Southern Right Whale Aerial Survey, Southern Australian Coast, August 2010

Final Report

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Summary

An aerial survey for southern right whales was conducted off the southern Australian coast in 2010, close inshore between C Leeuwin, Western Australia (34° 22'S, 115° 08'E) and Ceduna, South Australia (32° 08'S, 133° 41'E), the 18th annual survey undertaken since 1993. The majority of the 'Australian' population approaches that coast in winter/spring, cows about to give birth appearing at an average of three years, others less predictably. The 2010 flight, undertaken over 10-15 August, provided the usual counts and identifying photographs of 'all animals', cow/calf pairs (females accompanied by calves of the year) and 'unaccompanied' adults (non-cow/calf pairs, i.e. adults and juveniles of either sex). Usual concentrations, mainly but not exclusively, of cows and calves were encountered in and near Doubtful I Bay (WA), in and east of Israelite Bay (WA), and at Head of Bight (SA); relatively large numbers, particularly of 'unaccompanied' animals, were recorded east of Albany towards and including the Doubtful Island Bay area, as well as from east of Esperance through Tagon Bay to Cape Arid, and also from Israelite Bay towards Twilight Cove, WA. As in 2009, larger numbers than usual of 'unaccompanied' animals were found west of Eucla, WA, while the customary relatively high numbers of cow/calf pairs (43) and 'unaccompanied' adults (31) were present at Head of Bight, SA. The comparable number recorded (519 animals including 134 cow/calf pairs), was lower than in 2008 (702) and 2009 (782), but a low cow/calf count was to be expected given the very low count (of only 57 cow/calf pairs) in 2007, three years earlier. Exponential increase rates for 'all animals' for the period 1993-2010 (excluding 1996 and 1997 where there may have been some undercounting) are 0.0657 (95% CI 0.0381-0.0933) corresponding to a percentage annual increase of 6.79 (95% CI 3.88-9.78); for cow/calf pairs the figures are 0.0660 (95% CI 0.0288-0.1031) and 6.82 (95% CI 2.92-10.86) respectively. Identifying photographs were again obtained using a digital-camera system. From some 5100 images, 491 have been selected for further analysis. Computerised photographic matching, introduced comprehensively in late 2003, has continued, allied with a computerised database. Of 6208 images available from 1976-2009, mainly from the aerial surveys, comparison has been completed for 3892, resulting in 1353 separately identified individuals, mainly from 1980-2005. The sightings database currently contains information on 2671 separate sighting events from 1976. Population size has been estimated using a simple model based on the numbers of cow/calf pairs sighted; it 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. Minimum population size from which animals visiting the area surveyed are drawn is then estimated to be *ca* 2900. Given the relative paucity of animals that visit the remainder of the Australian coast, the 'western' population recorded between C Leeuwin and Ceduna is likely to represent the majority of the 'Australian' population, with a total Australian population of *ca* 3500.

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).

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) comes from comparisons of identifying photographs of individual animals obtained during the surveys.

The survey methodology has involved 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 has been 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 1998), observer/photographer (since 1998) and pilot (1998-2002, 2004, and 2006-2009).

From 1977 until 1992 the surveys covered the Western Australian south coast, east from Cape Leeuwin (34° 22'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* 700 km). In some years they went as far east as Twilight Cove (32° 16'S, 126° 02'E), covering some 500 nmiles (*ca* 900km). Comparison of the numbers recorded each year in the area covered most comprehensively for the nine-year period 1983-1992 showed significant increases in all three classes recorded. The annual increase rate, estimated then at around ten per cent, was somewhat higher than estimates obtained 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 as far east as Ceduna, SA (32° 08'S, 133° 41'E), to include the major calving locality at Head of Bight, SA (31° 28'S, 131° 08'E), as well as the historically significant right whaling area at Fowler Bay, SA (31°59'S, 132° 30'E). The area then covered extended over some 900 nmiles (*ca* 1700 km), taking in that part of the coast to which the majority of the current 'Australian' population has been recorded as visiting in winter. The most valid comparison of numbers from year to year (and therefore the most valid estimate of increase rate) is therefore available from that 'extended flight' dataset.

