POPULATION DYNAMICS OF RIGHT WHALES OFF SOUTHERN AUSTRALIA, 2007

Final Report, to 29 February 2008, on work done under the Agreement between the Commonwealth of Australia and the Western Australian Museum in relation to services for the above

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Summary

An annual programme of aerial survey for southern right whales continued off the southern Australian coast in 2007. 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 3-4 and 12 August and 28-29 September, 1 October, 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 31 August, 1-3 and 6 September, continued the series extended along the coast into South Australia from 1993; as since 2000, an additional leg, on the west coast between Perth and C Leeuwin, was flown on 6 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 – the latter in reduced numbers compared with previous years - were encountered in and near Doubtful I Bay (WA), in and east of Israelite Bay (WA), and at Head of Bight (SA). More 'unaccompanied' animals than usual were encountered near Albany, in the Doubtful I Bay area and in and north of Israelite Bay (WA). The number recorded on the 'long' flight in 2007 (286 animals including 57 cow/calf pairs) was considerably fewer than in recent years, although the 'unaccompanied' animals count was not unexpectedly low. Regression analysis, including inspection of residuals, of the long flight data from 1993 (excluding numbers for 1996 and 1997 where there seems to have been some undercounting) gives, for 'all animals', no evidence of anything other than an exponential increase. But for cow/calf pairs, the 2007 data point is clearly an outlier. For the present the 1993-2006 cow/calf increase rate of 8.10% (95% CI 4.48, 11.83) has been taken as the current 'best estimate' of annual increase rate for that part of the Australian population that visits the southern Australian coast between C Leeuwin WA and Ceduna, SA. 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 5069 images available from 1976-2007, mainly from the aerial surveys (including 376 from 2007), 3402 have so far been digitised; comparison has been completed for 3143 images, resulting in 1214 separately identified individuals, mainly from 1980-2004. 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 drastically 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).

At first funded by the Commonwealth Department of Primary Industry, from 1979 to 2006 the programme was 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), latterly from the Natural Heritage Trust through the Department. In 2006 the project was one of a number recommended through the Australian Centre for Applied Marine Mammal Science (ACAMMS), and funded by the Commonwealth Environment Research Fund (CERF).

Aerial Survey

Aerial surveys for right whales off the southern Australian coast have been undertaken annually since 1976.

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.

The survey methodology involves direct counts of animals observed within the search area. The latter includes virtually all the area to which right whales resort in winter/spring, close to the coast, in particular for the females to give birth. Most animals, particularly cows accompanied by their calves of the year, are easily observed in the relatively clear waters on the south coast, and no corrections are made for the probability of sighting (g(0)), which is assumed to be 1. This makes for a relatively simple sighting protocol, readily repeatable over the years. The most important factor is to ensure little or no change in pilot- or observer-efficiency, achieved in this case by employing, over as protracted a period as possible, the same charter company (since 1995), observer/photographer (since 1996) and pilot (in 2004, 2006 and 2007).

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 (*ca* 900 km). In some years they went as far as Twilight Cove (32° 17'S, 126° 05'E), covering some 500 nmiles (*ca* 900km). 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 (*ca* 1700 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). Since 2000 a further leg has been flown each year along the west coast, between Perth and Cape Leeuwin. In addition, 'short' flights along the southern 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 (in 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 (in 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 ± 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 have been flown in the context of continuing long-term assessment of the status of southern right whales in southern Australian waters 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 were by then 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 60ºS.

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 2007 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 2006, were reported in Bannister (2007).

The 2007 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 Objectives

Objective 1. Obtain aerial counts of right whales during winter/spring 2007 on the southern Australian coast between Cape Leeuwin WA and Ceduna SA for comparison with data from previous aerial surveys in the same area (particularly since 1993)

The three planned flights – two 'short' – Flights 1 and 3 - and one 'long' – Flight 2 – were undertaken as follows:

Flight 1, between Cape Leeuwin WA and Twilight Cove (Caiguna) WA, on 03, 04 and 12 August;
Flight 2, between Cape Leeuwin WA and Ceduna SA, on 31 August, 01-03 and 06 September;
Flight 3, between Cape Leeuwin WA and Twilight Cove (Caiguna) WA, on 28, 29 September and 01 October.

