

# Southern right whale residency, site fidelity and date of calving off southern Australia (1991–2021)

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## ABSTRACT

Southern right whale (*Eubalaena australis*) residency, site fidelity and date of calving were assessed using three decades (1991–2021) of shore-based photo-identification data collected at the Head of Bight (HOB) in the Great Australian Bight, South Australia. Females with calves exhibited prolonged seasonal residency up to 3.5 months, while unaccompanied adults were more transient. Over time, mean within-year residency declined significantly for both groups: from 71 to 53 days for females with calves, and from 20 to 14 days for unaccompanied adults. Site fidelity also declined: 57.6% of reproductive females (n = 554) returned to HOB across years, compared with 92% reported in the early 1990s (n = 61). Calving site fidelity was observed in 76.5% of known females. Some females were observed with a calf at HOB up to 13 times (mean = 2.16 calves, SD = 1.81). The mean calving date remained consistent over three decades (24 July, SD = 14.6). The HOB dataset also includes the only documented cases of natal site fidelity in Australia (n = 24), with resighting probability of calves increasing markedly after six years, supporting delayed return until sexual maturity. Whales not accompanied by a calf account for 20% of sightings, and a third of known reproductive females were recorded during non-calving years. These findings underscore the importance of coastal winter aggregation areas for reproduction and migration, supporting policy and legislative efforts to protect threatened species through marine protected areas (MPAs), in line with national recovery targets and the global goal for the conservation of natural ecosystems.

**KEYWORDS:** SOUTHERN RIGHT WHALE; PHOTO-IDENTIFICATION; REPRODUCTION; BREEDING GROUNDS; MOVEMENTS; SOUTHERN HEMISPHERE; CONSERVATION; MANAGEMENT; MONITORING; TRENDS; SITE FIDELITY

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## INTRODUCTION

Southern right whales (SRWs; *Eubalaena australis*) migrate to the Southern Hemisphere aggregation areas between the Austral winter and early spring to calve, nurse their young, mate and rest. They have a circumpolar distribution generally between 25°S and 65°S. SRWs were heavily exploited between the 1820s and 1900 with over 15,000 captured (Dawbin, 1986). They have been protected from commercial whaling in Australia since 1935, although signs of population increase were delayed until the early 1970s after illegal pelagic catches by the Soviet Union ended (Tormosov *et al.*, 1998). Reports of SRWs returning to the Australian coastline were recorded between the late 1950s and 1970s (Chittleborough, 1956; Bannister, 1994).

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SRWs are listed as 'Least Concern' under the IUCN Red List and 'Endangered' under the Australian Environment Protection and Biodiversity Conservation Act 1999 (ECPB Act). Two SRW populations are recognised off the Australian coast, a western and eastern population, based on mitochondrial DNA differences (Carroll *et al.*, 2011; Carroll *et al.*, 2015), historic whaling pressures and varying rates of population increase (Stamation *et al.*, 2020; Smith *et al.*, 2024). The western population (generally occupying Western Australia [WA] and South Australia [SA]) was estimated at 2,439 in 2023 and increasing around 4.5% p.a. (Smith *et al.*, 2024), which is below the biological maximum for the species of 7% (IWC, 2013). Despite previous periods of exponential growth, annual births have shown a decline since 2016, alongside reductions in the annual abundance of unaccompanied individuals, indicating a potential slowing and moderation of population recovery for the western population (Grundlehner *et al.*, 2025). In contrast, the eastern population (generally occupying Victoria, New South Wales, Tasmania and Queensland) was estimated at 268 individuals in 2017 and was not displaying signs of increase for female and calf pairs (Stamation *et al.*, 2020). The primary geographical distribution of SRW Biologically Important Areas (BIAs) for reproduction extends from Albany in WA to Warrnambool in Victoria, with infrequent sightings reported as far north as Exmouth in WA and Moreton Bay in Queensland, Eastern Australia (Department of Climate Change, Energy, the Environment and Water [DCCEEW], 2024).

