

Australian Marine Mammal Centre Grants Program

Final Report

- **Project No.** – 12/3
- **Title** - Monitoring Population Dynamics of right whales off Southern Australia, 2012 and 2013.
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1. Project Summary

A clear, plain English summary of approximately 500 words outlining the work undertaken and any significant findings (for publication on the Department's web site). Include what was done, why and the key findings resulting in recommendations summarised from the sections below.

To provide ongoing information on population trend and abundance, of this, the 'western' subpopulation of 'Australian' right whales, as well as photographs for individual animal identification, flights were conducted as planned off the southern Australian coast in 2012 and 2013 close inshore between Cape Leeuwin, Western Australia and Ceduna, South Australia. The flights were the 20th and 21st consecutive annual surveys undertaken there since 1993; for comparability of results with those earlier, the same type of aircraft, and the same pilot and observer/photographer, were involved as in most recent years. In general, right whales approach the coast in winter/spring, cows about to give birth appearing at an average of every three years, others less predictably. The two sets of flights, both over five days in late August, provided the usual counts and identifying photographs of 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). Flying conditions were excellent-good in 2012, and slightly more variable in 2013. Usual concentrations, mainly but not exclusively, of cows and calves were encountered in and near Doubtful I Bay (WA), in and north east of Israelite Bay (WA), and at Head of Bight (SA); in 2012 more than usual were present in the Albany area and in 2013 more than usual from Albany west to Augusta. The largest concentration of cow/calf pairs was as usual at Head of Bight, SA, with the highest number so far in the series, 79, recorded there on the 2013 flight. The total 2013 cow/calf pair count (246) was itself a record for the series so far, just higher than the previous record, in 2009 (244). For 'unaccompanied animals' concentrations were as usual present in the Albany area, where larger numbers than usual were present in 2013, as well as in and west and east of Israelite Bay; in 2012 there were notable sightings west of Eucla. The exponential 'all animal' rate of increase for

1993-2013 was 0.0657 (95% CI 0.0461-0.0853), equivalent to 6.79% (95% CI 4.72-8.91), and for cow/calf pairs 0.0713 (0.0445-0.0980) or 7.39% (4.55-10.29). The results to 2013 are the current 'best estimates' of increase rate for this sub-population. Identifying photographs were obtained: from 8192 images on the 2012 flight, 550 were selected for further analysis; corresponding figures for 2013 were 4435 and 522. A computer-assisted photographic matching program, introduced comprehensively in late 2003, is employed to identify individuals against the existing catalogue, allied with a computerised database. 8183 selected images are available up to and including those from the flight in 2013 since observations began in 1976; comparison has been completed for 5522, resulting so far in 1868 separately identified individuals. The sightings database now contains information on 3373 separate sighting events for the 1976-2013 series. Minimum population size is estimated, for this, the 'western' sub-population, as currently *ca* 2800, with the total 'Australian' population now likely to number just over 3000.

2. The Outcomes and Objectives – Key Findings

List the Project Objectives and address each one, noting the degree to which the objective was achieved through the research and issues that may have hampered its success. Describe the key findings as they relate to the objectives and the management questions identified in the initial application.

There were four specified objectives, as in a-d below.

Objective a) Efficient monitoring of population trend and abundance

A series of flying legs (nine in 2012 and 10 in 2013), covering Albany-Ceduna and return, Albany-Augusta and Augusta-Perth, was flown successfully over the periods 24-29 August 2012 and 19-23 August 2013.

The aircraft type (single engine Cessna), and observer/photographer (Andrew Halsall) have remained unchanged since 1998 and continued in 2012 and 2013. The aircraft was on charter from Great Southern Aviation, Albany, WA. The pilot (Jenny Schmidt) had flown the annual series of flights from 1998 to 2002, in 2004, and again in 2006-2011.

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 and photographs 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 'return' 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. Counts on the leg along the west coast, usually very small, are not included in the annual comparison.

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 'western' sub-population, i.e. the majority of the current 'Australian' population, is likely to be found at the appropriate season.

As in each year since 2007, the 2012 and 2013 surveys were designed to complement the previous annual surveys by continuing to provide data on peak numbers, and obtaining identifying photographs, of those southern right whales present in the area

Cape Leeuwin, WA – Ceduna SA.

The approximate position of the flight path followed in 2012 and 2013 (see Figures 1A and 1B) was the same as in previous years. Not shown is the additional leg flown along the west coast, searching an area similar to that along the southern coast, between Perth and Cape Leeuwin.

Flying is as far as possible undertaken in ‘good’ weather conditions, usually in wind speeds of not more than 15 knots. In 2012 that was achieved, with winds not exceeding 10 knots except on one of the nine legs, and in three cases in calm conditions for part of a leg (Table 1A). Conditions in 2013 were more variable, with calm conditions for parts of four of the 10 legs, but changeable conditions, with winds up to 20 knots in part of two legs on the inward flight, Ceduna-Albany, on 21-22 August (Table 1B).

Counts of ‘all animals’, ‘unaccompanied adults’ (i. e. adults unaccompanied by calves), and cow/calf pairs, were obtained, as summarised in Tables 1A and 1B. The 2012 comparable count for all animals (715) was the second highest in the series, not as high as in 2009 (782). The 2013 ‘all animal’ count (706), while also not as high as in 2009 or 2012, was the third highest in the series. The count of cow/calf pairs in 2012 (220) was not as high as in 2009 (244) or 2011 (236); however, in 2013 (246) it was the highest in the series so far, just higher than in 2009 (244).

Population trend

As in past years calculations of increase rates have been restricted to the data from C Leeuwin WA – Ceduna SA, using ‘maximum (comparable) count’ data (Tables 2A and B). Legs for which the maximum (comparable) count has been used are indicated, by *, in Tables 1A and B. A simple exponential regression (i.e. a linear regression of the natural log of the count on year) was fitted to the data for ‘all animals’ and ‘cow/calf pairs’. 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 indicated 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 (PS Hammond, pers comm.).

