations of subareas and years, and for the three whale classes 'all animals', 'unaccompanied adults' and 'cow/calf pairs'.

The surveys have been planned to provide information of two kinds:

- 1) on a possible increase in numbers over the period, and
- 2) on population dynamics.

1) has been obtained by comparison of the maximum estimated number of animals visiting the area each year. Information on 2) has come from comparisons of identifying photographs of individual animals obtained during the surveys.

From 1977 the surveys covered the WA south coast, east from Cape Leeuwin (34° 23'S, 115° 08'E) mainly to a point east of Israelite Bay, 25nm west of Pt Culver, at ca 124° 12'E, over a coastline length of ca 400 nmiles (900 km). In some years they went as far as Twilight Cove (32° 17'S, 126° 05'E), covering some 500 nmiles (1200km). These two areas correspond to areas A and B, respectively, in Fig 1. Comparison of the numbers recorded each year in the area covered most comprehensively for the nine-year period 1983-1992 (Area A), showed significant increases in all three classes recorded. The annual increase rate, estimated then at around ten per cent, was somewhat higher than estimates elsewhere, eg off South Africa and eastern South America, at around seven per cent. Given accruing information on movement of individuals between the Western Australian coast and South Australia, both within and between years, the surveys from 1993 were extended into South Australian waters to include the localities where, up to then, the majority of Australian sightings had been recorded, i.e. to Ceduna, SA, taking in the major calving area at Head of Bight, SA (31°30'S, 131°10E) and the historically significant right whaling area at Fowler Bay, SA (31°59'S, 132°34'E). The total area covered then extended over some 900 nmiles (2000 km) (Area C in Fig 1). The most valid comparison of numbers from year to year (and therefore the most valid estimate of increase rate) would be obtained from that 'extended flight' dataset.

The surveys along the southern Western Australian coast, in Areas A and B of Fig 1, took place at approximately monthly intervals from mid-July to late September/early October in each year. They showed that the maximum number of animals could be expected between mid-August and mid-September. As a result, the extended flights from 1995, in Area C, took place then, with only one such 'long' flight each year. (In 1993 and 1994, there were three 'extended' flights each year). In addition, 'short' flights along the WA coast, covering Area B, have continued from 1995, bracketing the 'long' flight, as far as

possible at first in late July and then late September/early October. While the 'long' flight has concentrated on obtaining a maximum count, each 'short' flight has continued to obtain as many identifying photographs as possible.

A power analysis undertaken by P Corkeron in 1992 (see Bannister, 1993) showed that a series of 'long' flights over five years, ie 1993-97, would be necessary to detect a trend in the data. Given the three-year calving interval, that was extended to six years to allow for two such cycles, ie to 1998.

Further power analysis by Corkeron in 1997 (see Bannister, 1997) confirmed a highly significant trend in the WA south coast 'short' flight results (e.g., for 'all' animals, the rate of increase, 1983-96, was  $10.28 \pm 2.18$  (2 s. e.), p<0.000). It showed non-significant trends for all classes in the 'long' series over the first four years, 1993-96, but indicated that the trends might be approaching significance and could become apparent for two classes, 'all' and 'unaccompanied' animals, by 1998. But the power analysis showed further that for the animals appearing close to the coast on a three-year cycle, ie cow/calf pairs, a significant detectable trend would become apparent over a period encompassing five adult female reproductive, i. e. three-year, cycles, involving fifteen years from 1993, i.e. to 2007 inclusive.

With the 1998 survey the six-year cycle from 1993 was completed. Surveys since then, funded so far for each year 1999-2006, have been flown in the context of continuing long-term assessment of the status of southern right whales in southern Australian waters, i.e. until at least 2007.

The Action Plan for Australian Cetaceans (Bannister et al, 1996) assigned 'vulnerable' status to Australian southern right whales, in recognition that despite the encouraging increase in numbers, they would need to recover sufficiently, i.e. to around 60 per cent of their estimated or likely pre-exploitation level, before being regarded as 'secure'. Of four species in the 'vulnerable' category, southern right whales were accorded top priority for action. Within the required actions recommended, top priority was given to continued monitoring of their population status through aerial survey.

Under the *Environment Protection and Biodiversity Conservation Act (1999)*, which came into force on 16 July 2000, right whales were included in the category Endangered. The categorisations reflected their low population numbers and further emphasised the need to continue the series of surveys reported here.

