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Aerial survey of the Australian southern right whale (*Eubalaena australis*) 'western' population and development of AI for photo-identification

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Contents

List of figures

Executive summary

Southern right whales (*Eubalaena australis*) were targeted by intense commercial whaling during the 19th and 20th century, resulting in overexploitation and near extirpation of the species throughout much of its range. In Australia, they were considered rare to virtually extinct between 1870 to 1960, with initial signs of recovery from the mid 1970's in south-west Australia. Aerial surveys of Southern right whales have been undertaken annually off the south-west Australian coast since 1976 to monitor recovery, resulting in a long-term dataset of sightings and photo-identification (photo-ID) data spanning 50 years. An aerial survey was undertaken between 15-22 August 2025 in coastal waters from Perth (Western Australia) to Ceduna (South Australia) to continue to monitor the recovery of this endangered species.

The survey reported a total 646 whales sighted, consisting of 304 cow-calf pairs and 38 unaccompanied adults. The 'western' population of Southern right whales in Australian waters shows a stalled population growth rate, with stalled growth in female-calf pairs since 2016 and a substantial decline (~74%) of unaccompanied animals since 2011. There continues to be highly fluctuating annual variation in abundance for both unaccompanied animals and female-calf pairs over the past decade, with persistent low numbers of unaccompanied animals. The results from this survey suggest the western population of southern right whales is no longer recovering at previous growth rates (since 1976), with current abundance well below (~20%) pre-whaling abundance. It is critical the Southern right whale is afforded high levels of protection in biologically important areas (e.g. reproduction BIA) and annual surveys are continued to assess the status of the species through long-term population trend data to inform federal and state conservation management actions and regulatory assessments of marine-based activities (e.g. coastal development, aquaculture and fisheries interactions, offshore wind and seismic surveys).

Continued development and implementation of Artificial intelligence (AI) tools occurred in 2025 to automate image workflows to process the photo-ID data and improve image processing/matching capabilities. This will improve photo-id data processing times and provide more contemporary data to inform demographic parameters and population dynamics for the 'western' population.

1. Introduction

Southern right whales (*Eubalaena australis*; SRWs) were hunted to near extinction by shore-based and pelagic commercial whaling throughout the Southern Hemisphere, during the 19th and 20th centuries and by 1920, only an estimated 300-400 whales remained (IWC, 2001; Jackson et al., 2008). In Australia, SRWs were considered rare to virtually extinct between 1870 to 1960, with only few sightings reported for almost 100 years until 1955 (Chittleborough, 1956; Smith et al., 2026). Since the mid-1970s, there were increased occurrences along the Australian coast, particularly for waters off Western Australia (WA) and South Australia (SA) (known as the 'western population'). Based on these increased sightings of SRWs, annual aerial surveys were initiated in 1976 along the south-west coast of Australia from Cape Leeuwin east to Twilight Cove to determine trends in population abundance, life history information, reproductive parameters, and obtain photo-ID data on whales aggregating close inshore in calving areas (Figure 1). From 1993, the aerial surveys were extended into SA waters to Ceduna, in response to evidence of intra- and inter-seasonal coastal movement and whale presence in key aggregation areas in SA. In south-east Australia (i.e. Victoria, Tasmania and New South Wales) there has been little sign of recovery in SRW numbers (Stamation et al., 2020) following intense commercial whaling. A working hypothesis assumes separation between the 'western' and 'eastern' sub-populations, which are believed to be separated by 'cultural memory' of the whales' migration routes to the eastern or western range breeding areas (Carroll et al., 2015). Abundances in the 'eastern' population (animals that visit the south-eastern Australian coast) have shown considerably less growth, and annual abundances remain an order of magnitude lower than in the western population (Stamation et al., 2020; Grundlehner et al., 2025). Consequently, the western population represents the majority of the 'Australian' SRW population.

The annual aerial surveys represent a long-term monitoring strategy to enable efficient monitoring of population abundance trends and obtain demographic parameters that can be used to inform and assess linkages between population dynamics and environmental changes in the whales' feeding grounds (Bannister et al., 2011). In addition to the long-term aerial survey dataset, annual cliff-based surveys have been conducted since 1991 at a key aggregation site at Head of Bight (SA) to monitor the species abundance and demographics at this key aggregation area (Charlton et al., 2022). While early stages of the species recovery exhibited exponential growth rates (e.g. 1976-2014; Bannister et al., 2016), inter-annual variation has increased in recent decades which caused a slowing in population growth rates (Bannister, 2016). More recently, this was shown to have caused and stalling growth trend around 2016 and even a declining trend in annual birth rates in the years thereafter (Grundlehner et al., 2025). The annual aerial survey data directly informs federal and state government conservation planning and decision making, including the species National Recovery Plan. Southern right whales are currently listed as 'Endangered' and 'Migratory' under the Australian *Environmental Protection and Biodiversity and Conservation Act 1999* (EPBC Act) and as 'Vulnerable' under the Western Australia government *Biodiversity Conservation Act 2016* and South Australia government *National Parks and Wildlife Act 1972*. This critical long-term monitoring aerial survey program addresses a *Very High* priority action (B1.2) in the National Recovery Plan for the Southern Right Whale (*Eubalaena australis*) (DCCEEW, 2024) to '*maintain long-term annual monitoring programs of the western population across its range that are capable of measuring and evaluating population recovery, including continuance of aerial surveys and photo-identification'*.

The photo-ID data is an important tool for monitoring population trends over time and provides sighting histories of individuals and associated population demographic data (e.g. calving intervals) and connectivity between the ‘western’ and ‘eastern’ populations. The annual aerial surveys contribute photo-ID to the national Southern right whale photo-id database; the Australasian Right Whale Photo-Identification Catalogue (ARWPIC). However, processing photo-ID data currently requires manual review and matching of individuals, and a significant time investment to compare with the increasingly larger national catalogue of photo-ID images. Recent advances in the application of deep learning algorithms and fully automated image workflows to North Atlantic right whales (Bogucki et al., 2019) demonstrate the feasibility of using artificial intelligence (AI) for processing SRW photo-ID data. Further work continues in the development and application of AI tools for processing SRW photo-ID data within this project (Smith et al., 2025).

Figure 1. Female and calf interacting with a group of dolphins near Fowlers Bay (South Australia) off the southern coast of Australia during 2025 aerial survey.

2. Methods

2.1 Aerial survey count and whale photo-ID

Aerial surveys of SRWs were undertaken following established survey protocols since 1993 when the aerial surveys were extended into SA waters to Ceduna (Bannister, 2001; Smith et al., 2024). Aerial surveys are undertaken using a high wing, single engine aircraft (Cessna 172RG) using a survey team that comprises the same pilot and when possible the same photographer as previous surveys since 1997, and a data scribe. The survey is conducted along the southern coast of Australia between Perth (WA) and Ceduna (SA) (Figure 2) during the expected period of peak whale abundance, specifically for female-calf pairs. The survey comprises an 'outward' route from Perth east to Ceduna and then an 'inward' return route from Ceduna to Perth. Flights are conducted on days when average wind speeds are typically less than 15 knots within *ca* one nautical mile of the coast, given the highly coastal distribution of SRWs. Survey flights are undertaken at an altitude of 1000 feet and photographs of the individual markings (i.e. photo-ID of callosity patterns) of the whales at 500 feet.