The exponential rate of increase over the period 1993-2012 for ‘all animals’ is 0.0665 (95% CI 0.0446-0.0883), corresponding to a percentage annual increase of 6.87 (95% CI 4.56-9.23); for cow/calf pairs the figures are 0.0703 (95% CI 0.0405-0.1000) and 7.28 (95% CI 4.14-10.52) (Table 3A). For 1993-2013, the relevant figures are, for ‘all animals’ 0.657 (0.0461-0.0853) and 6.79 (4.72-8.91), and for cow/calf pairs 0.0713 (0.0455-0.0980) and 7.39 (4.55-10.29) (Table 3B). As in 2011 (see Table 3A), the most recent estimates have smaller Standard Errors and narrower 95% Confidence Intervals (each by *ca* 11%) than previously and thus continue to show improvement over earlier years. The relevant exponential plots for 1993-2012 and 1993-2013 are shown in Figures 3A and B. The results for 1993-2013 represent the current ‘best estimates’ of increase rate in this population.

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 (Fig 3a, b),

both for ‘all animals’ as well as for cow/calf pairs, for 1998-2003; it breaks down in 2004 but is again apparent for 2005-7 (allowing for the very low count in 2007), but not thereafter. 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.

Population size

In recent years (e. g. as in Bannister, 2007), 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, i.e. in the ‘eastern’ sub-population, the estimate for this, the ‘western’ sub-population, i.e. as recorded between C Leeuwin and Ceduna, is likely to represent the majority of the ‘Australian’ population.

At an International Workshop held in Buenos Aires in 2011 (IWC, 2013) a model was developed, based largely on evidence from increasing populations off Argentina and South Africa, where total population is obtained by multiplying the adult female population (over a three year period) by 3.94.

The number of reproductive females (i. e. cows accompanied by calves) recorded as visiting the surveyed area of coastline in the three-year period 2010-2013 was 702 (Table 2B). Using the Buenos Aires formula, the total population in 2012 (the midpoint of 2011-2013) would be 2756. The 2012 figure (2756) is the current ‘best estimate’ of that part of the Australian population visiting the survey area; the total Australian population would then be somewhat more than 3000.

Objective b) Study of linkages between population dynamics and environmental changes on the feeding grounds

As the basis for meeting this objective, identification photographs were as usual obtained on the flights. As since 2003, a digital camera (Canon EOS, with 100-400mm lens) was used, images being assessed on a laptop after each leg.

8185 selected images are now available from the years 1976-2013. By far the majority have come from the aerial surveys, but a few are from other sources, including the Antarctic (from the International Whaling Commission Southern Ocean Whale and Environmental Research – SOWER – Surveys, and the Japanese Research

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).

Programme in the Antarctic – JARPA).

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. ‘Matched’ individuals 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. It is contained in an ‘Individual Whale’ database. That database currently contains information on 1868 individual animals.

This part of the project is long-term and ongoing. The long-term aim is to provide data for a study similar to that of Leaper et al (2006) which required, *inter alia*, life history information for individual animals over a long time period (in that case, some 30 years). From 8192 images obtained on the 2012 flight, 550 were selected for further analysis; corresponding figures for 2013 were 4435 and 522. The relatively large number of images obtained in 2012 was caused by the photographer’s enthusiasm in using a new model of camera with motor drive. More conservative operation occurred in 2013.

Preparatory work (digitisation) has been completed for all 550 selected photographs from 2012, and is being undertaken for 2013. The final stage in the matching programme, comparison of each digitised image against those already in the catalogue, is next to be undertaken. ‘Matching’ has been completed for 5523 images, from the years up to and including some of 2011; 1868 separate individuals have been recognised so far. That final, ‘comparison’, stage has recently been temporarily interrupted by an anomaly in the computerised comparison program which it has not so far been possible to resolve, despite attempts by local IT experts and discussions with the major international proponent of the process (Dr Vicky Rowntree, University of Utah, USA). It should however be resolved shortly.

A computerised relational database, devised for this study by GP Donovan, Head of Science, International Whaling Commission, is used for recording sightings events (as ‘Sightings Histories’) associated with identified individuals. Some modifications were made in 2009-11 by Gaia Resources, Perth, under contract to the Western Australian Museum, to facilitate linkage within the database of ‘best’ images to individually identified animals (‘Individual Whales’, as above), and to tabulate individual sighting histories. The ‘Sightings’ database currently includes 3373 ‘histories’, and is now complete for the period 1976-2013.

Objective c) To continue collection of the dataset from the southern WA-SA coast

This is ongoing, using the whale numbers and photographs obtained on the two surveys in 2012 and 2013, as in a) and b) above. An additional outcome of the surveys is information on distribution of individual animals along the coastline.

Figures 2A and B show the approximate positions of whales sighted on the two flights respectively. The plots are for those legs on which maximum counts were made; they are those used in compiling the data of Tables 2A and B. The numbers of animals in each individual sighting are recorded in the body of each figure.

Notable features of right whale distribution in 2012, as shown in Figure 2A, were:

- the usual concentrations, mainly but not exclusively of cow/calf pairs, in and near Doubtful Island Bay (Gordon Inlet-Point Ann, Point Charles) WA, and in and north east of Israelite Bay, WA;
- more than usual cow/calf pairs in the Albany area, with relatively large numbers of ‘unaccompanied’ animals there also, as well as from Tagon Bay to and beyond Israelite Bay towards Twilight Cove, WA. (In 2011, unusually, there were no sightings of ‘unaccompanied’ animals in the Tagon Bay/Yokinup area, west of Cape Arid);
- as in 2009, 2010, and 2011, larger numbers than usual of ‘unaccompanied’ animals west of Eucla, WA;
- the largest number of cow/calf pairs on the flight as usual at Head of Bight, SA, though not as many as in 2011, itself a record year there (68 in 2012 compared with 74 in 2011);
- only four cow/calf pairs and four ‘unaccompanied animals’ at Fowler Bay, SA where in 2011 much larger numbers than usual (16 cow/calf pairs, 23 adults) were seen.