The surveys are consistent with actions contained in the Right Whale Recovery Plan prepared under the provisions of the *Act*.

#### Photoidentification

Systematic photoidentification has been undertaken off WA since 1980, and has continued annually in conjunction with the aerial survey. Within the 'WA catalogue', up to 1995 some 600 aerial photographs of individually identified animals had been obtained, including some in South Australian waters. 'Matching' of animals within the

catalogue and with those identified separately by S Burnell from Head of the Bight, SA, was undertaken comprehensively up to and including animals identified in 1995, but the numbers involved since then have been too great for effective use of the manual methods then used. Using those manual methods, 159 animals were identified more than once. Of those, 118 were identified 'between years', 73 of them cows accompanied by calves of the year. Long-term information was obtained, particularly on breeding rate, probable age at first parturition, and within- and between-year movement along the coast, including to and from WA and SA. There were also more recent 'matches' with animals identified south of WA in colder water feeding grounds (Bannister et al, 1997; Bannister et al, 1999), including the first recorded movement between warm water breeding grounds and the Antarctic south of 60°S.

Identification photographs have continued to be obtained on all flights since 1995. In late 2003 a computerised matching system (see Hiby and Lovell, 2001) was implemented for comparison of all available photographs, in conjunction with a sightings database developed by G P Donovan, Head of Science, International Whaling Commission.

The Action Plan for Australian Cetaceans (Bannister et al, 1996) gave continuation of southern right whale photoidentification second priority (to aerial survey) in its recommended required actions for this taxon in Australian waters.

Photoidentification is consistent with actions contained in the Right Whale Recovery Plan being prepared under the *Environment Protection and Biodiversity Conservation Act* (1999).

This report covers the 2006 aerial survey and associated activities. A comprehensive account of the background and results of the programme to 1988 was given in Bannister (1990). The aerial survey results were updated to include results to 1997 in a paper prepared for the Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison, Cape Town, March 1998 (Bannister, 2001). The most recent results, through 2005, were reported in Bannister (2006).

The 2006 surveys were as usual conducted under permits from the WA Department of Conservation and Land Management and the SA Department of Environment and Natural Resources. No Commonwealth permit was required since all work was to be undertaken within State waters.

#### 2. Major activities undertaken

#### 2.1 Aerial survey

The three planned flights for 2006 were carried out geographically as in previous years: two 'short' flights between C Leeuwin (Augusta) and Twilight Cove WA (Figure 1, Area B), and one 'long' flight between C Leeuwin and Ceduna SA (Figure 1, Area C) (see Table 1). As since 2000 an additional leg was flown along the west coast between Fremantle and Augusta (Cape Leeuwin) given reports each year of a few animals on that coast.

The first ('short') flight, planned for the last week in July, could not be flown until 3-5 August, given prevailing bad weather at the end of July. The next ('long') flight, planned for the peak abundance period, mid-August-mid-September, took place over the five days 28-29 August and 2 September, while the last (second 'short') flight took place over the three days 27-29 September.

As in 2005, the aircraft type (single engine Cessna, on charter from Great Southern Aviation, Albany) and observer/photographer (Andrew Halsall) remained unchanged. The pilot, J Biser, had piloted the aircraft on two flights in 2004 and one in 2005.

All flights took place in good-reasonable conditions (winds at or below 15 knots, see Table 1), with the best weather encountered on the return legs of the second flight (Ceduna-Albany, 28-29 August, winds 5-10 knots), on the Perth-Augusta leg of that flight (2 September, 0-5 knots) and on the last flight (27-29 September, winds 4-8 knots).

#### 2.2 Photoidentification

## 2.2.1 Aerial photography

Identifying photographs were again obtained on the three flights. As since 2003, a digital camera was used, images being assessed on a laptop after each leg. With the pilot now more experienced than in 2005 the difficulties experienced then in positioning the plane for photography were not encountered in 2006.

#### 2.2.2 Photographic analysis

Scanning of useful images obtained since photographs were obtained regularly (from 1980, although some were obtained opportunistically from 1976) is complete to the introduction of digital photography, i. e. to 2002 inclusive. All digital images obtained since then have been reviewed and a selection made of those suitable for matching.