Figure 2. Approximate survey area for Southern right whales off the southern coast of Australia (within *ca* one nautical mile) in 2025 between Perth (Western Australia) and Ceduna (South Australia). The dashed line represents the offshore boundary of the survey area, which is illustrative only as its distance to the coastline is not set to scale.

Most animals, particularly females with calves, are easily observed in the relatively clear waters on the southern coastline and no corrections are made to account for detection probability of a sighting ($g(0)$) in the survey data (i.e. assumed $g(0) = 1$). When whales are sighted, a direct count of the number of whales within a group (including numbers of calves) and GPS position are recorded. The aircraft then descends to enable photographs to be taken for individual identification of whales, requiring clear aerial photographic images of the head callosity pattern and/or other identifying characteristics. Photo-id images are geotagged using a Canon EOS 5D DSLR/EOS R7 and Canon 100-400 USMII lens. At the end of survey, photographs of individuals identified from their head callosity pattern are manually reviewed for quality and where the callosity patterns are unobstructed (e.g. from water-wash over the head) and clearly discernible, whale photo-IDs and images are submitted to ARWPIC.

Each annual survey involves multiple flight 'legs' along the coast, with each leg comprising sections of the coastline that can typically be surveyed in one or two flights within a day, dependant on weather. Given the survey comprises an 'outward' and 'inward' route, each 'leg' is surveyed twice dependent on weather. The maximum count on either the 'outward' or 'inward' flight on each 'leg' are then used to obtain estimates of both population trend and current population size, which is consistent and comparable to surveys since 1993.

2.2 Population estimate and trend analysis

A population trend analysis was undertaken following statistical methods from Grundlehner et al. (2025) using a Bayesian Generalized Additive Mixed Model (GAMM) applied in the R-INLA package (Lindgren & Rue, 2015), following protocols established by Zuur (2012) and Zuur et al. (2017). Annual abundances as a function of the year of observation covering the entire study period (1976-2025) over the total study area were modelled by 'segment length' separately for calves and unaccompanied individuals. Due to non-linear patterns in the observed abundances over time, a smoother function was applied to the temporal (year) effect and an interaction term was included in this smoother, allowing the fit of a unique smoother function for each individual segment, preventing segment-related patterns in model residuals. An interpolated temporal trend for the total number of calves and unaccompanied animals over the entire study area for the entire study period was established using the fitted GAMMs.

The total population size estimate for the 'western' population is obtained using two different methods:

1. A simple model adopted at the 2011 International Right Whale Workshop (IWC, 2013) based on the numbers of female-calf pairs (i.e. mature females) sighted. The rolling sum of female-calf pairs over the most recent three years (representing a 3-year calving interval) is multiplied by a single conversion factor (3.94) to convert estimates of mature females to the total number of individuals in the population.
2. The estimated mean calf abundance (as modelled by the GAMM) in the focal year (i.e. 2025) is used, multiplied by an assumed calving interval (i.e. 3, 4 or 5-years) and multiplied by the IWC conversion factor (3.94). A 3-year and 5-year calving interval can be used for a lower and upper range estimate.

2.3 Development of AI tools for processing photo-ID data

Matching photo-ID images of individual SRWs in Australian waters occurs within the online platform of ARWPIC using a code-based categorical matching framework (i.e. BigFish CodeCompare). Existing open-source AI algorithms (e.g. Piev2) have been adapted and applied for automating the processing of SRW photo-ID data within the ARWPIC database. Building on the development of AI tools in 2024 (Smith et al., 2025), two new tools will be developed to extend semi-automated sightings data processing and facilitate AI matching of photo-ID images:

1. An auto-creation of events and sightings.
2. An AI photo-ID matching interface within ARWPIC will be developed

3. Results

3.1 Aerial survey

An aerial survey of the ‘western’ population of Australian SRWs was undertaken between Perth (WA) and Ceduna (SA) over a total ten days and six survey days, between the 15-22 August 2025 over a combined 38.3 survey hours. During the entire survey there were a total 1,030 SRWs recorded, including 487 calves. This count inevitably incorporates double counts of individual whales given the survey area is surveyed twice (due to outward and inward flights) (Appendix A: Southern right whale aerial survey summary data). There were an additional eleven groups and 30 individuals of humpback whales, for which only adults were sighted (Appendix A: Southern right whale aerial survey summary data).

The maximum whale counts from each leg (either ‘outwards’ or ‘inwards’) between Cape Leeuwin and Ceduna were used to determine population size and trend for the ‘western’ population, which totalled 542 SRWs comprising 447 female-calf pairs and 38 unaccompanied whales, including one yearling (Appendix A: Southern right whale aerial survey summary data).

3.2 Distribution

The distribution in sightings of SRWs during the 2025 aerial survey were generally consistent with previous years for both female-calf pairs and unaccompanied animals, within three main regions of the aerial survey area (Figure 3):

1. Albany east to Doubtful Island Bay.
2. Israelite Bay (east to Point Culver).
3. Head of Bight in South Australia.

Female-calf pairs showed a greater concentrated and clumped pattern in distribution compared to unaccompanied animals, within the three main areas identified above (Figure 3a). Unaccompanied whales consist of adults (males and females) without a calf and have a broader distribution, particularly from Albany to Doubtful Island Bay and Esperance to Caiguna (Figure 3b). There were substantially fewer sightings of unaccompanied animals in the 2025 surveys. From 14,456 images obtained on the 2025 flight, preliminary analysis is being undertaken to select individual photo-IDs to conduct computer-assisted AI ‘matching’ with those whales already available in the ARWPIC catalogue.

3.3 Trends in abundance

3.3.1 Population trend analysis

Overall, the total number of SRWs in the western population sighted during the 2025 aerial survey (N = 649) was comparable to recent years (since 2008), although the proportion of unaccompanied animals to female-calf pair sightings has varied considerably in recent years (since 2020). There were substantially fewer sightings of unaccompanied animals in the 2025 surveys (N=38) compared to 2023 and 2024 (N = 154, 108 respectively) and similar to 2022 (N = 32) whereas the highest number of female-calf pair sightings were recorded since 2017 (N = 303), with a ratio of 1:8 unaccompanied to female-calf pairs in 2025 similar to 2022 (1:7.7). Within the time series there are notable years of substantially lower total counts of whales (Appendix B: Summary table of aerial survey count data).