Female SRWs exhibit fidelity to calving and nursing grounds (Best & Scott, 1993; Burnell, 2001; Rowntree *et al.*, 2001; Crespo *et al.*, 2017). Long-term photo-identification (photo-ID) studies show that many females return to the same areas to calve over several decades (Best *et al.*, 2001; Burnell, 2001; Bannister *et al.*, 2011; Charlton, 2017). Early SRW sightings in Australia were restricted to areas where the largest remnant populations existed post-commercial whaling (Bannister, 2001; Burnell, 2001). Conspecific attraction and historic whaling effort combined with philopatry and habitat suitability appear to have been the main drivers of SRW calving ground occupation (Payne, 1986; Best *et al.*, 2001; Burnell, 2001; Rowntree *et al.*, 2001; Pirzl, 2008). While site fidelity of SRWs to calving grounds has been typically high, there is evidence that SRWs can shift selected calving habitat and display flexibility in their philopatric behaviour (Best *et al.*, 1993; Groch *et al.*, 2005; Carroll *et al.*, 2014; Charlton, 2017; Watson *et al.*, 2021). The winter habitat range of the western population of SRWs has dispersed into small and emerging aggregation areas with increased abundance in south-western Australia in recent years (Bannister, 2017; Charlton *et al.*, 2019a; Kemper *et al.*, 2022; Salgado Kent *et al.*, 2022; DCCEEW, 2024). Habitat occupancy has expanded in recent years due to density pressures at major aggregation areas, causing whales to recolonise historically important areas (O'Shannessy *et al.*, 2025). Movement of calving and non-calving adults has been recorded across broad distances within and across seasons (Pirzl *et al.*, 2009; Roux *et al.*, 2015; Charlton, 2017; Watson *et al.*, 2021).

Coastal aggregation areas on the southern coast are occupied by SRWs between May and October with peak numbers recorded in August (Burnell, 2001; Charlton *et al.*, 2019b). Residency and site fidelity of western Australian SRWs were previously reported for 1991–1995 (Burnell & Bryden, 1997; Burnell, 2001). Since 1991, shore-based research at the HOB in South Australia – one of Australia's key BIAs for reproduction – has provided long-term data on SRW population biology and dynamics (Burnell, 2001; Charlton *et al.*, 2019a, b; 2022; O'Shannessy *et al.*, 2023, 2025). The 29-year photo-ID dataset (1992–2021) offers continuous sighting histories of known individuals, including those photographed at birth, enabling assessments of natal site fidelity.

With increasing population size, expanding habitat use, evidence of variable recovery in south-western Australia (Grundlehner *et al.*, 2025; O'Shannessy *et al.*, 2025), updated analyses of residency and site fidelity are needed to inform management of this threatened species. Aligned with recovery objectives in the National Recovery Plan for the Southern Right Whale (DCCEEW, 2024), this study uses long-term mark-recapture data from HOB to assess residency patterns, site and natal site fidelity, and calving dates. We hypothesise a decline in site fidelity among calving females and unaccompanied adults compared with the early 1990s to reflect increasing coastal dispersal with population recovery.

## MATERIALS & METHODS

### Study site

HOB is located within the GAB in the far west of SA (31°29'S, 131°08'E, Fig. 1) approximately 270 km west of Ceduna and 210 km east of the WA border (using shortest swim distance). The study is completed on the Yalata