And in 2013 (Fig 2B):

- the usual concentrations of cow/calf pairs in and near Doubtful I Bay, WA, in and east of Israelite Bay, WA and at Head of Bight, SA (where the highest number, 79, was recorded for the annual series since 1993);
- again relatively large numbers of cow/calf pairs in and east of Albany, and more than usual from Albany west to Augusta;
- ‘unaccompanied’ animals present in relatively large numbers just west of, at (with 20 seen at Middleton Beach on 23 August), and east of, Albany WA;
- larger numbers than usual of cow/calf pairs concentrated in Israelite Bay itself (these are usually distributed more evenly in the Bay and to its north east);
- concentrations of ‘unaccompanied’ animals again from Tagon Bay towards and Beyond Israelite Bay to Twilight Cove, WA, with none west of Eucla WA, but more than usual from there towards Head of Bight SA;
- six cow/calf pairs but only one unaccompanied animal at Fowler Bay, SA.

Objective d) The digitizing (for archiving) of existing aircraft survey sighting records along the WA coast from 1976 to 1992, and along the southern Australian coast, C Leeuwin WA -Ceduna SA from 1993 to 2011.

Digitised database records for the years to 2011 have already been provided to the Australian Antarctic Division (through Dr Double) for archiving. Sighting records relating to all photographs selected for ‘matching’ since 1976 have been included in the sightings database. Relevant sighting records from the 2012 and 2013 surveys (282 records relating to 1072 selected photographs) have now also been entered into the sightings database and are available for archiving.

3. Implications for Management

What are the key recommendations for management based on the findings.

The project has so far provided information on the following, for the ‘western’ Australian subpopulation:

- Current population increase (of ca 7%)
- Current population size (ca 2800)
- Information on distribution, with concentrations of different classes (cow/calf pairs, ‘unaccompanied animals) in specified areas.

4. Other Benefits

How has this project advanced the field of research? (e.g. scientific discoveries, new methodologies)

The field has been advanced by the new information provided in Item 3. above.

5. Problems Encountered (if any)

Describe any major problems encountered during the Activity and how they were addressed.

No specific problems were encountered in the fieldwork (aerial survey) in either year, 2012, 2013, which was carried out successfully. A problem has been encountered in the computer-assisted photo-matching system: the initial stages of the program (digitising of images obtained on the two flights) has been completed for the 2012 images and is underway for those from 2013, but the final stage, computerised comparison of the images with those already in the catalogue, has encountered a computer problem which it has not yet been possible to correct, although it is hoped to do shortly.

6. Communication

How will results be communicated to management

Through this report and to the Scientific Committee of the International Whaling Commission.

Stakeholder engagement feedback (plain English for feedback to stakeholders) News releases, website information

Students supported (if any) none

PhD Theses and dissertations (if any) none

Publications (other than theses and dissertations) none

Planned publications On the status, and biology, of the major (‘western’) subpopulation of right whales off Australia. Either in The Journal of Cetacean Research and Management, or Marine Mammal Science

Presentations To the Right Whale Workshop, Society for Marine Mammalogy Biennial Conference, Dunedin, NZ, Dec 2013 – Powerpoint presentation: *An Iconic Aussie: Estimating increasing success.*

7. Project Outputs

| A list of the actual outputs of the research including milestones, progress reports and data products such as models etc. | Proposed date of completion | Actual date of completion |
|---|-----------------------------|---------------------------|
| Population trend and number from 2012 survey | 12/12 | 12/12 |
| Progress Report on 2012 survey | 02/13 | 08/13 |
| Population trend and number from 2013 survey | 12/13 | 12/13 |
| Final report on 2012 and 2013 surveys combined | 03/14 | 03/14 |

Table 1. A. Right whale aerial survey C. Leeuwin WA-Ceduna SA, 2012. Summary of results.

| Flight No. ² | Date | Leg | Whale sightings | | | | | | | | Weather ³ | Flying hrs |
|---------------------------|-------|---|-----------------|-----------------|----------|----------------------------|---------------------------------|----------|----------|----------------------|----------------------|-------------|
| | | | Right whales | | | | Other large whales ⁴ | | | | | |
| | | | A ⁵ | C | Y | T | A | C | Y | T | | |
| Outward legs, from Albany | 24/08 | 1. Albany-Esperance* | 130 | 54 | 0 | 184 incl 54 calves | 6 | 0 | 0 | 6 | 0-9 | 4.8 |
| “ | “ | 2. Esperance-Caiguna, excl Twilight Cove | 215 | 66 | 0 | 281 incl 66 calves | 1 | 1 | 0 | 2 | 9 | 4.0 |
| “ | 25/08 | 3. Caiguna-Nullarbor, incl Twilight Cove, excl Head of Bight* | 59 | 13 | 0 | 72 incl 13 calves | 0 | 0 | 0 | 0 | 0-10 | 4.7 |
| “ | “ | 4. Nullarbor-Ceduna, incl Head of Bight | 85 | 64 | 0 | 149 incl 64 calves | 0 | 0 | 0 | 0 | 10 | 2.4 |
| <i>Total Outward</i> | | <i>1-4. Albany-Ceduna</i> | <i>489</i> | <i>197</i> | | <i>686 incl 197 calves</i> | <i>7</i> | <i>1</i> | <i>0</i> | <i>8 incl 1 calf</i> | | <i>15.9</i> |
| Inward legs, to Albany | 26/08 | 5. Ceduna-Nullarbor incl Head of Bight* | 96 | 71 | 0 | 167 incl 71 calves | 0 | 0 | 0 | 0 | 0-10 | 2.6 |
| “ | “ | 6. Nullarbor-Caiguna excl Head of Bight, incl Twilight Cove | 50 | 9 | 0 | 59 incl 9 calves | 1 | 0 | 0 | 1 | 10-15 | 3.8 |
| “ | 27/08 | 7. Caiguna-Esperance excl Twilight Cove* | 217 | 71 | 0 | 288 incl 71 calves | 0 | 0 | 0 | 0 | 5-8 | 4.5 |
| “ | “ | 8. Esperance-Albany* | 122 | 49 ⁶ | 0 | 171 incl 49 calves | 1 | 0 | 0 | 1 | 10-7 | 4.2 |
| <i>Total Inward</i> | | <i>5-8. Ceduna-Albany</i> | <i>485</i> | <i>200</i> | <i>0</i> | <i>685 incl 200 calves</i> | <i>2</i> | <i>0</i> | <i>0</i> | <i>2</i> | | <i>15.1</i> |
| Additional legs | 29/08 | 9. Albany-Augusta-Perth (Jandakot) ^{7*} | 3 | 1 | 0 | 4 incl 1 calf | 3 | 0 | 0 | 3 | 8-10 | 4.2 |
| <i>Total additional</i> | | <i>9. Albany-Augusta-Perth (Jandakot)</i> | <i>3</i> | <i>1</i> | <i>0</i> | <i>4 incl 1 calf</i> | <i>3</i> | <i>0</i> | <i>0</i> | <i>3</i> | | <i>4.2</i> |