As in 2006, 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, one flight in 2005, and all flights in 2006.

Flying is only undertaken in appropriate weather conditions, particularly in wind speeds of not more than 15 knots. That was generally achieved on all flights in 2007.

Flying on all legs on Flight 1 occurred in wind speeds of between 5 and 10 knots. On Flight 2, wind speeds were more variable: excellent conditions (wind speed 0 knots) were encountered between Ceduna, SA and Nullarbor SA, including Head of Bight, on 2 September, but were more variable at other times. Between Caiguna WA and Albany WA on 2-3 September they ranged between 10 and 15 knots. On the final part of the inward flight Nullarbor-Caiguna on 2 September, bad weather prevented sighting in the Twilight Cove/south of Caiguna area.

On Flight 3, wind speeds were generally between six and 10 knots, but ranged from 0-6 knots between Caiguna, WA and Esperance, WA on 29 September and 8-15 knots on the final two legs, Albany-Augusta and return, on 1 October.

A summary of operations, including wind speeds referred to above, is given in Table 1.

Objective 2. Obtain identification photographs for comparison with the existing WA catalogue (i.e. since 1976)

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. A total of nine digital memory cards was utilised, comprising some 3800 images.

Objective 3 – *obtain continuing information on increase rate, population size, distribution, movements and biological parameters*
This objective is being met in two parts. The first part, obtaining information on increase rate and population size uses counts from the most recent, i. e. 2007, 'long' flight' for comparison with data from 1993.

The second part, using identification photographs obtained under Objective 2, is ongoing. 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 and for inclusion in the 'WA catalogue', which includes animals from South Australia, some other eastern states and the Southern Ocean.

Using the Hiby-Lovell computer-assisted comparison system (Hiby and Lovell 2001), digitised 'extractions' have been made for images up to and including those obtained in 2004, and for some since then. Similarly, images up to and including 2004 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 has been 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 2007 survey completed 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 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 figures in Table 2 for the years 1993-2006 have been revised slightly from those presented in earlier reports to remove some inconsistencies and correct some anomalies.

Each leg (except along the west coast between Perth and Cape Leeuwin) is generally covered twice, and though the observer has a general instruction to count on the outward leg and photograph on the return, counts tend to be obtained both ways. For Table 2 the numbers are now for those legs where the cow/calf count is a maximum. Even though there may be up to two days between 'outward' and 'inward' counts (though usually not more than a day) the relatively sedentary cow/calf pairs are most unlikely to have moved between legs and thus confounded the results. The same cannot be said for 'unaccompanied' animals, which come and go much more rapidly and unpredictably.

The 2007 total count ('all animals', Table 2) at 286 was lower than any since 2003 (273), largely as a result of the very low number of cow/calf pairs recorded. That contrasts with the very high count in 2005 (591) and the relatively high count in 2006 (427). The 2007 cow/calf pair count (57) is the second lowest in the series – only that for 1994 (48) (excluding counts for 1996 and 1997 where there may have been some undercounting, see Bannister 1998, 2002) is lower. On the other hand the 2007 count of 'unaccompanied' animals (172) is the second highest in the series.

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 counts of 23 adults and 12 calves at Head of Bight on 1 September and 31 adults, 12 calves and 2 'yearlings' on 2 September compare favourably, though at the bottom end of the range, with daily counts of 12-20 calving pairs recorded at Head of Bight between 15 and 31 August (S Burnell, pers. comm.).