Using the Hiby-Lovell computer-assisted comparison system (Hiby and Lovell 2001), digitised 'extractions' have been made up to 2000 for most images, and for some since then. Similarly, most images up to and including 2000 have been 'matched', and some since then. A computerised database, devised for this study by G P Donovan, Head of Science, International Whaling Commission, is used for recording associated sightings data.

#### 3. Outcomes

#### 3.1 Long term assessment

As indicated in Item 1 the project is part of a long-term assessment of the status of southern right whales, both in Western Australian waters and along the remainder of the southern Australian coast as far east as Ceduna, SA, within which the majority of the current 'Australian' population is likely to be found at the appropriate season.

The 2006 survey contributed to completion of the 15-year programme begun in 1993, i.e. to 2007.

## 3.2. Aerial survey, Cape Leeuwin WA – Ceduna, SA

3.2.1 Assessment of numbers

Counts of 'all animals', 'unaccompanied adults' (i. e. adults unaccompanied by calves), and cow/calf pairs, were obtained for all areas, as summarised in Table 1. The overall total right whale count for the three flights was less than in 2005, itself a 'bumper' year, but was still the second highest count obtained in the series.

The best comparison for the population as a whole, assuming most of the 'Australian' population resorts to the coast between C Leeuwin and Ceduna, is between the maximum annual counts for the second ('long') flight each year, i. e for Area C (Fig. 1). As since 2002, only the results for that dataset, i.e. the 'long' flight, are considered here (Table 2).

The total ('all animals') count in 2006, 447, was some 25% less than the previous highest count (600 in 2005), but that was itself 45% higher than any previous count. The 2006 count is still the second highest count in the series since 1993. The count for 'unaccompanied' animals, relatively variable from year to year, was 43% lower than the previous highest count (248 in 2005), but at 143 in 2006 it was higher than counts in seven of the eleven previous years (excluding 1996 and 1997, in which there may have been some undercounting, see Bannister, 1998, 2002).

Given the relatively ephemeral nature of visits by 'unaccompanied' animals, the best long-term comparison is between annual counts of cow/calf pairs. At 152, the number of cow/calf pairs in 2006 was the second highest recorded; it was 14% lower than the previous highest count (176 in 2006).

As a check on counts from the aircraft, comparisons were made, as in past years, with those for comparable dates from shore-based operations at Head of Bight, South Australia. The aerial survey counts there of 59 adults, 43 calves on 27 August and 57 adults, 45 calves on 28 August compare favourably, particularly for calves, with the highest count, on 19 August in perfect conditions, of 55 adults and 43 calves there from the land-based operation (R Pirzl, pers. commn). As would be expected, counts of adults, which include 'unaccompanied' itinerant animals, are more variable than those for the relatively sedentary (at that time of year) calves in cow/calf pairs.

Restricting calculations of increase rates to the data from Area C, i.e. from 1993, gives the results shown in Table 3 and Figure 2. Because of probable undercounting in 1996 and 1997 (see above), the data for those years have again been excluded from the analysis.

As in 2005, the results for all three datasets are significant at the 95% level. Before 2005, while increase rates for 'all animals ' and 'cow calf pairs' were significant, that for 'unaccompanied' animals had only approached significance. The calculated increase rate point estimates for the period 1993-2006 for 'all animals' and 'cow/calf pairs' (Table 3: 6.74, 7.56 %) are very similar to those obtained for 1993-2005 (6.99, 7.53%, see Bannister 2006). The point estimate for unaccompanied animals is slightly higher than in 2005 (6.53, 5.75, respectively). While still relatively wide, the 95% confidence interval

for the cow/calf pair increase rate (4.61, 10.51) is 16% narrower than for 1993-2005 (4.03, 11.04).

Given the three-year periodicity in calving, different three-year cohort strengths could be expected, although the increase rates to 2003 were non-significant (Bannister 2004). The number recorded in 2004 was lower than might have been expected for that (#3, 1995-2004) previously 'strongest' cohort, while for 2005 it was considerably higher than expected for that (#1, 1993-2005), or any other, cohort. Similarly, the 2006 figure (for cohort #2, 1994-2006) is rather higher than expected (Table 4). Breeding success, as exemplified by cohort strength from year to year, has recently been correlated with changes in sea surface temperature attributed to climate change (Leaper et al, 2006), and year-to-year differences between and within cohorts are likely.