² excludes overland (non-sighting) flight Jandakot-Albany, 29/08

³ as indicated by wind speed, knots

⁴ all humpbacks; no other large whales recorded

⁵ A=adult, C=calf, Y='yearling', T=total

* counts used in Table 2

⁶ one dead calf on beach near L. Qualillup (121° 44'E) not included in count

⁷ sightings only between Albany and Augusta; none between Augusta and Perth

| | | | | | | | | | | | | |
|-----------------------|---------------|----------------|------------|------------|----------|---------------------------------|-----------|----------|----------|--|--|-------------|
| Total 2012 | 5 days | 9 legs | 977 | 398 | 0 | 1375 incl 398 calves | 12 | 1 | 0 | 13 incl 1 calf | | 35.2 |
| Total 2011 | 5 days | 10 legs | 856 | 465 | 0 | 1321 incl 465 calves | 25 | 2 | 0 | 27 incl 2 calv es | | 34.7 |

Table 2. A. Right whale aerial survey, C. Leeuwin WA-Ceduna SA, 1993-2012. Comparable (maximum) numbers seen.

| Year | a. All animals | b. 'Unaccompanied' animals | c. Cow/calf pairs |
|-------------------|-------------------|----------------------------------|----------------------|
| 1993 | 167 | 47 | 60 |
| 1994 | 191 | 95 | 48 |
| 1995 | 267 | 139 | 64 |
| 1996 ⁸ | 233 | 123 | 55 |
| 1997 ¹ | 254 | 148 | 53 |
| 1998 | 342 | 120 | 111 |
| 1999 | 325 | 157 | 84 |
| 2000 | 259 | 113 | 73 |
| 2001 | 447 | 163 | 142 |
| 2002 | 377 | 163 | 107 |
| 2003 | 273 | 85 | 94 |
| 2004 | 356 | 142 | 107 |
| 2005 | 591 | 237 | 177 |
| 2006 | 427 | 127 | 150 |
| 2007 | 286 | 172 | 57 |
| 2008 | 702 | 230 | 236 |
| 2009 | 782 | 294 | 244 |
| 2010 | 519 | 251 | 134 |
| 2011 | 657 | 185 | 236 |
| 2012 | 715 | 275 | 220 |

Table 1. B. Right whale aerial survey C. Leeuwin WA-Ceduna SA, 2013. Summary of results.

| Flight No. ⁹ | Date | Leg | Whale sightings | | | | | | | | Weather ¹⁰ | Flying hrs-mins |
|---------------------------|------------|--|-----------------|----|---|--------------------|----------------------------------|---|---|---------------|-----------------------|-----------------|
| | | | Right whales | | | | Other large whales ¹¹ | | | | | |
| | | | A ¹² | C | Y | T | A | C | Y | T | | |
| Outward legs, from Albany | 19/08/2013 | 1. Albany-Esperance | 124 | 64 | | 188 incl 64 calves | 6 | 1 | | 7 incl 1 calf | 0/5 | 4-40 |
| " | 19/08 | 2. Esperance-Caiguna | 138 | 89 | | 227 incl 89 calves | 1 | 1 | | 2 incl 1 calf | 5/0 | 4-00 |
| " | 20/8 | 3. Caiguna-Nullarbor, incl Head of Bight | 132 | 68 | | 200 incl 68 calves | 1 | | | 1 | 0/5 | 4-45 |

⁸ Probable undercounts (see Bannister 1998, 2002)