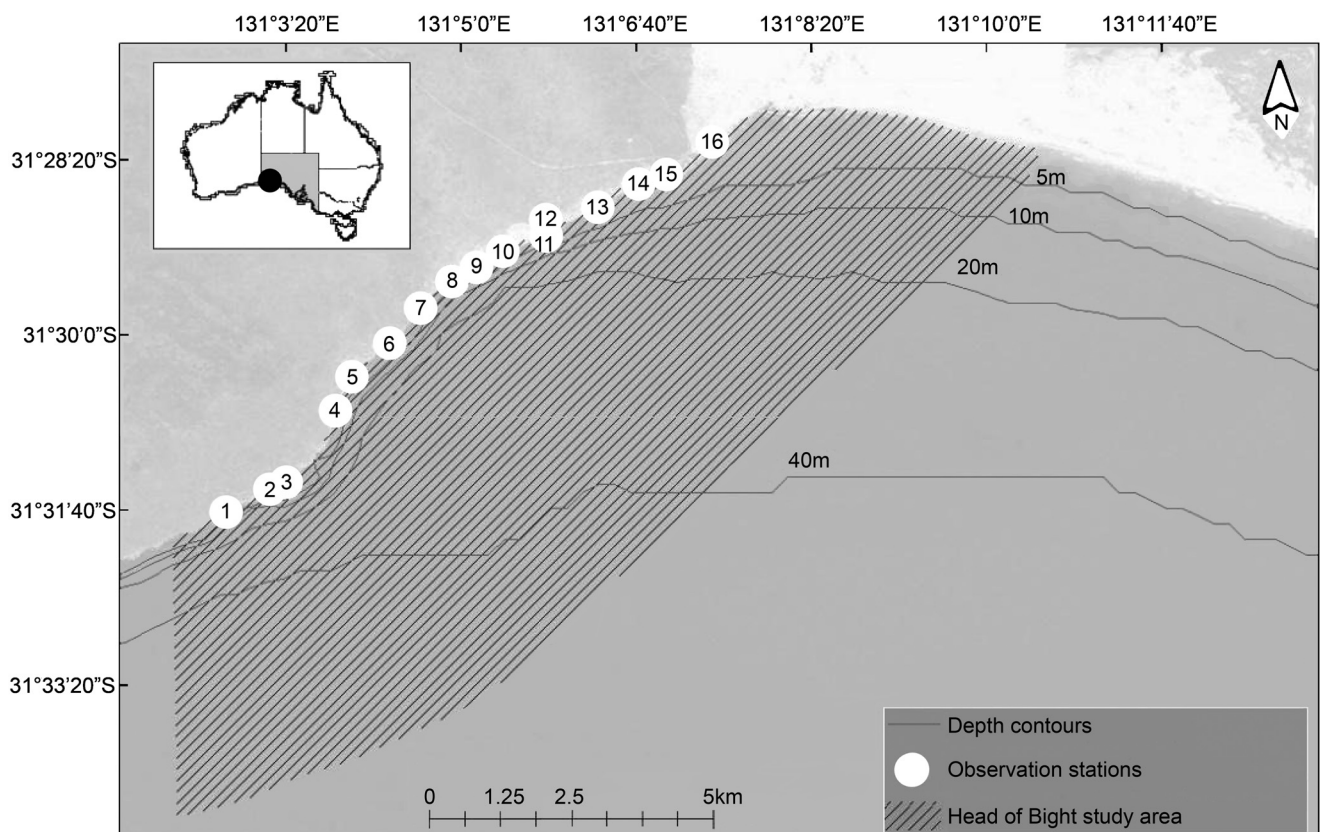


Figure 1. Boundaries of the study site and location of observation stations for Southern Right Whales at Head of Bight in the central Great Australian Bight, South Australia.

Anangu Community's land and on the land and sea country of the Far West Coast Aboriginal Peoples along the Bunda Cliffs of the Nullarbor Plain. The HOB aggregation area is within the Marine Mammal Protection Zone of the GAB Marine Park (GABMP) (Commonwealth Waters) and the Far West Coast Marine Park. The Marine Park Whale Sanctuary was established in 1995 to protect the wintering SRW aggregation at HOB. The study site is selected to include the primary aggregation area and extends approximately 15 km along the coast and 8 km offshore (Fig. 1). Observations and photography were collected from the clifftop vantage points 33–53 m in elevation.