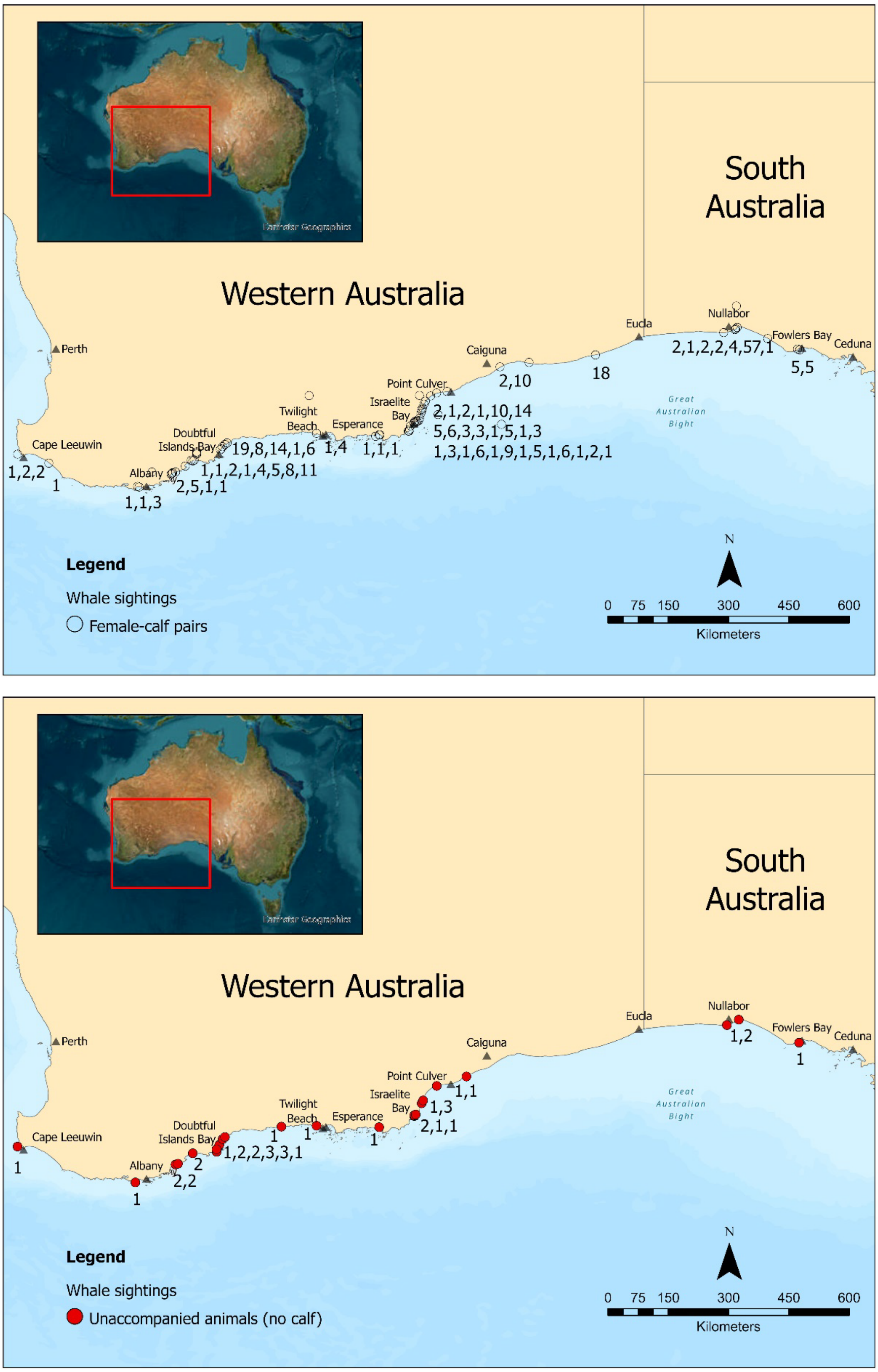


Figure 3. Map of the survey area covered during the 2025 annual aerial survey and sightings of a) female-calf pairs and b) unaccompanied Southern right whales.

The raw count data continues to demonstrate considerable inter-annual variation, with a simple approximation of the population size of the ‘western’ population based on incorporation of the 2025 counts and the applied conversion factor (see section 2.2), resulting in an estimated 2,466 whales (CI: 1,036, 3,897)(Figure 4).

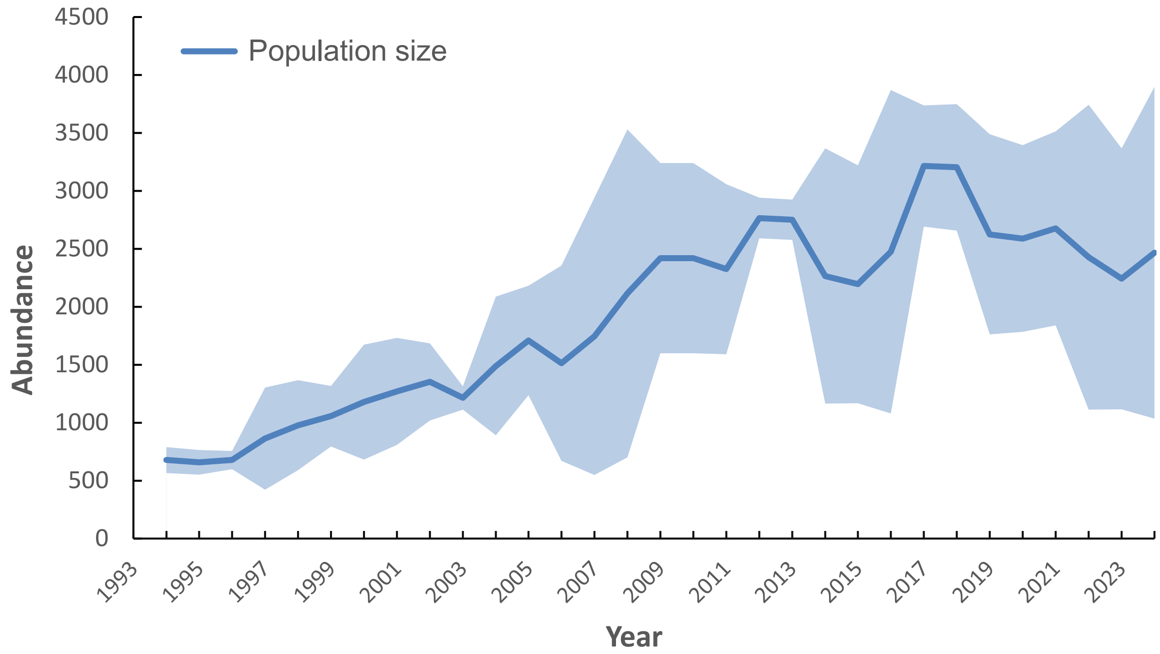


Figure 4. Population size (95% CI) and trend for the ‘western’ population of southern right whales based on the applied simple conversion factor to unmodelled count data.

A population estimate is also provided following the population estimate approach outlined in Grundlehner et al. (2025), which uses the mean estimated calf abundance (as modelled by the GAMM) instead of a rolling 3-year average of female-calf abundances. For a conservative estimate, a 3-year calving interval can be used and a 5-year interval for a more pragmatic estimate (Figure 5) as follows:

- Assuming a 3-year calf interval, we found an estimated population size of 2,665 individuals (CI: 1915–3414) individuals.
- Assuming a 4-year calf interval, we found an estimated population size of 3,553 individuals (CI: 2554–4552) individuals.
- Assuming a 5-year interval we get a more pragmatic population size estimate of 4,441 individuals (CI: 3193–5690).