⁹ excludes overland (non-sighting) flight Jandakot-Albany, 29/08, 1hr 50 mins

¹⁰ as indicated by wind speed, knots

¹¹ all humpbacks; no other large whales recorded

¹² A=adult, C=calf, Y='yearling', T=total

* maximum counts used in Table 2

| | | | | | | | | | | | | |
|-------------------------|-------|---|------------|------------|----------|-----------------------------|-----------|----------|----------|-------------------------|-------------|--------------|
| “ | 20/08 | 4. Nullarbor-Ceduna, excl Head of Bight | 26 | 17 | | 43 incl 17 calves | 1 | | | 1 | 5 | 2-15 |
| <i>Total Outward</i> | | <i>1-4. Albany-Ceduna</i> | <i>420</i> | <i>258</i> | <i>0</i> | <i>678 incl 238 calves</i> | <i>9</i> | <i>2</i> | <i>0</i> | <i>11 incl 2 calves</i> | | <i>15-40</i> |
| Inward legs, to Albany | 21/08 | 5. Ceduna-Nullarbor incl Head of Bight* | 118 | 83 | | 201 incl 83 calves | | | | | 10/20 | 3-25 |
| “ | 21/08 | 6. Nullarbor-Caiguna excl Head of Bight* | 30 | 3 | | 33 incl 3 calves | | | | | 20 | 4-15 |
| “ | 22/08 | 7. Caiguna-Esperance * | 154 | 90 | | 244 incl 90 calves | 2 | | | 2 | 0/11 | 4-35 |
| “ | 22/08 | 8. Esperance-Albany incl Middleton Beach* | 127 | 65 | | 192 incl 65 calves | 3 | | | 3 | 10/7 | 4-35 |
| <i>Total Inward</i> | | <i>5-8. Ceduna-Albany</i> | <i>429</i> | <i>241</i> | <i>0</i> | <i>670 incl 241 calves</i> | <i>5</i> | <i>0</i> | <i>0</i> | <i>5</i> | | <i>16-50</i> |
| Additional legs | 23/08 | 9. Albany-Augusta excl Middleton Beach* | 31 | 5 | | 36 incl 5 calves | 3 | | | 3 | 5/10 | 5-00 |
| | 23/08 | 10. Augusta-Perth (Jandakot) | 3 | | | 3 | | | | | | |
| <i>Total additional</i> | | <i>9, 10. Albany-Augusta-Perth (Jandakot)</i> | <i>34</i> | <i>5</i> | <i>0</i> | <i>39 incl 5 calves</i> | <i>3</i> | <i>0</i> | <i>0</i> | <i>3</i> | <i>5/10</i> | <i>5-00</i> |
| Total 2013 | | 10 legs | 883 | 504 | 0 | 1387 incl 504 calves | 17 | 2 | 0 | 19 incl 2 calves | | 36-25 |
| Total 2012 | | 9 legs | 977 | 398 | 0 | 1375 incl 398 calves | 12 | 1 | 0 | 13 incl 1 calf | | 35-12 |

Table 2. B. Right whale aerial survey, C. Leeuwin WA-Ceduna SA, 1993-2013. Comparable numbers seen.

| Year | a. All animals | b. 'Unaccompanied' animals | c. Cow/calf pairs |
|--------------------|---------------------------|---|------------------------------|
| 1993 | 167 | 47 | 60 |
| 1994 | 191 | 95 | 48 |
| 1995 | 267 | 139 | 64 |
| 1996 ¹³ | 233 | 123 | 55 |
| 1997 ¹ | 254 | 148 | 53 |
| 1998 | 342 | 120 | 111 |
| 1999 | 325 | 157 | 84 |
| 2000 | 259 | 113 | 73 |
| 2001 | 447 | 163 | 142 |
| 2002 | 377 | 163 | 107 |
| 2003 | 273 | 85 | 94 |
| 2004 | 356 | 142 | 107 |
| 2005 | 591 | 237 | 177 |
| 2006 | 427 | 127 | 150 |
| 2007 | 286 | 172 | 57 |
| 2008 | 702 | 230 | 236 |
| 2009 | 782 | 294 | 244 |
| 2010 | 519 | 251 | 134 |
| 2011 | 657 | 185 | 236 |
| 2012 | 715 | 275 | 220 |
| 2013 | 706 | 214 | 246 |

Table 3. A. Best fit regressions to the data of Table 2, C. Leeuwin WA-Ceduna SA, excluding 1996, 1997

| Period | 1993-2012 | | 1993-2011 | |
|-----------------------------------|--------------------|-----------------------|--------------------|-----------------------|
| | All animals | Cow/calf pairs | All animals | Cow/calf pairs |
| Exponential increase | 0.0665 | 0.0703 | 0.0660 | 0.0697 |
| SE | 0.0103 | 0.0140 | 0.0115 | 0.0156 |
| 95% CI | 0.0446-0.0883 | 0.0405-0.1000 | 0.0415-0.0904 | 0.0364-0.1030 |
| p | 0.00001 | 0.00013 | 0.000038 | 0.00046 |
| R² | 0.723 | 0.611 | 0.688 | 0.569 |
| Percentage annual increase | 6.87 | 7.28 | 6.82 | 7.21 |
| SE | 1.035 | 1.413 | 1.154 | 1.575 |
| 95% CI | 4.56-9.23 | 4.14-10.52 | 4.24-9.46 | 3.70-10.85 |

¹³ Probable undercounts (see Bannister 1998, 2002)

Table 3. B. Best fit regressions to the data of Table 2, C. Leeuwin WA-Ceduna SA, excluding 1996, 1997

| Period | 1993-2013 | | 1993-2012 | |
|-----------------------------------|--------------------|-----------------------|--------------------|-----------------------|
| Class | All animals | Cow/calf pairs | All animals | Cow/calf pairs |
| Exponential increase | 0.0657 | 0.0713 | 0.0665 | 0.0703 |
| SE | 0.00930 | 0.0127 | 0.0103 | 0.0140 |
| 95% CI | 0.0461-0.0853 | 0.0445-0.0980 | 0.0446-0.0883 | 0.0405-0.1000 |
| p | 0.000002 | 0.00003 | 0.00001 | 0.00013 |
| R² | 0.746 | 0.651 | 0.723 | 0.611 |
| Percentage annual increase | 6.79 | 7.39 | 6.87 | 7.28 |
| SE | 0.934 | 1.27 | 1.035 | 1.413 |
| 95% CI | 4.72-8.91 | 4.55-10.29 | 4.56-9.23 | 4.14-10.52 |