#### 3.2.2 Distribution

Figure 3 shows the approximate positions of whales sighted on the three flights. The plots are for those legs on which maximum counts were made; in the case of Flight 2 (the 'long' flight, C Leeuwin WA – Ceduna SA) they are those used in compiling the data of Table 2. The numbers of animals in each individual sighting are recorded on the chart.

Notable features of right whale distribution in 2006 included:

- the usual relatively large concentrations of cow/calf pairs in the Doubtful Island Bay area (Gordon Inlet-Point Ann, Point Charles) WA, and in and north east of Israelite Bay, WA;
- more cow/calf pairs than usual just east of Albany, WA on Flight 1, including 5 cow/calf pairs at Cape Riche;
- relatively large numbers of 'unaccompanied' animals in the Doubtful Island Bay area, and in and to the north east of Israelite Bay, WA on Flight 1;
- 3 cow calf pairs and 5 adults at Twilight Cove, WA on Fight 1, and 6 cow/calf pairs in that area on Flight 2;
- 5 cow/calf pairs and several groups of 'unaccompanied' animals along the coast near Eucla, WA on Flight 2;
- 45 cow/calf pairs and 12 adults at Head of Bight, SA, on Flight 2;
- 2 cow/calf pairs and 2 adults in and near Fowler Bay, SA, on Fight 2, compared with 3 cow/calf pairs and one adult there in 2005.
- a higher proportion than usual of 'unaccompanied' animals on Flight 3, particularly in the Cape Arid-Cape Pasley-Point Malcolm area, west of Israelite Bay, WA; such animals are often recorded just west of that area, for example in Yokinup Bay, but usually earlier in the season.

#### 3.2.3 Population size

In recent years (e. g. as in Bannister, 2005), and pending mark-recapture analysis using photographically identified animals, population size for that part of the 'Australian' population found on the southern coast between C Leeuwin, WA and Ceduna, SA has been estimated using a simple model based on the numbers of cow/calf pairs sighted on the 'long' flights. Given the relative paucity of animals that visit the remainder of the

southern Australian coast, the population recorded between C Leeuwin and Ceduna is likely to represent the majority of the 'Australian' population.

The model assumes that each reproductive female is recorded on the coast only once in three years, that the sex ratio is unity, that there are probably some unreproductive adult females present, and that in an expanding population there are at least as many immature animals as adults. In increasing populations there is evidence that the proportion immature can be as much as 61% (in gray whales, Rice and Wolman (1971)) or certainly more than 50% (in bowhead whales, Zeh et al (1993)). Indeed, at the 1998 Cape Town assessment meeting the ratio immature: adult was estimated to be as high as 1.41:1 (IWC 2001).

From the 'long' flight counts over the three-year period 2004-2006, the number of reproductive females (i. e. cows accompanied by calves) recorded as visiting the coast was 434 (Table 2). Assuming a three-year calving cycle, that represents the minimum number of adult females in the population. The adult population of both sexes would then be at least 868.

As the basis for its estimate of the Australian population, the Cape Town Assessment Meeting (IWC, 2001) used the 1995 sighting figure of reproductive (mature) females of 65 (i.e. 195 over three years) for the area C. Leeuwin–Ceduna. Allowing for additional animals off the remainder of the Australian coast, *ca* 1.41 as the ratio immatures:adults, and population growth rate of 7.5%, 1997 'Australian' population size was based on 254 mature females, giving an estimate of 1197; *pro-rata* the figure for that part of the population visiting the area C. Leeuwin-Ceduna in 1997, based on 225 mature females, would have been 1060. Given the number of reproductive females recorded there for the three year period 2004-2006 (434, see Table 2), *pro rata* the total visiting the area in that period would then be (434/225) x 1060, i.e. 2045.

2045 represents the number as at 2005 (the mid-point of 2004-2006). Allowing for continued increase since then, the current number of animals visiting the survey area is therefore likely to be some 2100, with a total Australian population of ca 2400.

#### 3.3 Photoidentification

Implementation of the Hiby-Lovell computerised matching system (Hiby and Lovell, 2001) has continued. In late 2003 it replaced the manual methods used previously.

The system compares digitised extracts of photographs of individual head callosity ('topside') patterns. 4571 images are currently available from the years 1976-2006, including 419 from 2006, stored as jpegs and tifs and also, to 2001, as flashpix. By far the majority originate from the aerial surveys, but a few images are included from other sources, including the Antarctic (from JARPA and SOWER surveys).