## Data collection

### Study period

Field surveys were completed at HOB annually between June and October since 1991. Study effort varied among years (Table 1). For interannual comparison of maximum daily counts during the peak season, annual surveys were completed between mid-to-late August. Opportunistic photo-ID data were collected annually at HOB during 1991–2021 (30 years), providing life history data on known individuals. While survey effort varied among years, data were consistently collected during the peak abundance period in mid-to-late August (Table 1). For 12 years (1991–1997, 2014–2019 and 2021), extended surveys were completed between June and October (Table 1), providing data for the assessment of residency at the site and date of calving. At the time of analysis, 28 years of data (1991–2019) were processed and available for assessment of site fidelity, and 12 years of data were available for the assessment of residency and data of calving.

### Photo identification

The study methods are consistent with the long-term shore-based photo-ID study, completed annually at HOB since 1991 (Burnell & Bryden, 1997; Burnell, 2001; Charlton *et al.*, 2019b; O'Shannessy *et al.*, 2023).

Photo-ID of SRWs is achieved through photographing the callosity patterns on the rostrum of individual whales and resighting individuals over time. Callosity patterns are keratinised skin patches colonised by cyamids that

form on the dorsal surface of the rostrum, the lip line of the lower jaw and posterior to the blowhole on SRWs (Payne *et al.*, 1983). Callosities provide individually unique markings on SRWs that persist throughout life (Payne *et al.*, 1983). To record callosity patterns and other unique identifying marks, high-resolution telephoto images are taken from the clifftop vantage points at HOB. A Nikon 7100 or D100 digital SLR camera with a Nikon 500 mm (effective 750 mm) or Sigma 500 mm lens mounted on a Manfrotto tripod was used.

Dorsal and ventral photographs were obtained wherever possible. Aerial, left and right lateral perspectives of callosity patterns, as well as the size and shape of ventral pigmentation (also persistent and unique), and the ano-genital configuration (sex), were documented with opportunistic photographs. Markings and any scarring were likewise photographed. Photography was concentrated primarily on adults as callosity patterns are well developed. Photo-ID effort for calves was increased later in the season, as they were generally too young to distinguish unique callosity patterns for future identification early in the season.

Digital photo-ID images were sorted daily in the field, including within-season cross-matching of individuals to document the total number of individuals identified in that year. Individuals were then matched against the long-term catalogue (Big Fish v6 Microsoft Access), including all calves photographed in previous years to document previously sighted and newly sighted whales.

Photo-ID images were contributed by John Bannister of the Western Australian Museum (WAM) and Josh Smith of Murdoch University from annual aerial surveys completed at HOB (2014–2022). The long-term HOB photo-ID catalogue includes sighting histories from matches completed with the WAM catalogue 1993–2007 and reproductive females to 2012 (Burnell, 2008; Charlton *et al.*, 2022). The methodology for collection of images during annual aerial surveys are outlined in Bannister (2017) and summarised in Charlton *et al.* (2019b). Individual sighting records from aerial survey photo-ID images contribute to the assessment of site fidelity and residency. Because of the three-to-four-month duration of the study period between 2014 and 2019, the aerial survey data from the single survey contributed single resights of individuals that were sighted many times throughout the season. Therefore, the observer bias introduced by including aerial survey images is obsolete.

Aerial images of SRWs at the HOB during 2016–2021 (excluding 2020 due to COVID-19 restrictions), recorded using Unmanned Aerial Vehicles (UAVs), were contributed by Murdoch University to the assessment of residency. Methods for data collection using UAVs are outlined in Christiansen *et al.* (2018).

## Data analysis

### Residency

Intra-seasonal residency of females with calves and unaccompanied adults were assessed using photo-ID resights collected between June and September 2014–2021 and compared with earlier published data collected between June and October 1992–1994 (Burnell & Bryden, 1997). A short field season (less than six weeks) was completed in 2020 and therefore was not included in residency analysis. Residency was assessed for individuals sighted at least twice. The date of first and last sighting was considered the period of residence. The assessment of residency was limited by the survey duration and therefore residency is considered a minimum duration that SRWs occupy the site. Females with calves that arrived at HOB after 1 September were excluded from residency estimates because this is after the peak abundance period and maximum date of calving. It was therefore assumed that those females were transiting through the site and not selecting calving habitat.