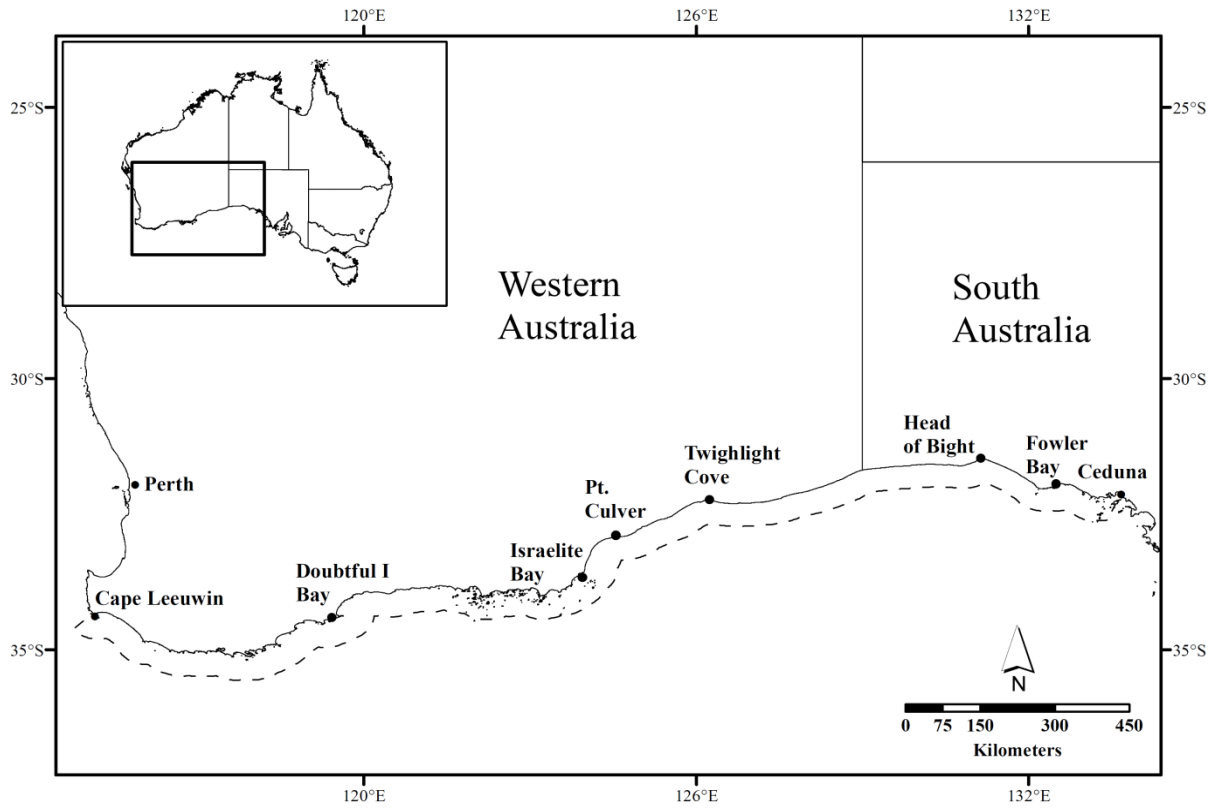


Fig 1. Right whale aerial survey off southern Australia from 1993. Dashed line represents approximate survey route.

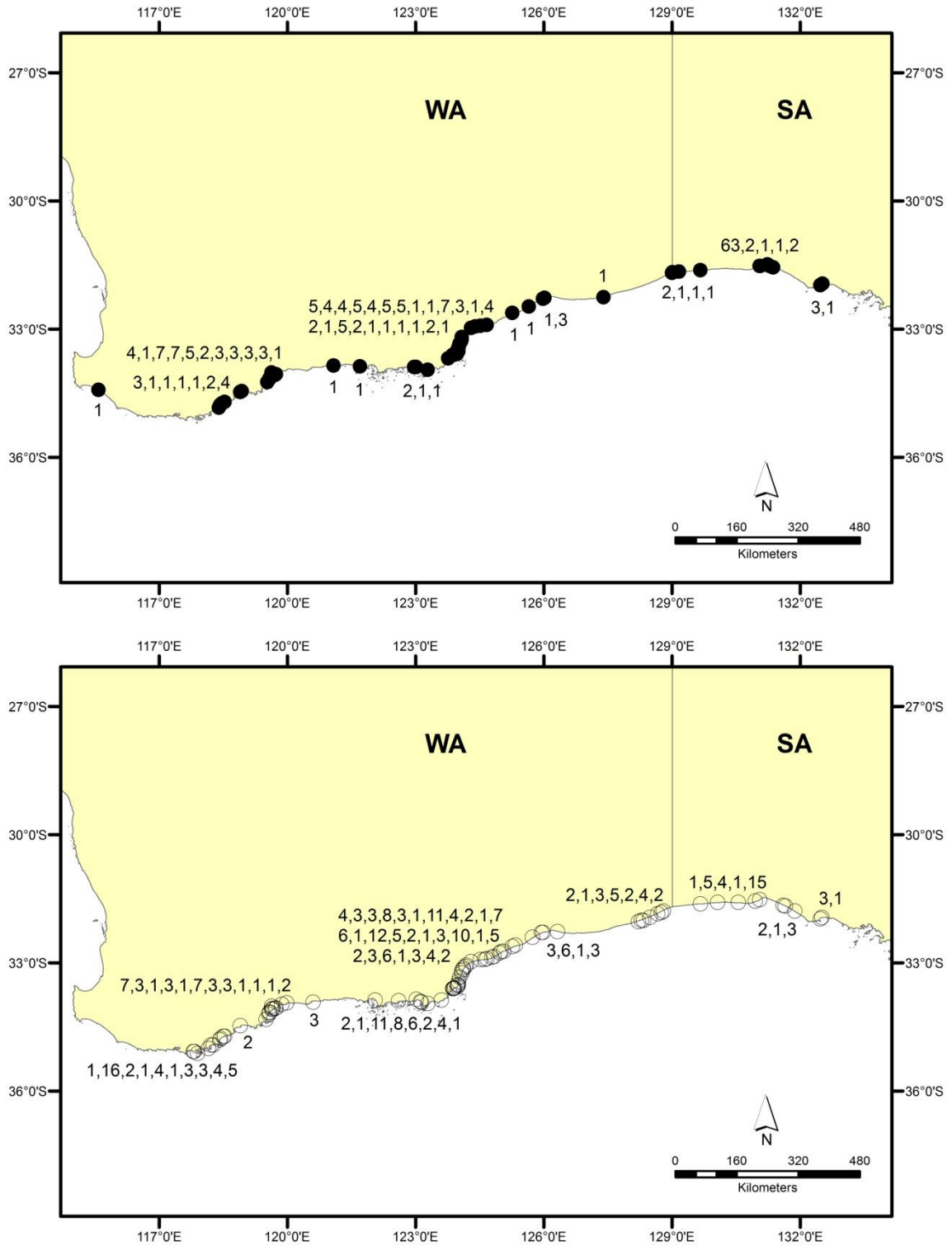


Figure 2. A. Aerial Survey, WA-SA, 2012. Approximate positions of right whale sightings on the flight. Localities as in Figure 1.
a) Cow-calf pairs (●)
b) Unaccompanied animals (○)