3.2.2. Assessment of trend

In past reports calculations of increase rates have been restricted to the data from Area C, i.e. from 1993. The same has been followed this year, but the calculations have been undertaken by Prof Phil Hammond of the University of St Andrews, Scotland. Using essentially the same methodology as in past years, a simple exponential regression (i.e. a linear regression of the natural log of the count on year) for 'all animals', including the 2007 data point, gives an exponential rate of increase of 0.0524. Without the low 2007 data point, the rate is 0.0671. Whether or not the low 2007 data point is indicative of a slowing of the population growth rate was investigated by examining the residuals of the simple exponential regression, but there is no evidence of anything other than an exponential increase: the residual plot shows a fairly even scatter of points above and below the fitted regression line. Indeed, the variability in the counts from year to year is so high that evidence of anything other than exponential growth would take a long time to be supported statistically. For cow/calf pairs, the 2007 data point is clearly an outlier. Including that point, the estimated rate of increase (0.0508) is lower and less precise than for 'all animals'. The opposite is true if the 2007 data point is excluded, in which case the rate of increase is 0.0778. Table 3 summarises the results, including conversion of the exponential rate to an annual percentage increase. The relevant plots, including plots of the residuals, are shown in Figures 3 and 4.

For the present, recognising that the 2007 cow/calf count seems to have been unusually low, it seems appropriate to consider the increase rate for cow/calf pairs, 1993-2006, i. e.

8.10% (95% CI 4.48, 11.83) as the current 'best estimate' of annual increase rate for that part of the Australian population that visits the southern Australian coast between C Leeuwin WA and Ceduna, SA.

Given the three-year periodicity in calving, different three-year cohort strengths can be expected. A three-year cycle is obvious in the counts for 1998-2003, although it breaks down thereafter. 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). Leaper et al found that conception can be affected by high sea surface temperatures (themselves the result of earlier El Niños) in the autumn months preceding conception the following winter, with a resulting effect on pregnancy rates the following year. The El Niños recorded in 2002-3 and/or 2004-5 could thus have had an effect on calving rates off the southern Australian coast in 2007.

In that context, the contrasting lack of a marked decrease in unaccompanied animals in 2007 may reflect the presence on the coast then of more non-calving females than usual. Whether that is the case should be determinable once the 2007 photographic 'matching' results are available. Alternatively, or in addition, non-breeding cows may well have changed cohorts, in which case higher cow/calf pair counts might be expected in 2008 and 2009.

3.2.3. Distribution

Figure 2 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 2007, as shown in Figure 2, included

- the usual 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 Flights 1 and 2, continuing a situation first noted in 2006;
- relatively large numbers of 'unaccompanied' animals in and east of the Albany area, in the Doubtful Island Bay area, as well as in and to the north east of Israelite Bay, WA on Flights 1 and 2;
- only 1 cow/calf pair recorded at Twilight Cove WA, but relatively large numbers of unaccompanied adults west of the Cove on Flights 1 and 2;
- only 12 cow/calf pairs (compared with 45 in 2006, and 57 in 2005) but considerably more 'unaccompanied' adults than usual in and near Head of Bight, SA on Flight 2;
- one cow/calf pair and 11 adults in and near Fowler Bay, SA, on Flight 2, compared with two cow/calf pairs and two adults there in 2005;
- a number of 'unaccompanied' animals in the Cape Arid-Cape Pasley-Point Malcolm area, west of Israelite Bay, WA, and also east of the Bay, on Flight 3; such animals are often recorded just west of that area, for example in Yokinup Bay, but usually earlier in the season.

3.2.4. Feeding

An individual apparently feeding on a small swarm of krill was photographed on 6 September on the Perth-Augusta leg of Flight 2, at 33° 15S, 114° 40 E, off Bunbury, WA. It was one of two adults recorded at that time. This appears to be the first confirmed record of such feeding by a right whale on the WA coast.

3.2.5. Population size

In recent years (e. g. as in Bannister, 2007), 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).