It is recognised that the introduction of UAV technology in 2016 increased the effort for collecting resight data. The challenge in collecting the resight data for all individuals also increased with time given that whale abundance at the site increased from around 20 females with calves in the early 1990s to over 100 females with calves in the 2010s and 2020s. Observer bias was not assessed or tested statistically, although the close proximity to the base of the cliff observation points and the whales' slow movements greatly reduced the chance of missed sightings. A one-way Analysis of Variance (ANOVA) was performed in XLSTAT statistical software 2023.1.3 to compare the effect of years on mean residency.

### Site fidelity

Site fidelity was assessed for the calving female population using 28 years (1991–2019) of interannual resights from photo-ID data collected through dedicated annual surveys. Opportunistically collected photo-ID records prior

to 1991 were also included in the analysis. An individual was considered to display a degree of fidelity to HOB if it was sighted at least twice at the site in different years, either with or without a calf. The calving site fidelity of females with a calf was assessed based on the number of sightings of a female with a calf in different years.

The site fidelity of SRWs seen only once at HOB and not sighted elsewhere was deemed indeterminable (Burnell, 2001). This study assessed only sighting histories recorded at HOB and does not consider other sightings of the same individuals in other areas in Australia.

### *Natal site fidelity*

Calves identified in their year of birth at HOB that were later sighted with a calf of their own were considered to show natal site fidelity. The mean number of calves for each individual with natal site fidelity was assessed. The probability of sighting the calves at HOB prior and post maturity was assessed by plotting the total number of calves identified against the number of calves resighted prior to the mean age of first parturition of nine years (Charlton *et al.*, 2022). Unique callosity patterns develop in calves at around 2–3 months. Only calves that had developed callosity patterns were inserted into the master photo-ID catalogue as known-aged individuals and were therefore available for analysis.

### *Date of calving*

The date of calving was estimated using data from seven seasons from 2014–2021 (excluding 2020) when data were collected between mid-June and the end of September and resight information on pregnant females was available. A female was determined pregnant if she was sighted as an unaccompanied adult and later that season sighted with a calf. The mean date of calving was estimated using the average between the last day an individual was sighted as a pregnant female (or unaccompanied adult) and the first date sighted with a calf. There is a bias considering that the exact date of calving is unknown. By selecting the mean date between sightings, the adult without calf (underestimate) and with calf (overestimate) is used to counteract the bias. No observer bias was applied to account for the likelihood that calves were sighted after their date of birth. These data build on the assessment of date of calving completed by Burnell & Bryden (1997) using data from 1993–1994.

## **RESULTS**

### **Residency**

#### *Photo-identification success*

Survey effort varied among years (1992–2021). During 1992–1994 and 2014–2021 (excluding 2020 due to COVID-19 restrictions), extended field seasons were undertaken at HOB and allowed for the assessment of seasonal residency. During 1992–1994, surveys were completed on average for 114 days, and, during 2014–2021, surveys were completed on average for 100 days (Table 1). The mean number of photo-ID sightings recorded per year between 2014 and 2021 for female and calf pairs was 683 (SD = 348.6, range = 239–1,328) and for unaccompanied adults was 146 (SD = 48.3, range = 90–212). Interannual variation in maximum abundance of SRWs at HOB and in number of individuals photo identified in the study site was also observed between 2014 and 2021 (Table 1).

Photo-ID success was high and exceeded 100% when the number of individuals photo identified was compared with the maximum daily count of the year for both female and calf pairs and unaccompanied adults. The total number of unique females accompanied by a calf that were photo identified between 2014 and 2021 ( $n = 626$ ) exceeded the maximum daily counts ( $n = 475$ ) by a third (Table 1), indicating substantial movement of individuals into and out of the site during the survey period. For unaccompanied adults, the total number of individuals photo identified between 2014 and 2021 ( $n = 588$ ) exceeded the maximum daily counts ( $n = 185$ ) by over three times (Table 1), supporting the transient nature of unaccompanied adults across coastal areas during wintering months.