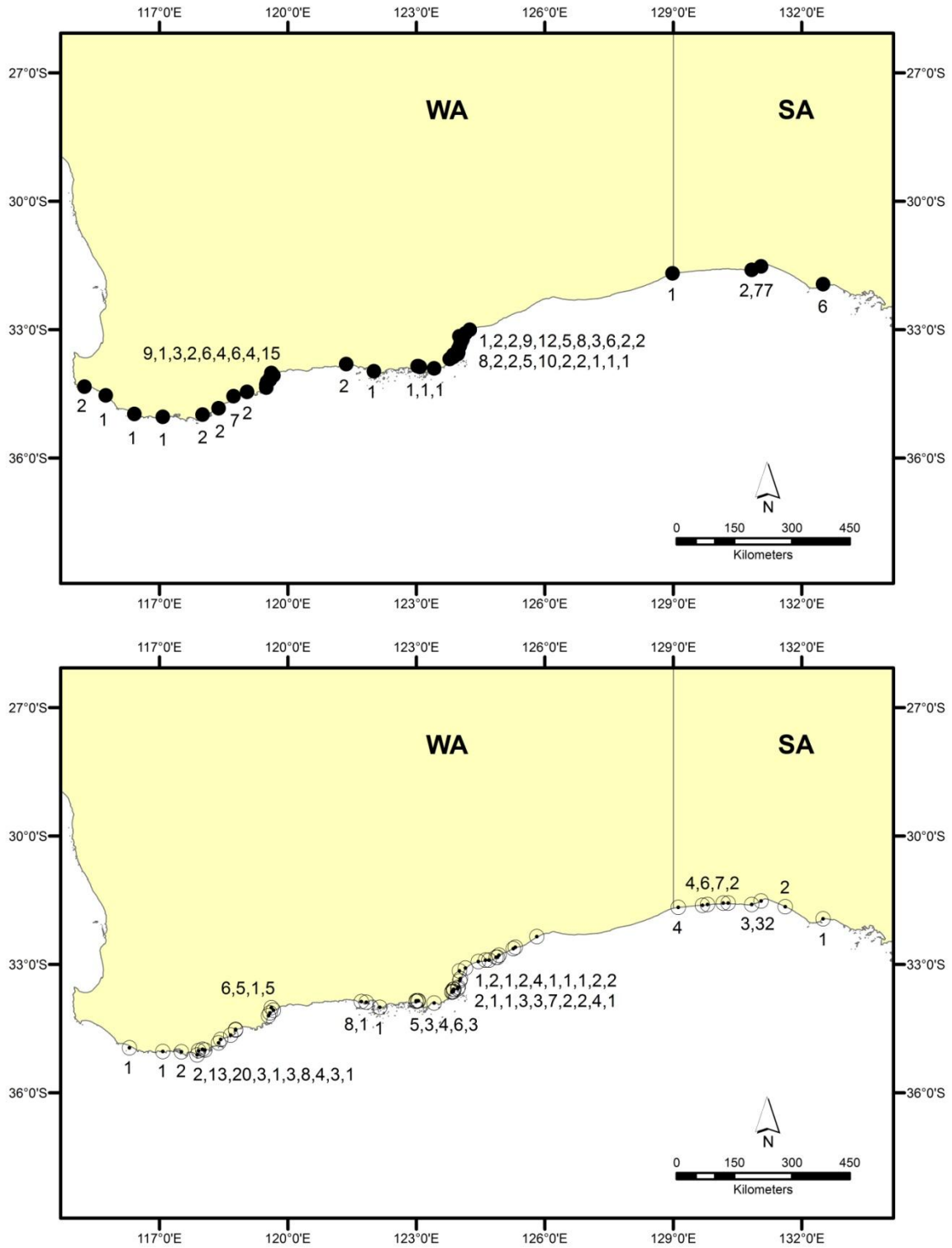
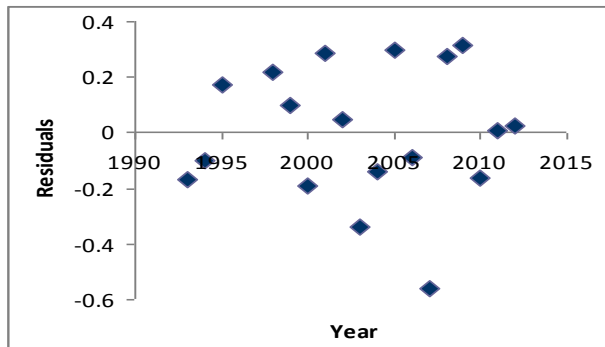
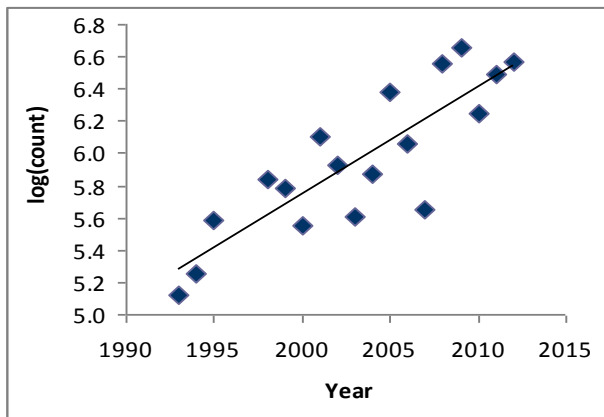


Figure 2. B. Aerial Survey, WA-SA, 2013. Approximate positions of right whale sightings on the flight. Localities as in Figure 1.
a) Cow-calf pairs (●)
b) Unaccompanied animals (○)

a.



b.