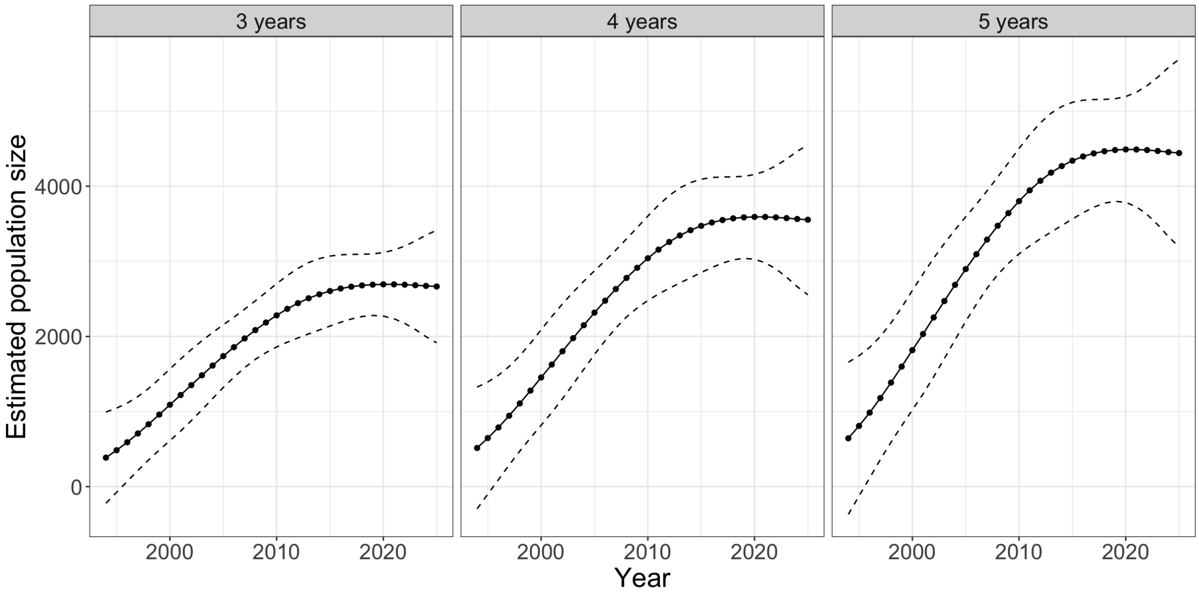


Figure 5. Visualization of estimated population sizes using interpolated female-calf pair abundances (displayed in Figure 6a), the IWC conversion factor and assumed calf intervals of 3 to 5-years. Dashed lines represent 95% confidence interval.

Population trend analyses show that despite the relatively high calf abundances observed in 2025 compared to previous years, there continues to be a stalling in calf abundance (Figure 6**Error! Reference source not found.**a). However, the 2025 abundances have slightly reduced the magnitude of the post-2016 declining trend in calf abundances reported in Grundlehner et al. (2025). The temporal trend still demonstrates that the 'peak' years in higher calf sightings do not sufficiently compensate for the years when there is lower calf abundance to support an overall increased trend in abundance. The temporal trend for the abundance of unaccompanied individuals demonstrate a more pronounced continued decline in abundance (Figure 6**Error! Reference source not found.**b). Since peak abundances in 2011, the mean modelled trend reveals a decline in abundance of 74% over the 14 years.

3.4 Development of AI tools for photo-ID data

The development and application of AI to SRWs in Australian waters involved refinement of existing open source AI algorithms (Piev2 and Miew-IDv3) to develop an automated workflow and tools to interface with ARWPIC. The work in 2025 is an extension to the tools developed in 2024 (Smith et al., 2025) and comprised functions within ARWPIC for 1) auto-creation of events and sightings and 2) an AI photo-ID matching interface. This work is being undertaken in conjunction to, and parallel with, initiatives for incorporation of AI for SRW photo-ID matching by the Southern Right Whale Research Consortium within the International Whaling Commission.

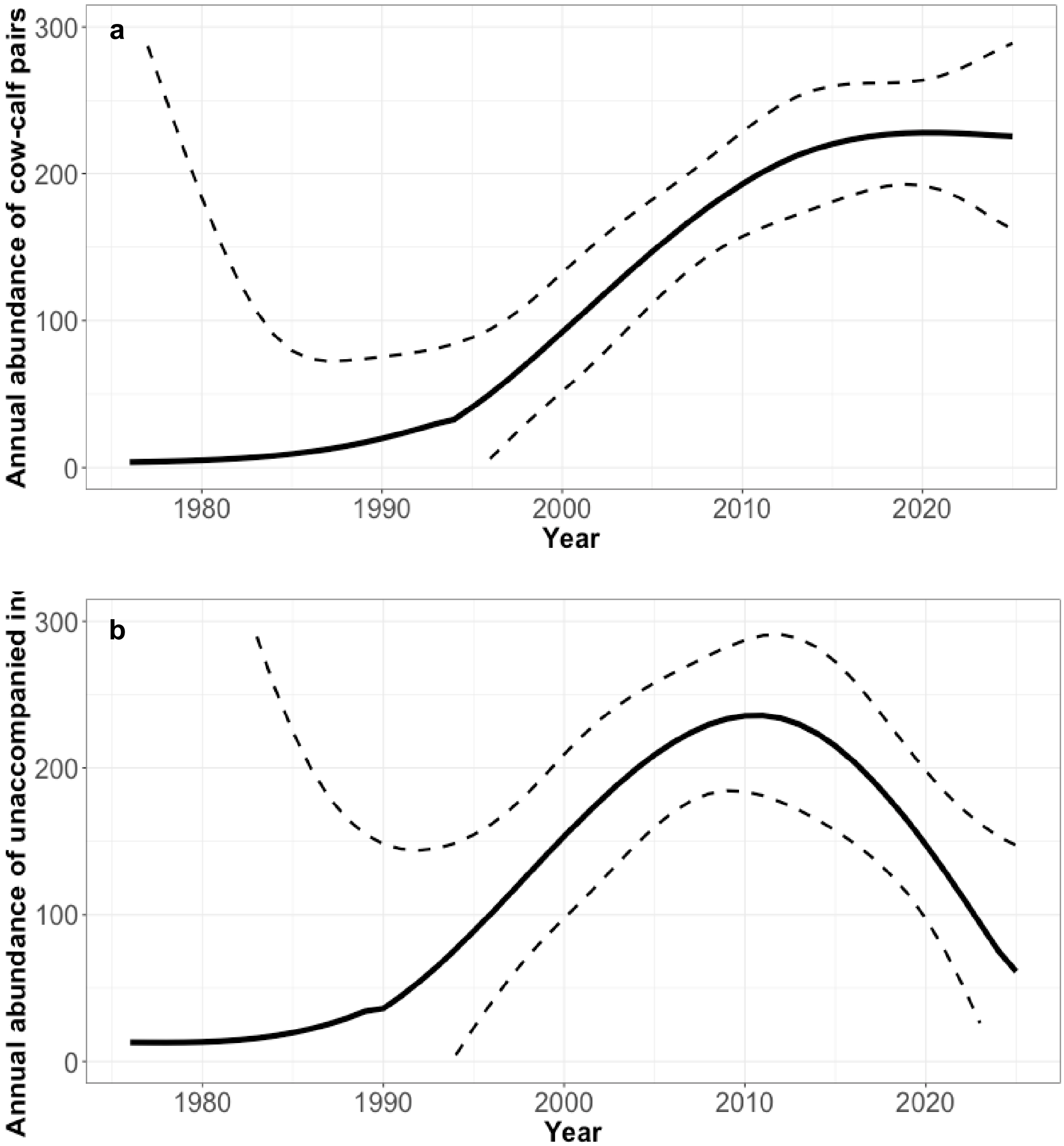


Figure 6. Interpolated trendline for annual abundances of a) female-calf pairs and b) unaccompanied individuals (solid line) and 95%-confidence interval (dashed line).