The surveys along the southern Western Australian coast to 1992 took place at approximately monthly intervals from mid-July to late September/early October 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 took place

then, with only one such 'long' flight each year. (In 1993 and 1994, there were three 'extended' flights each year.) From 2000 a further leg was flown each year along the west coast, between Perth and Cape Leeuwin. In addition, 'short' flights along the southern WA coast continued from 1995, bracketing the 'long' flight, as far as possible in late July and late September/early October. While the 'long' flight concentrated on obtaining a maximum count, each 'short' flight 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) showed that for animals appearing close to the coast on a three-year cycle, ie cow/calf pairs, a significant detectable trend should 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.

The annual surveys from 1993 to 2007 were completed as planned, although the results for 1996 and 1997 were excluded from calculations of population trend because of possible undercounting then (see Bannister 1998, 2002). From 2008, only one flight, C Leeuwin-Ceduna (the previous 'long' flight), has been undertaken.

A significant trend in numbers of all classes of observed animals was observed in the series to 2006. But the 2007 count was considerably lower than in previous years – since 2003 for 'all animals' and 1994 for cow/calf pairs. The 2007 figure was considered an 'outlier', and was not included in the estimate of overall population increase at that time.

Given the apparently anomalous count in 2007, funding for a further 'long' flight was obtained (through the Australian Centre for Applied Marine Mammal Science – ACAMMS – now the Australian Marine Mammal Centre – AMMC) for a flight in August 2008. The overall number recorded (702 animals including 236 cow/calf pairs) was higher than in any previous year in the series, contrasting markedly with the very low figure recorded in 2007 (Bannister, 2009).

At a right whale workshop held under AMMC auspices in March 2009, priority in future work was given to development of a long-term monitoring strategy a) to allow efficient monitoring of population trend and abundance, and b) to study linkages between population dynamics and environmental changes on the feeding grounds. Pending development of the monitoring strategy a further survey was planned for August 2009. Although a funding proposal received favourable consideration a final decision was not available in time, and funding for the August survey was obtained from an alternative source, The Island Foundation, Massachusetts, USA.

Development of the long-term monitoring strategy was not complete by the winter season, 2010, and a further aerial survey was proposed, and funded (through the AMMC). This report gives the results of that (2010) survey. Flying was undertaken under permit SP 000070 from the Western Australian Department of Environment and Conservation and C23489-14 from the South Australian Department of Environment and Natural Resources for operations in State waters under their jurisdiction.

2. Major activities undertaken

2.1 Objectives

Objective 1. to continue collection of one of the key datasets, i.e.

a) to obtain aerial counts of right whales during August 2010 on the southern Australian coast between Cape Leeuwin WA and Ceduna SA (the current major distribution area of 'Australian' right whales) for comparison with data from previous aerial surveys in the same area (particularly since 1993).

The series of nine legs, covering Albany-Ceduna and return, Albany-Augusta and Augusta-Perth, was flown over the period 10-15 August. To meet the pilot's prior commitments the survey began a few days before the planned optimum period, although the final leg was flown on the first day of that period.

The aircraft type (single engine Cessna), and observer/photographer have remained unchanged since 1998. The aircraft was on charter from Great Southern Aviation, Albany, WA. The pilot had flown the annual series of flights from 1998 to 2002, in 2004, and again in 2006-2009.

Flying is only undertaken in 'good' weather conditions, usually in wind speeds of not more than 15 knots.

Each flying 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 comparison with past years' data the maximum count, of cow/calf pairs, for each duplicated leg has been taken as the comparable number, in addition to the count for leg 9 (Albany-Augusta, usually covered only once). 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.

b) to obtain identification photographs for comparison with the existing WA catalogue (i.e. since 1976)

Identifying photographs were as usual obtained on the flight. As since 2003, a digital camera (Canon EOS 5D, with 100-400mm lens) was used, images being assessed on a laptop after each leg.

c) to obtain continuing information on increase rate, population size, distribution, movements and biological parameters

As in previous years this objective is being met in two parts. The first part, obtaining information on increase rate and population size uses maximum counts from the flight (see Item 1) for comparison with 'long' flight data from the years since 1993.