Given the very low count of cow/calf pairs in 2007 it seems unrealistic to use that figure in the estimation. But as noted above, the number of 'unaccompanied' animals does not show such a corresponding reduction. In that event the actual number of animals in the population (apart from calves of the year) may not have declined markedly, in which case it seems appropriate to retain the figure calculated in 2006, as follows.

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 at least some 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. 5069 images are currently available from the years 1976-2007, including 376 obtained on the 2007 flights. By far the majority have originated from the aerial surveys, but a few images are included from other sources, including the Antarctic (from JARPA and SOWER surveys).

3402 images have so far been digitised; computer-assisted comparison ('matching') has been completed for 3143, mainly for the years 1980-2004, but including some from both before and since then. 1214 separate individuals have been recognised so far, again mainly from the period 1980-2004. The remaining images from 2005-2007 are currently being analysed.

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, and for 683 individuals, mainly to 2002.

4. Other species
Only one other large whale species, the humpback, was seen on the 2007 flights. 53 confirmed sightings were recorded, including six calves, considerably more than the 12 including two calves recorded in 2006. As usual, most sightings were on Flight 1, and generally west of Esperance, all presumably on the northward migration.

5. Evaluation against criteria
As required under clause 5.9 of the Schedule to the Agreement under which this work has been undertaken, the following evaluation is presented.

5.1. The degree to which the activity has achieved the objectives.
Objectives 1 and 2, undertaking aerial survey and obtaining identification photographs (see Item 2.1) were achieved successfully. The flights were undertaken as planned, within the required time frame and in generally appropriate weather conditions (see Items 2.1 and 3.2). An appropriate series of photographs was obtained, many of high quality, suitable for photoidentification (see Items 2.1 and 3.3).

As discussed in Item 2.1, Objective 3 comprises two parts. The first, obtaining information on increase rate and population size, has been achieved. To meet a request from the ACAMMS scientific advisory committee seeking clarification on the

quantitative analysis involved in the project, advice was sought from Prof Phil Hammond, of the University of St Andrews, Scotland, who has considerable experience in such matters. Indeed he undertook the trend analysis reported in Item 3.2.2. Population size is also considered under Item 3.2.2. For reasons given there the increase rate obtained from cow/calf counts for the period 1993-2006 is considered the current 'best estimate'.

The second part, using identification photographs obtained under Objective 2 to obtain information on distribution, movements and biological parameters, depends on completion of the photographic matching programme, which is ongoing (see Item 3.4). To obtain the necessary results that part of the programme will need to be continued over the next few months, as anticipated in the project proposal, Items 6 and 7.

5.2. *Appropriateness of the approaches used in developing and implementing the activity*
The particular fieldwork approaches – aerial survey and photoidentification - are well-established for right whales. While the survey uses simple maximum counts and not more sophisticated techniques such as line transect, the methodology is appropriate for relatively sedentary animals such as right whales, particularly cow/calf pairs generally easily visible in clear shallow coastal waters, where sighting probability (g(0)) is assumed to be 1. The simple exponential regression methodology for obtaining trend information is appropriate for the data. The photographic techniques are now well–established and the computer-assisted matching system provides a practicable method of handling relatively large numbers of photographs.

5.3. Effectiveness
The activity has effectively met its objectives in all respects except the second part of Objective 3 - obtaining information on distribution, movements and biological parameters. That depends on completion of the photographic matching programme, which is ongoing (see Item 3.3).

6. Acknowledgements

Julie Biser piloted all three flights. Andrew Halsall was again the observer/photographer on all flights. Chris Burton generated the plots for Figure 2. Additional assistance came from Jasmine Antonini, Stephen Burnell, Doug Coughran, Grefin Harsa, and staff of the Department of the Environment and Water Resources, particularly Robyn McCullough. Vicky Rowntree continues to provide advice on the matching program, as does Greg Donovan on the database. Phil Hammond made valuable comments on data analysis and undertook the trend analysis in Item 3.2.2.

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 Executive Director, Collections and Content Development.

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