3.4.1 Auto-creation of events and sightings

The streamlined automated workflow within ARWPIC for processing imagery currently enables the bulk upload/import of photo-ID images, the detection of a whale's head within an image, and the systematic orientation of the head to facilitate matching. To extend the automated workflow, an auto-creation of *Events* and *Sightings* was developed using the imported imagery. An *Event* is defined as any occasion when photo-ID data are collected, whether through citizen science, opportunistic photographs, or dedicated surveys. Each *Event* is characterised by its date, time, location, and details of group composition. A Sighting refers to an individual whale or a mother–calf pair documented during that *Event*.

The process uses the timestamp metadata from imported images and groups the images into structured records of five-minute intervals to define *Events* and the PIEv2 algorithm then compared images within each Event to identify individual whales or female–calf pairs as *Sightings* (Figure 7). This functionality was tested using the annual aerial survey data from 2015 to 2025, comprising over 73,000 images. Of these, more than 52,000 were successfully processed through the AI pipeline, and over 50,000 were converted into *Events* and *Sightings*.

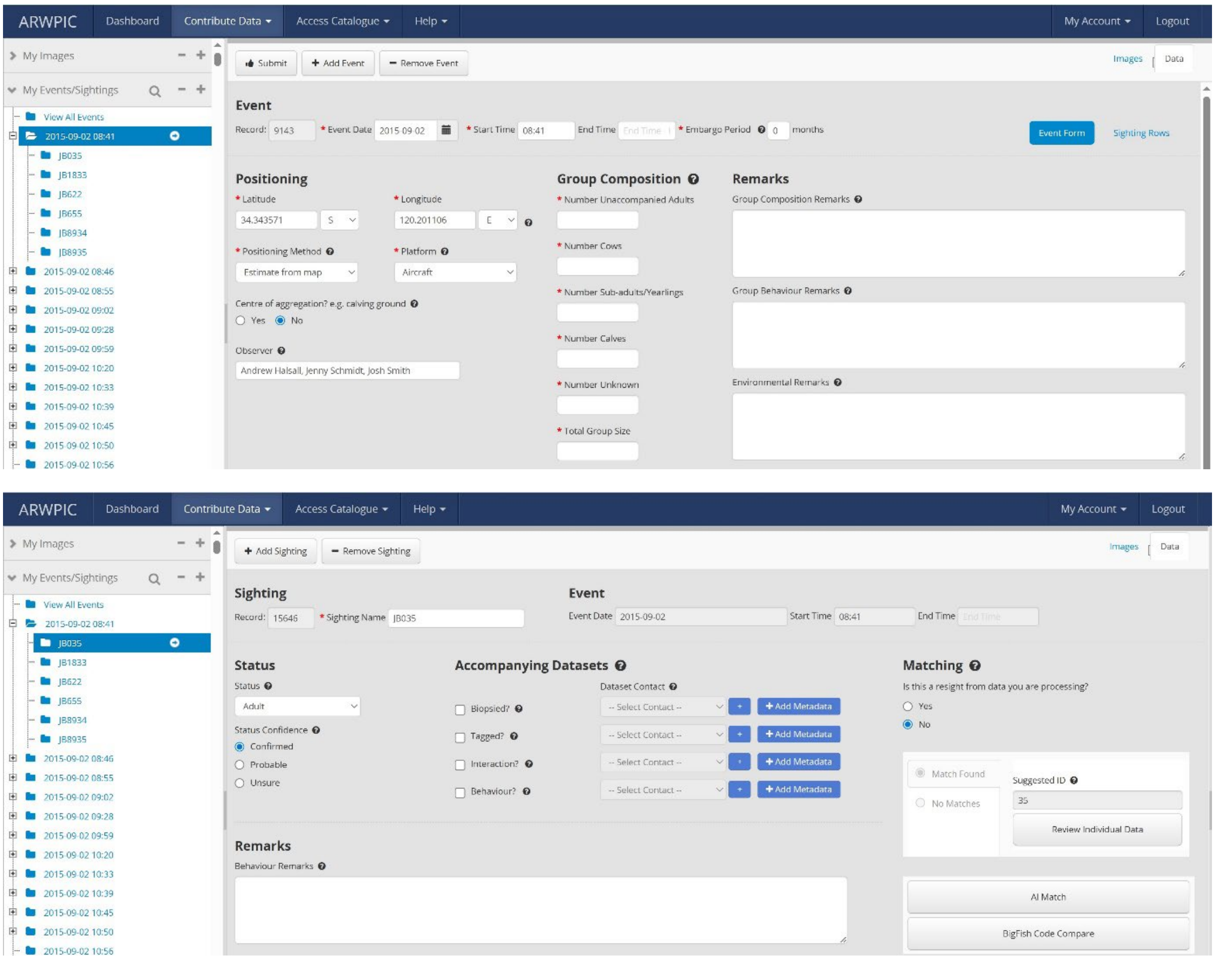


Figure 7. Screenshot of the output from the auto-creation process of *Events* (upper image) and *Sightings* (lower image) within ARWPIC.

3.4.2 AI photo-ID matching interface

A new matching screen has been added to ARWPIC to make the photo-ID matching process more user-friendly and incorporate the AI matching functionality. The interface is divided into three panels: the left shows the sighting images, the centre displays potential matches suggested by the AI, and the right provides detailed information and additional images of the selected whale. Once the ARWPIC Data Curator confirms a match, the sighting is linked to the catalogue record of that individual whale. This design was developed in consultation with ARWPIC users and is now fully implemented within ARWPIC (Figure 8).

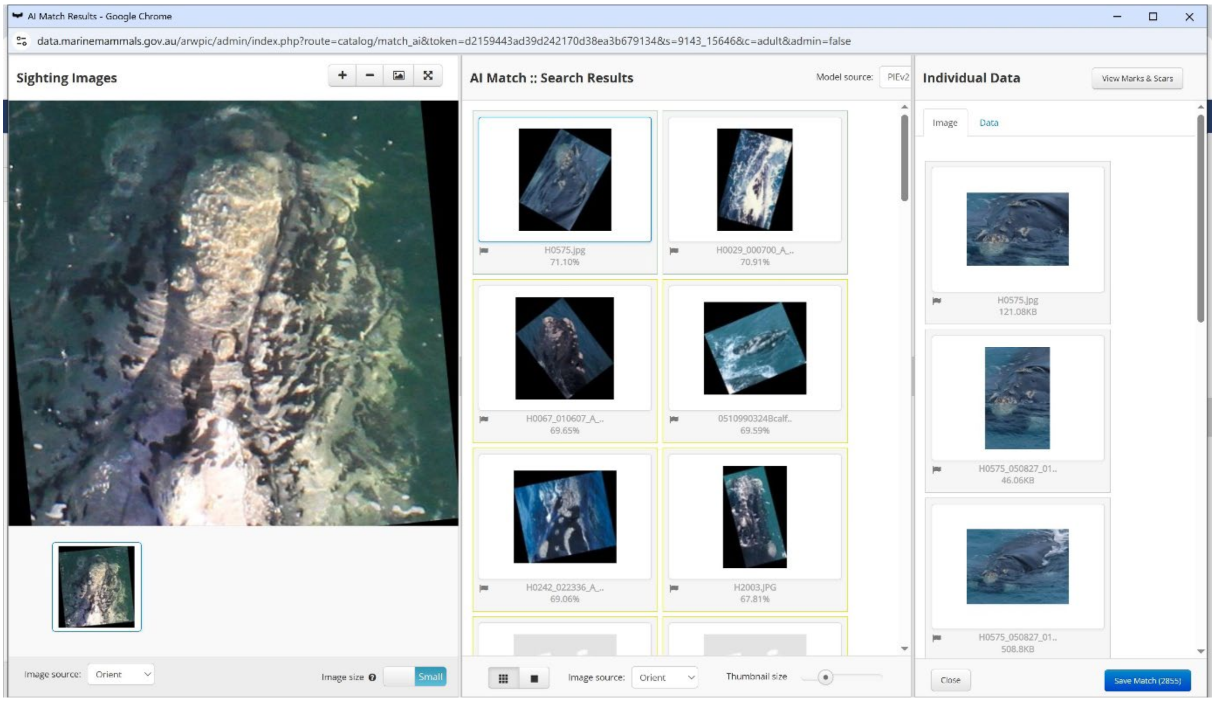


Figure 8. The AI match interface screen displaying the potential photo-ID matches from the AI matching functionality.