The second part, using identification photographs obtained under Objective 2, involves review of all images obtained on the flight. A selection is made of those suitable for 'matching' with those from previously identified individuals; they are then included in the 'WA catalogue', comprising animals from Western Australia and South Australia, as well as from some other eastern states, the southern Indian Ocean and the Antarctic.

A computer-assisted comparison system (Hiby and Lovell 2001), is used to 'match' individual photographs obtained on the flights with those already available in the 'WA catalogue'. From late 2003 it replaced manual methods used previously. The system compares digitised extracts of overhead ('topside') photographs of individual head callosity patterns.

A computerised database, devised for this study by G P Donovan, Head of Science, International Whaling Commission, is used for recording associated sightings data. Some modifications were made in 2009-10 by Gaia Resources, Perth, under contract to the Western Australian Museum, to facilitate linkage within the database of 'best' images to individually identified animals.

3. Outcomes

3.1 Long term assessment

As indicated in Item 1 the project up to and including 2007 formed 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.

As in 2008 and 2009, the 2010 survey was designed to complement the previous annual surveys by providing data on peak numbers, and obtaining identifying photographs, of those southern right whales present in the area Cape Leeuwin, WA – Ceduna SA.

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

3.2.1 Assessment of numbers

The approximate position of the flight path followed in 2010 (see Figure 1) was the same as in previous years. Not shown is the additional leg flown along the west coast, between Perth and Cape Leeuwin.

Flying in appropriate conditions, usually winds <15 knots, was achieved on all flights in 2010 (Table 1), although there was a delay for one day at Esperance owing to bad weather on 13 August. Conditions were marginal at the start of leg 8 (Esperance-Albany) on 14 August, but they improved considerably during the flight.

Counts of 'all animals', 'unaccompanied adults' (i. e. adults unaccompanied by calves), and cow/calf pairs, were obtained, as summarised in Table 1.

Although because of the availability of the pilot the 2010 flight began five days earlier than the beginning of the optimum allotted period the effect on counts of 'all animals' is likely to have been virtually nil, and that on cow/calf pairs negligible, although a larger number of small or very small calves was recorded in the photographs than usual. While not as high as the two very high counts in 2008 and 2009, the 2010 overall count was higher than any other since 2005 (Table 2). The count for cow/calf pairs was relatively low, indeed lower than any since 2004, apart from the very low count of 2007. But given the very low count then, three years earlier, a relatively low cow/calf figure in 2010 was to be expected.

3.2.2. Assessment of trend

As in past years calculations of increase rates have been restricted to the data from C Leeuwin – Ceduna, using 'maximum count' data (Table 2). Legs for which the maximum count has been used are indicated in Table 1. A simple exponential regression (i.e. a linear regression of the natural log of the count on year) for 'all animals', gives an exponential rate of increase over the period 1993-2010 of 0.0657 (95% CI 0.0381-0.0933) corresponding to a percentage annual increase of 6.79 (95% CI 3.88-9.78); for cow/calf pairs the figures are 0.0660 (95% CI 0.0288-0.1031) and 6.82 (95% CI 2.92-10.86) (Table 3). Both datasets include the low 2007 points which were such a feature of the results then (see Bannister 2008). At that time whether or not the low 2007 data point was indicative of a slowing of the population growth rate was investigated by examining the residuals of the simple exponential regression, but there was no evidence of anything other than an exponential increase: the residual plot showed a fairly even scatter of points above and below the fitted regression line. Indeed, the variability in the counts from year to year was so high that evidence of anything other than exponential growth would take a long time to be supported statistically. Table 3 summarises the current results, including conversion of the exponential rate to an annual percentage increase, and comparison with 1993-2009. The 1993-2010 estimates have smaller Standard Errors and narrower 95% Confidence Intervals than for 1993-2009 and are thus an improvement over those from earlier years. They are therefore the current 'best estimates' of increase rate in this population. The relevant exponential plots are shown in Figure 3.