2611 images have so far been digitised; computer-assisted comparison ('matching') has been completed for 2065, mainly for the years 1980-2000, but including some from 2001-2003.

#### 3.4 Photographic catalogue

The 'WA' catalogue is maintained by Bannister at the WA Museum. Its usefulness has been greatly enhanced by the computerisation of all images as above, and by employing a sightings/identified animals database developed by G P Donovan. The database currently comprises entries for 2265 separate sighting events from 1976, mainly to 2002. So far 858 separate individuals have been identified, again mainly from 1976-2002.

#### 4. Other species

Only one other large whale species, the humpback, was seen on the 2006 flights. Only 12 confirmed sightings were recorded, including two calves, considerably fewer than the 78 (including 1 calf) recorded in 2005. As usual, most sightings were on Flight 1, and all were west of Esperance (Table 1), all presumably on the northward migration. One was recorded at Cape Clairault, just south of C Naturaliste, on the Flight 2 Perth–Augusta leg.

### 5. Acknowledgments

Julie Biser piloted all three flights. Andrew Halsall was again the observer/photographer on all flights. Chris Burton generated the plots for Figure 3. Additional assistance came from Grefin Harsa, Rebecca Pirzl, Doug Coughran, Gordon Wyre, Lex Hiby, and staff of the Department of the Environment and Heritage, particularly Robyn McCullough. Vicky Rowntree continues to provide advice on the matching program, as does Greg Donovan on the database.

Facilities and administrative and other assistance were again provided to the Project Manager at the Western Australian Museum through the courtesy of the Trustees, the Chief Executive Officer, and the Head, Science and Culture.

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Flight No. <sup>1</sup>	Date	Leg		,		Whale sightin	ngs				Weat- her <sup>2</sup>	Flying hrs-mins
			Right whales			Other large whales <sup>3</sup>						
			A <sup>4</sup>	C	Y	Т	Α	C	Y	Т		
1.	03/08/ 06	Albany- Esperance	64	26	0	90 incl 26 calves	2	0	0	2	10	4-25
		Esperance- Caiguna incl Twilight Cove	101	45	0	157 incl 45 calves					15	4-40
	04/08	Caiguna- Esperance excl Twilight Cove and westwards to E Toolinna Cove	100	37	1	137 incl 37 calves, 1 yrling					0-10	4-15
		Esperance- Albany	51	28	0	79 incl 28 calves	1	1	0	2 incl 1 calf	15-10	4-10
	05/08	Albany-Augusta	17	6	0	23 incl 6 calves					5	2-35
		Augusta-Albany	23	7	1	31 incl 7 calves, 1 yrling	6	1	0	7 incl 1 calf	5	2-30
Total flight 1	3days	6 legs	356	149	2	507 incl 149 calves, 2 yrlings	9	2	0	11 incl 2 calves		22-35
2	26/08	Albany- Esperance	46	31		77 incl 31 calves	0	0	0	0	8-13	3-05
		Esperance- Caiguna, excl Twilight Cove	80	46		126 incl 46 calves	0	0	0	0	13-15	3-20
	27/08	Caiguna- Nullarbor, incl Twilight Cove, excl HOB	46	9		55 incl 9 calves	0	0	0	0	5-15	4-25
U.		Nullarbor- Ceduna, incl HOB	63	45		108 incl 45 calves	0	0	0	0	15	2-20
	28/08	Ceduna- Nullarbor, incl HOB	66	54		120 incl 54 calves	0	0	0	0	8	2-35
		Nullarbor- Caiguna, excl HOB, incl Twilight Cove	64	11		75 incl 11 calf	0	0	0	0	10	3-55
		Caiguna- Esperance excl Twilight Cove	915	51	1	143 incl 51 calves, 1 yearling	0	0	0	0	10-5	3-15
	29/08	Esperance- Albany	60	31		91 incl 31 calves	0	0	0	0	10	4-05

# Table 1. Right whale aerial survey, WA-SA, 2006. Summary of results

<sup>&</sup>lt;sup>1</sup> all flights ex Albany WA, in Cessna 175
<sup>2</sup> as indicated by wind speed, knots
<sup>3</sup> all humpbacks; no other large whales recorded
<sup>4</sup> A=adult, C=calf, Y='yearling', T=total
<sup>5</sup> excludes 1 adult dead on beach at Thistle Cove (34°00'S, 122°11'E)