4. Discussion and conclusions

The total count from the 2025 aerial survey of 649 whales is comparable to the recent time series over the past 15 years (i.e. since 2010), with the exception of very low counts in 2020 and 2023 (Figure 4, Appendix B: Summary table of aerial survey count data). While the overall count remained relatively consistent, this was predominantly due to the highest counts of female-calf pairs (N=304) since 2017 (N=303). In contrast, this was the second lowest count for unaccompanied animals (N=38) in the history of the surveys since 1993, and comparable to 2022 (N=32), with substantially fewer sightings of unaccompanied animals in the past six years (Appendix B: Summary table of aerial survey count data). Since peak abundances of unaccompanied animals in 2011, the mean modelled trend reveals a decline in abundance of 74% over the past 14 years. Patterns in substantial declines in unaccompanied animals have also occurred in the South Africa population of SRWs, that occurred at a similar time of 2010 to that in Australia in 2011 (Grundlehner et al., 2025; Vermeulen et al., 2025). Population trend analyses for female-calf pairs show that following a period of exponential growth rates from 1976 to 2011 in Australia, recent trends since then demonstrate a stalling in calf abundance. With higher calf abundances in 2025 (Figure 4a) there is a reduced magnitude in declines in calf abundance, although the 'peak' years in higher calf sightings do not sufficiently compensate for the years when there is lower calf abundance to support an overall increased trend in abundance. Consequently, there continues to be a stalling in calf abundance and in the overall population growth rate (**Error! Reference source not found.**, Figure 4). Based on the simple population estimation approach using the IWC conversion factor, the population size of the 'western' population is an estimated 2,242 (CI; 1,036-3,897) whales using a 3-year rolling sum of calf abundances, or 2,665 whales (CI; 1,915–3,414) similarly assuming a 3-year calving interval but based on interpolated mean annual abundances from the trend analyses.

Analysis of the long-term aerial survey data by Grundlehner et al. (2025) revealed the population size is approximately 16-26% of pre-whaling abundance, annual births have started declining since 2016, and calving intervals have increased from an average 3 years to 4-5 years. This is also reflected in data from local studies at the large aggregation area at the Nullabor (Figure 3), as photo-ID data revealed an evident lengthening in calf intervals in females visiting the Head of Bight (Charlton et al., 2022; Charlton et al., 2026). Many of the trends evident in the aerial survey data for the western population of SRWs, such as strong initial population growth rates, recent declines in calf abundances and unaccompanied animals, and increased calving intervals have also demonstrated in other populations such as South America (e.g. Crespo et al., 2019) and South Africa (Vermeulen et al., 2025). Observed increases in calving intervals from 3 years to 4 and 5-years intervals and declines in reproductive success has been linked to declines in whale body condition (Vermeulen et al., 2025) and deterioration of body condition and reproductive success have been linked to environmental changes in SRW foraging areas (Vermeulen et al., 2025; Charlton et al., 2026). For example, SRW breeding success in the Argentina population, has been inversely correlated to sea surface temperature (SST) anomalies on foraging grounds and high sea surface temperatures related to El Niño events affecting conception rates and consequently pregnancy rates in the following year (Leaper et al. 2006). Thus, extreme climate events on the foraging and/or calving grounds could negatively influence the female breeding cycle and potentially explain a slowing in the rate of population increase in SRWs across the Southern

Hemisphere. However, many studies to date linking female reproductive success and environmental changes in foraging areas are correlational relationships. More direct empirical data is needed to demonstrate these linkages and better inform our understanding of population dynamics and the influences of environmental and climate change. Specifically, it remains unresolved (1) what causal mechanisms in environmental change are affecting SRWs, (2) whether the effects of environmental changes alone sufficiently explain observed population-level changes and (3) whether other drivers such as demographic factors, predation, anthropogenic impacts or post-whaling ecosystem scale changes are also involved (Grundlehner et al., 2025; Vermeulen et al., 2025; Charlton et al., 2026).

Population demographic data informs an understanding of population parameters, and enables modelling of population dynamics and consideration of influences of interest. Photo-ID data provides a fundamental source of information that can inform population dynamics, although processing and matching photo-ID images to an existing catalogue can be time-consuming and impede providing up to date population demographic data. AI tools have successfully been developed in this project during 2023/24 to automate image workflows (e.g. AI server infrastructure, bulk image import, head detection and orientation, preliminary algorithm training) into the national photo-ID repository (ARWPIC) and in 2025 functionality was extended to include the auto-creation of events and sightings data and an AI photo-ID matching interface. The development of the AI tools for improved data processing/matching capabilities of Australian SRW photo-ID data is a major advancement to current methods and is being undertaken in conjunction with and parallel to initiatives for incorporation of AI for SRW photo-ID matching across the Southern Hemisphere by the Southern Right Whale Research Consortium within the International Whaling Commission.

4.1 Implications for species conservation management

Given the eastern population is estimated at only 268 individuals (Stamation et al., 2020) and there is limited evidence of growth, the status of SRWs in Australian waters is largely based on trends in abundance and demographic data from the western population. Continued annual population aerial surveys to inform long-term population trend data from the western population will be the best approach to identifying changes in the population growth rate and is a *Very High* recovery action (B1.2) identified in the National Recovery Plan for the Southern Right Whale (DCCEEW, 2024). Annual surveys still represent the best frequency for detecting change over longer time scales given the high inter-annual variability, the limited understanding of the drivers causing the variation, and increasing calving intervals (i.e. 3-5 years) (Charlton et al., 2022; Derville et al., 2023; Grundlehner et al., 2025; Charlton et al., 2026).

Considerable inter-annual variation in whale numbers makes it difficult to detect consistent and reliable changes in abundance from one year to the next (and over longer periods), and inhibits our ability to understand cumulative impacts to the population from natural and anthropogenic threats. To evaluate the recovery of the SRW population, it will be critical to understand potential drivers in annual variability in whale numbers for both the eastern and western population, particularly as it relates to the female breeding cycle and variation in seasonal distribution and abundance of unaccompanied whales. This includes identifying possible influences from short-term climate dynamics, longer-term climate change, and/or potential impacts from increasing anthropogenic threats, as well as assessing genetic and demographic population stability. Given some threats operate over longer time scales (e.g., climate change), there should be a focus on managing threats that can be reduced in the short term (e.g., anthropogenic underwater noise, vessel strike, entanglement).