Given the three-year periodicity in calving, different three-year cohort strengths can be expected, particularly for cow/calf pairs. A three-year cycle is apparent, in fact both for 'all animals' as well as for cow/calf pairs, for 1998-2003 (Fig 3a, b); it breaks down in 2004 but is again apparent for 2005-7 (allowing for the very low count in 2007). Southern right whale breeding success, as exemplified by cohort strength from year to year, has been correlated with changes in sea surface temperature attributed to climate change in the South Atlantic (Leaper et al, 2006) where 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. Similar effects have been demonstrated for the Australian

population by Pirzl et al (2008), where annual calf production has been linked to variability in the El Niño-Southern Oscillation (ENSO), with reduced reproductive output associated with El Niño conditions on a 2.5 to 3-year time lag. Extended intervals between successful calving events were associated with variability in the Southern Annular Mode (SAM)[1] on a 3-year time lag.

3.2.3. Distribution

Figure 2 shows the approximate positions of whales sighted on the 2010 flight. The plots are for those legs on which maximum counts were made; 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 2010, 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;
- relatively large numbers, particularly 'unaccompanied' animals, east of Albany towards and including the Doubtful Island Bay area, and from east of Esperance through Tagon Bay to Cape Arid, and from Israelite Bay towards Twilight Cove WA;
- as in 2009, larger numbers than usual of 'unaccompanied' animals west of Eucla, WA;
- the usual relatively high number of cow/calf pairs (43) and 'unaccompanied' adults (31) at Head of Bight, SA;
- only two cow/calf pairs and one adult in Fowler Bay, SA.

3.2.4. 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 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 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 right whale worldwide assessment meeting (IWC 2001) the southern right whales ratio immature:adult was estimated to be as high as 1.41:1.

[1] SAM is the dominant climate signal in the Southern Ocean; it is a measure of oscillations in atmospheric pressure between the polar region and ~40°S and affects oceanic conditions through changes in the strength and latitude of westerly winds (see Pirzl et al 2008 for further explanations and references).

The number of reproductive females (i. e. cows accompanied by calves) recorded as visiting the coast in the three-year period 2008-10 was 614 (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 1228.

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 immature: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 614 reproductive females recorded there for the three year period 2007-9, *pro rata* the total visiting the area in that period would then be (614/225) x 1060, i.e. 2892.

2892 represents the number as at 2009 (the mid-point of 2008-2010), and is the minimum number of animals from which those visiting the survey area is drawn. The total Australian population would then be *ca* 3500.

3.3 Photoidentification

Some 5100 images were obtained on the 2010 flight, on six DVDs. 491 images have been selected for further analysis.

Digitised 'extractions' have been so far made for all images through 2009; those from 2010 are currently being analysed.

Computer-assisted comparison ('matching') has been completed for 3892 images. Those for 'all animals' up to and including 2005 have been 'matched', as well as all known females (ie cows accompanied by calves) up to and including 2006, together with some from both categories since then. 1353 separate individuals have been recognised so far, mainly from the period 1980-2005.

3.4 Photographic catalogue

The 'WA-SA' catalogue is maintained by Bannister at the WA Museum. Its usefulness has been greatly enhanced by the computerisation of images as above, and by employing a sightings/identified animals database originally developed by G P Donovan. The database currently comprises entries for 2671 separate sighting events from 1976, and for 1353 individuals.

6208 selected images are now available from the years 1976-2009, including 501 from the 2009 flight. By far the majority have originated from the aerial surveys, but a few are from other sources, including the Antarctic (from the Japanese Research Programme in the Antarctic – JARPA - and International Whaling Commission Southern Ocean Whale and Environmental Research – SOWER - Surveys).

6. Acknowledgements

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