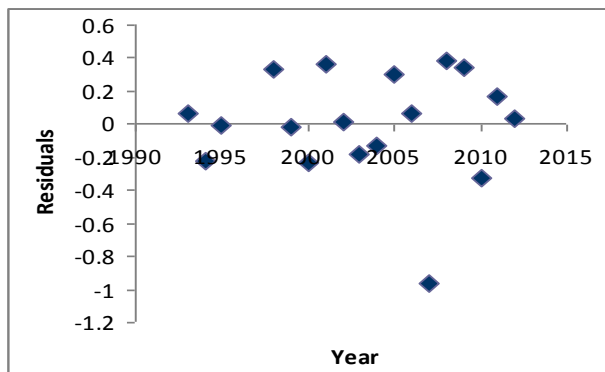
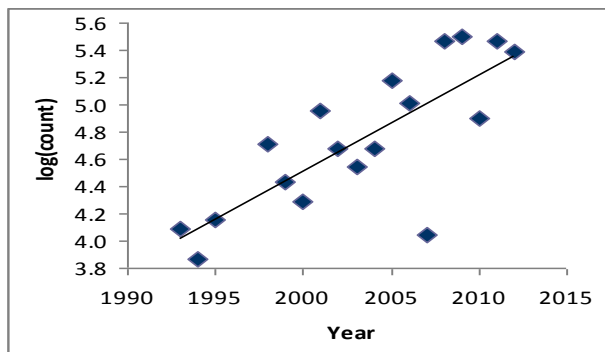
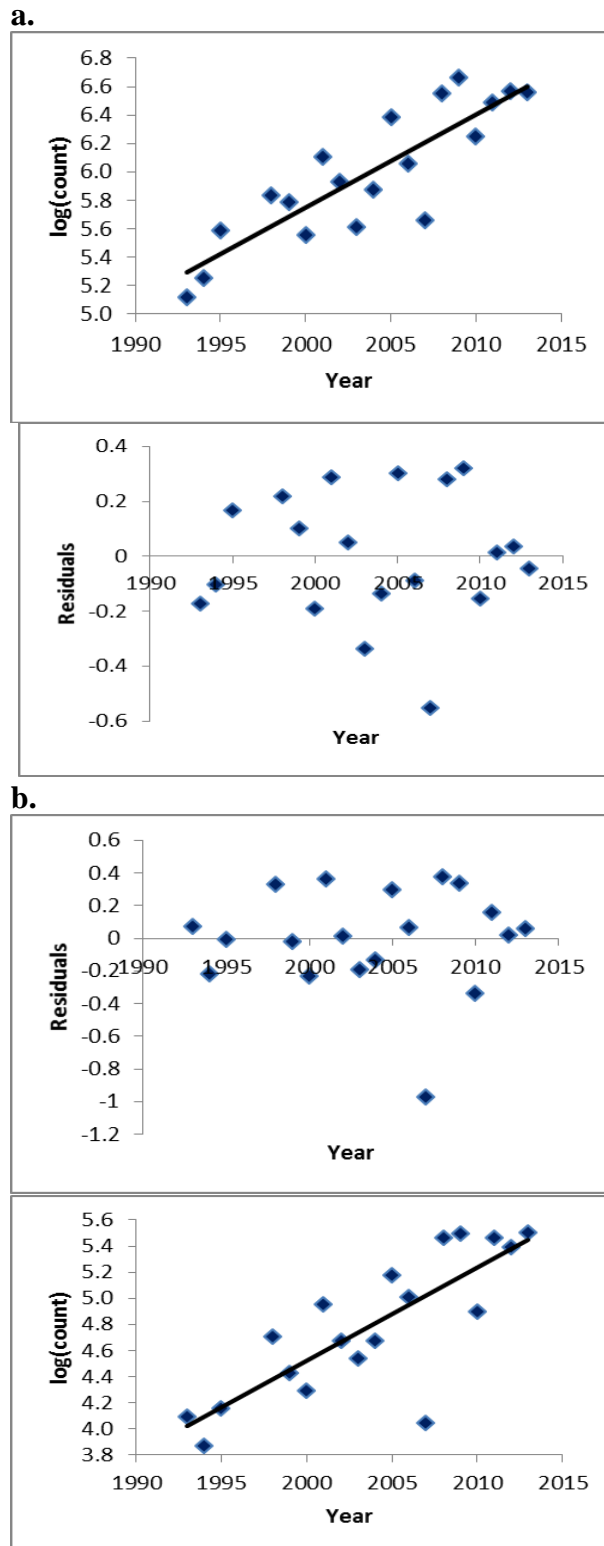


Fig 3. A. Regression and residual plots for the data of Table 2 (1993-2012).

a) All animals, b) Cow/calf pairs (both excl 1996, 1997)



**Fig. 3. B. Regression and residual plots for the data of Table 2 (1993-2013).
a) All animals, b) Cow/calf pairs (both excl 1996, 1997)**

Attachment A

Acknowledgements

Jenny Schmidt (flying for Great Southern Aviation) piloted the two flights, with Andrew Halsall (Andrew Halsall Photography) as observer/photographer. Dr Josh Smith (Murdoch University) produced Figures 1 and 2. Prof. Philip Hammond (St Andrews University, Scotland) undertook the trend analysis in Item 2, Objective a). Facilities and administrative and other assistance continue to be provided at the Western Australian Museum to the Recipient through the courtesy of the Trustees, the Chief Executive Officer, and the Executive Director, Collections and Research.

Attachment B

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Tables 1-3, A and B

Figures 1, 2-3 A and B