It is critical the SRW is afforded high levels of protection in Biologically Important Areas (e.g. reproduction and migration BIAs – see the Australian Marine Spatial Information System), with State government Marine Parks being extremely important for continued protection of SRWs in their coastal calving and nursing areas. In South Australia, there are three designated Whale Nursery Protection Areas under the *National Parks and Wildlife (Protected Animals) Marine Mammals Regulations 2025* (Fowlers Bay, Sleaford Bay, Encounter Bay) and in Western Australia the newly established South Coast Marine Park includes a whale conservation Special purpose zone that affords protection in key aggregation areas such as Bremer and Doubtful Island Bay and Israelite Bay. It is also critical that annual surveys are continued to assess the status of the species through long-term population trend data and data are used to inform federal and state conservation management actions and regulatory assessments of marine-based activities

References

Bannister, J. L. (2001). Status of southern right whales (*Eubalaena australis*) off Australia. *Journal of Cetacean Research and Management* (Special Issue 2), 103–110. https://doi.org/10.47536/jcrm.vi.273

Bannister, J. L., Bravington, M., Burnell, S. H., & Hedley, S. L. (2011). *Monitoring population dynamics of right whales off southern Australia*. Final Report to the Australian Marine Mammal Centre.

Bannister, J. L., Hammond, P. S., & Double, M. C. (2016). *Population trend in right whales off southern Australia 1993–2015*. Paper SC/66b/BRG/09 presented to the IWC Scientific Committee.

Bogucki, R., Cygan, M., Khan, C. B., Klimek, M., Milczek, J. K., & Mucha, M. (2019). Applying deep learning to right whale photo identification. *Conservation Biology*, *33*(3), 676-684. https://doi.org/10.1111/cobi.13226

Carroll, E. L., Baker, C. S., Watson, M., Alderman, R., Bannister, J., Gaggiotti, O. E., Grocke, D. R., Patenaude, N., & Harcourt, R. (2015). Cultural traditions across a migratory network shape the genetic structure of southern right whales around Australia and New Zealand. *Scientific Reports*, *5*. https://doi.org/10.1038/srep16182

Charlton, C., Germishuizen, M., O'Shannessy, B., McCauley, R., Vermeulen, E., Seyboth, E., Brownell, R. L., & Burnell, S. (2026). Climate-driven reproductive decline in Southern right whales. *Scientific Reports*, *16*(1), 5352. https://doi.org/10.1038/s41598-026-36897-1

Charlton, C., McCauley, R. D., Brownell Jr, R. L., Ward, R., Bannister, J. L., Salgado Kent, C., & Burnell, S. (2022). Southern right whale (*Eubalaena australis*) population demographics at major calving ground Head of Bight, South Australia, 1991–2016. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *32*(4), 671-686. https://doi.org/10.1002/aqc.3771

Chittleborough, R. G. (1956). Southern Right Whale in Australian Waters. *Journal of Mammalogy*, *37*(3), 456–457. https://doi.org/https://doi.org/10.2307/1376772

Crespo, E. A., Pedraza, S. N., Dans, S. L., Svendsen, G. M., Degrati, M., & Coscarella, M. A. (2019). The southwestern Atlantic southern right whale, *Eubalaena australis*, population is growing but at a decelerated rate. *Marine Mammal Science*, *35*(1), 93-107. https://doi.org/https://doi.org/10.1111/mms.12526

DCCEEW. (2024). *National Recovery Plan for the Southern Right Whale (Eubalaena australis)*.

Derville, S., Torres, L. G., Newsome, S. D., Somes, C. J., Valenzuela, L. O., Vander Zanden, H. B., Baker, C. S., Bérubé, M., Busquets-Vass, G., Carlyon, K., Childerhouse, S. J., Constantine, R., Dunshea, G., Flores, P. A. C., Goldsworthy, S. D., Graham, B., Groch, K., Gröcke, D. R., Harcourt, R.,…Carroll, E. L. (2023). Long-term stability in the circumpolar foraging range of a Southern Ocean predator between the eras of whaling and rapid climate change. *Proceedings of the National Academy of Sciences*, *120*(10), e2214035120. https://doi.org/10.1073/pnas.2214035120

Grundlehner, A., Smith, J. N., Bannister, J. L., Andrews-Goff, V., Brasier, M., Double, M. C., & Corney, S. P. (2025). The End of an Era? Trends in Abundance and Reproduction of Australian Southern Right Whales () Suggest Failure to Re-Establish Pre-Whaling Population Size. *Global Change Biology*, *31*(5), e70218. https://doi.org/10.1111/gcb.70218

IWC. (2013). Report of the IWC workshop on the assessment of Southern Right Whales. *Journal of Cetacean Research Management*, *Supplement 14*. https://doi.org/https://archive.iwc.int/pages/home.php

IWC. (2001). *Report of the Workshop on the Comprehensive Assessment of Right Whales: A Worldwide Comparison*. J. Cetacean Res. Manage. https://journal.iwc.int/index.php/jcrm/article/view/270

Jackson, J. A., Patenaude, N. J., Carroll, E. L., & Baker, C. S. (2008). How few whales were there after whaling? Inference from contemporary mtDNA diversity. *Molecular Ecology*, *17*(1), 236-251. https://doi.org/10.1111/j.1365-294X.2007.03497.x

Lindgren, F., & Rue, H. (2015). Bayesian Spatial Modelling with R-INLA. *Journal of Statistical Software*, *63*(19), 1 - 25. https://doi.org/10.18637/jss.v063.i19

Smith, J. N., Allen, S., Jenner, C., Jenner, M., Bateman, J., Klein, T., Passeck, N.-j., Sprogis, K., Double, M., Franklin, W., Franklin, T., Stack, S., Watson, M., & Charlton, C. (2026). *Spatial (re)occupation of southern right whales in low latitudes of Australia* [Unpublished manuscript - in preparation].

Smith, J. N., Double, M., & Kelly, N. (2024). *Relative abundance of the 'western' population of southern right whales (Eubalaena australis) from an aerial survey off southern Australia: Final Report on 2023 survey*. Report to the National Environmental Science Program. Murdoch University. https://www.nespmarinecoastal.edu.au/wp-content/uploads/2024/10/Project-3.15-Aerial-survey-of-SRW-Final-Report-2023v2.pdf

Smith, J. N., Double, M., & Townsend, A. (2025). *Aerial survey of the Australian southern right whale (Eubalaena australis) 'western' population and development of AI for photo-identification*. Report to the National Environmental Science Program. Murdoch University. https://www.nespmarinecoastal.edu.au/wp-content/uploads/2025/08/Project-3.15_SRW-aerial-survey-2024_final2.pdf

Stamation, K., Watson, M., Moloney, P., Charlton, C., & Bannister, J. (2020). Population estimate and rate of increase of southern right whales Eubalaena australis in southeastern Australia. *Endangered Species Research*, *41*, 373-383. https://doi.org/https://doi.org/10.3354/esr01031

Vermeulen, E., Wilkinson, C., Best, P. B., & Findlay, K. (2025). Four decades of annual monitoring reveal declining reproductive success of a migratory baleen whale. *Sci Rep*, *15*(1), 34713. https://doi.org/10.1038/s41598-025-18252-y

Zuur, A. F. (2012). A beginner's guide to generalized additive models with R.