	02/09	Perth <sup>6</sup> (Jandakot)- Augusta-	1			1	1	0	0	1	0-5	2-15
		Augusta-Albany	13	5		18 incl 5 calves	1? (bre- ach)	0	0	1? (bre- ach)	5-10	2-05
Total Flight 2	5 days	10 legs	530	283	1	814 incl 283 calves, 1 yrlng	1 + 1?	0	0	1+1?		31-20
3.	27/09	Albany- Esperance	25	21		46 incl 21 calves	0	0	0	0	8	3-30
		Esperance- Caiguna, incl Twilight Cove	587	33		91 incl 33 calves	0	0	0	0	8-5	4-35
	28/09	Caiguna- Esperance, excl Twilight Cove	62	35		97 incl 35 calves	0	0	0	0	5-4	3-55
		Esperance- Albany	27	24		51 incl 24 calves	0	0	0	0	4-5	4-05
	29/09	Albany-Augusta	3	3		6 incl 3 calves	0	0	0	0	5	2-25
		Augusta-Albany	6	4		10 incl 4 calves	0	0	0	0	5	2-30
Total Flight 3	3 days	6 legs	181	120		301 incl 120 calves	0	0	0	0		21-00
Total flights 1-3	11 days	22 legs	1067	552	3	1622 incl 552 calves, 3 yearlings	10+1?	2	0	12 incl 2 calves, +1?		74-55
Totals 2005: 3 flights	12 days	18 legs <sup>8</sup>	1409	677	11	2097 incl 677 calves, 11 yrlings	77 hb 3 sperm	1	0	78 hbs incl 1 calf; 3 adult sp.wh		75-50 hrs

<sup>&</sup>lt;sup>6</sup> excludes overland leg, Albany-Perth (Jandakot), 2h 25 min
<sup>7</sup> excludes adult dead on beach as on Flight 2, leg 7
<sup>8</sup> fewer legs flown in 2006 through the Albany/Augusta/Albany leg not being divided at Augusta

Area		С	
	C Le	euwin WA-Ced	una SA
Class	a all animals	b unaccompani- ed animals	c cow/calf pairs
1993	182	56	63
1994	199	101	49
1995	255	125	65
1996 <sup>9</sup>	233	123	55
1997 <sup>9</sup>	254	148	53
1998	338	122	108
1999	262	102	80
2000	305	123	91
2001	414	148	133
2002	378	164	107
2003	273	83	95
2004	371	157	106
2005	600	248	176
2006	447	143	152

Table 2. Right whale aerial survey, WA-SA,1993-2006. Comparable numbers seen.

Table 3. Best fit regressions to the data (logN) of Table 2, C. Leeuwin WA-Ceduna SA (Area C)

Period	1993-	-2006 (excl 1996,	1997)
Class	a	b	с
Increase (%)	6.74	5.75	7.56
р	0.000	0.017	0.000
R <sup>2</sup>	0.726	0.448	0.766
95% CI	3.82, 9.66	1.25, 10.24	4.61, 10.51

<sup>9</sup> probably undercounts (see Bannister 1998, 2002)

Year		Cohorts	
	1	2	3
1993	63		
1994		49	
1995			65
1996 <sup>10</sup>	(55)		
1997 <sup>10</sup>		(53)	
1998			108
1999	80		
2000		91	
2001			133
2002	107		
2003		95	
2004			106
2005	176		
2006		152	

# Table 4. Numbers of cow/calf pairs, Area C, 1993-2006 (data of Table 2) by three-year cohort

<sup>10</sup> probably undercounts (see Bannister 1998, 2002)



# Figure 1. Aerial survey, WA-SA, 2006. Approximate position of flight path

..... traversed on 'short' flights ------ additional traversed on 'long' flight

A: traversed 1976-1991

**B:** traversed 1986, 1987 and 1992

C: traversed 1993 – present (see Table 1)



Figure 2. Aerial survey, WA-SA, 1993-2006. Regressions for data of Table 2.





a. Cow calf pairs (•)



Figure 3. Aerial Survey, WA-SA, 1993-2006. Approximate positions of right whale sightings on the three flights. Localities as in Figure 1.

b. 'Unaccompanied' adults ( $\circ$ ), and yearlings ( $\Box$ )