Zuur, A. F., Ieno, E. N., & Saveliev, A. A. (2017). *Beginner's guide to spatial, temporal,and spatial-temporal ecological data analysis with R-INLA. Volume I, Using GLM and GLMM / Alain F Zuur, Elena N Ieno, Anatoly A Saveliev*. Highland Statistics.

Appendix A: Southern right whale aerial survey summary data

Flight	Date	Leg	Leg / flights	Whale sightings							Weather[1]	Flying hrs
				Right whales				Other large whales[2]				
				A[3]	C	Y	T	A	CC	T		
Additional leg	15-08-25		1&2 Perth-Augusta-Albany *	10	8	0	18	20	0	20	270 / 10	4.3
Outward legs Albany to Ceduna	16-08-25	1	3&4 Albany-Ravensthorpe-Esperance *	118	98	1	217	6	0	6	070 / 10	4.7
	17-08-25	2	6&7 Esperance-Israelite Bay-Caiguna *	109	98	0	207	2	0	2	330 / 15	4.8
	18-08-25	3	8&9 Caiguna-Nullarbor (excl HoB)	22	19	0	41	2	0	2	0 / 10	4.3
	18-08-25	4	10 Nullarbor-Ceduna * (incl HoB) *	80	77	0	157	0	0	0	0 / 10	2.8
Total Outward			**1-10 Perth-Albany-Ceduna**	**339**	**300**	**1**	**640**	**30**	**0**	**30**		**20.8**
Inward legs Ceduna to Albany	19-08-25	4	11 Ceduna-Nullarbor (incl HoB)	75	72	0	147	1	0	1	350 / 20	2.9
	19-08-25	3	12&13 Nullarbor-Caiguna (excl HoB) *	24	23	0	47	0	0	0	315 / 25	3.7
	DNS	2	14&15 Caiguna-Esperance	-	-	-	-	-	-	-		-
	22-08-25	1	16 Esperance-Albany	104	92	0	196	0	0	0	310 / 10	3.6
Total Inward			**11-16 Ceduna-Albany**	**203**	**187**	**0**	**390**	**1**	0	**1**		**15.2**
Total	**6 days**		**16 flights**	**542**	**487**	**1**	**1030**	**31**	**0**	**31**		**35.9**

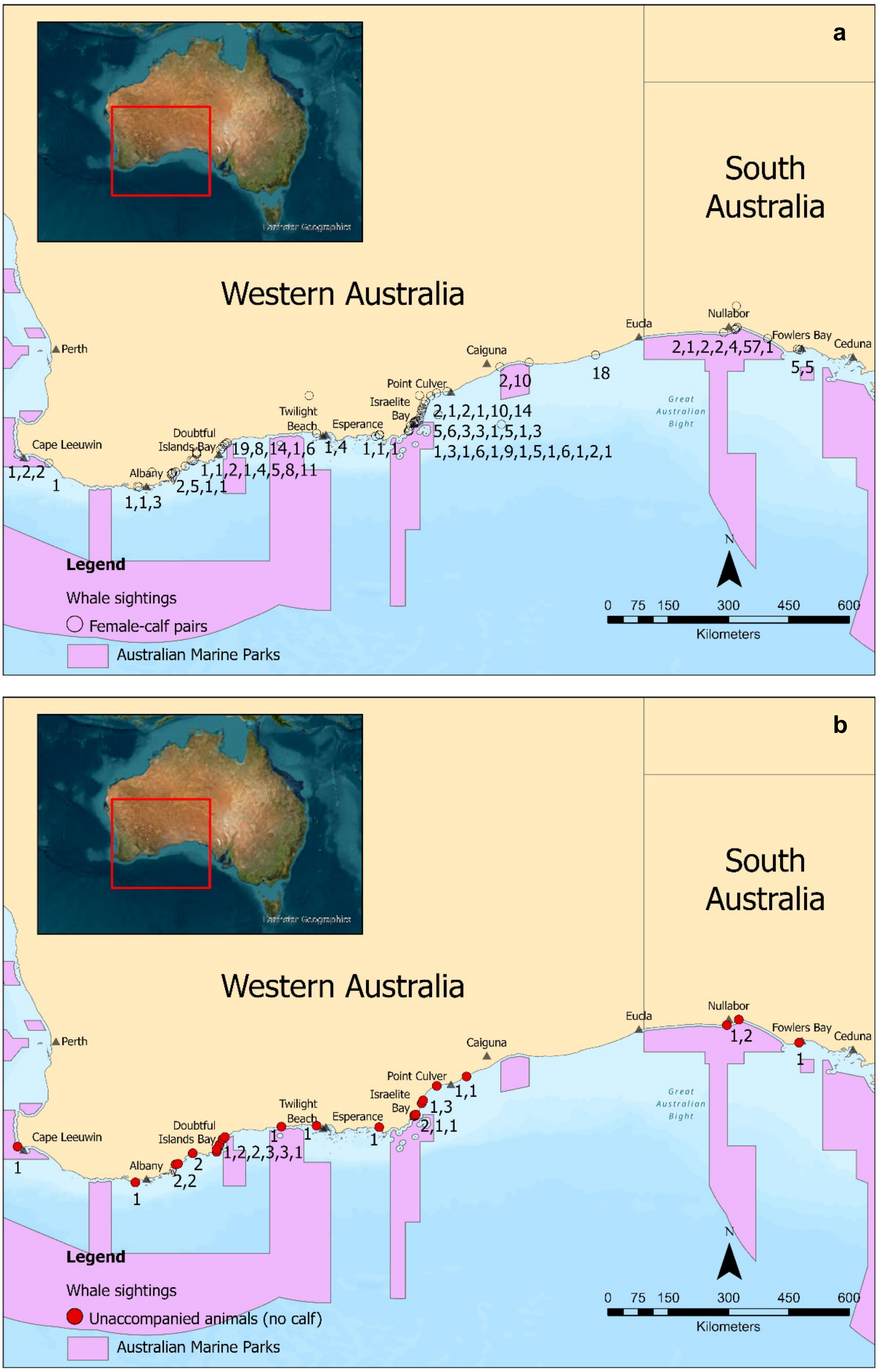
[1] direction of wind/wind speed (knots)
[2] all humpback whales; no other large whales recorded
[3] A = adult, C = calf, Y = 'yearling', T = total, CC = cow/calf pair
[*] survey legs with maximum numbers of whales used for mapping and calculating trend (i.e. in Table 2)
DNS = Did Not Survey

Appendix B: Summary table of aerial survey count data

Total comparable maximum counts of southern right whales from annual aerial surveys undertaken between Cape Leeuwin (WA) and Ceduna (SA) since 1993.

Year	All animals	Unaccompanied animals	Cow/calf pairs
1993	167	47	60
1994	191	95	48
1995	267	139	64
1996	233	123	55
1997	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
2014	623	159	232
2015	462	268	97
2016	628	172	228
2017	847	241	303
2018	821	251	285
2019	600	150	225
2020	384	72	156
2021	666	114	276
2022	526	32	247
2023	349	154	93
2024	576	108	229
2025	646	38	304

Appendix C: Sightings maps and Australian Marine Parks



Appendix C. Map of sightings of **a)** female-calf pairs and b) unaccompanied southern right whales.

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