#### *Residency periods*

Residency periods were available for 473 females with calves and 185 unaccompanied adults that were sighted at least twice in a season (2014–2021). The mean number of photo-ID resights of individual whales between

Table 1

Southern right whale study periods at Head of Bight, South Australia, 1992–94 (Burnell & Bryden, 1997) and 2014–21, mean residency periods for calving females and unaccompanied adults, maximum daily counts per year and photo identification achieved, and mean number of resights. The data include a combination of two methods with the introduction of Unmanned Aerial Vehicles for collection of photo-ID data post 2016.

Year	Start–Finish dates and study period (days)	Mean days within aggregation area and range		Maximum daily count, (no. of individuals photo identified) and photo ID achieved (%)		Mean resights per individual (range)	
		Calving females	Unaccompanied adults	Calving females	Unaccompanied adults	Calving females	Unaccompanied adults
1992	25 Jun–10 Oct: 108	72	18	18 (17) 94%	7 (18) 257%	NA	NA
1993	18 Jun–13 Oct: 118	75	20	26 (26) 100%	21 (41) 195%	NA	NA
1994	19 Jun–12 Oct: 116	66	21	23 (24) 104%	24 (74) 308%	NA	NA
Mean 1992–94	<b>114 days</b>	<b>70.9 (2–118)</b>	<b>20.4 (2–93)</b>	<b>22 (67) 100%</b>	<b>17 (133) 256%</b>	NA	NA
2014	19 Jun–28 Sep: 102	29 (2–73)	15 (2–52)	60 (87) 145%	17 (47) 276%	3 (1–10)	2 (1–6)
2015	18 Jun–25 Sep: 100	53 (2–92)	14 (2–47)	28 (36) 129%	27 (78) 289%	6 (1–17)	2 (1–5)
2016	16 Jun–25 Sep: 102	60 (2–99)	16 (2–51)	81 (92) 114%	29 (105) 362%	6 (1–22)	2 (1–8)
2017	16 Jun–25 Sep: 102	44 (2–92)	9 (2–37)	74 (97) 131%	27 (96) 356%	8 (1–24)	2 (1–6)
2018	16 Jun–25 Sep: 102	59 (2–94)	18 (2–58)	67 (97) 145%	23 (93) 404%	8 (1–26)	2 (1–13)
2019	16 Jun–25 Sep: 102	53 (2–84)	10 (2–32)	53 (68) 128%	25 (68) 272%	11 (1–32)	2 (1–8)
2020	20 Jul–31 Aug: 43*	23 (2–43)*	8 (2–22)*	51 (58) 114%	20 (43) 220%	5 (1–13)	2 (1–6)
2021	27 Jun–25 Sep: 91	50 (1–92)	16 (1–41)	61 (89) 146%	17 (58) 341%	11 (1–30)	2 (1–8)
Mean 2014–21	<b>100 days</b>	<b>51 (1–99)</b>	<b>14 (1–58)</b>	<b>58 (78) 134%</b>	<b>22 (68) 302%</b>	<b>8 (1–32)</b>	<b>2 (1–13)</b>

\*Excluded from analysis.

2014 and 2022 was 8.3 (SD = 6.3, range = 1–32) for female and calf pairs and 1.8 (SD = 1.4, range = 1–13) for unaccompanied adults. The number of resights of individuals per year varied across years (Table 1).

Mean residency for female and calf pairs at HOB between 2014 and 2021 was 51.1 days (SD = 21.2, range = 2–99 days) and for unaccompanied adults was 13.9 days (SD = 14.0, range = 2–58 days) (Table 1). There was interannual variation in the mean residency period recorded for females with a calf, with the lowest mean residency of 29 days recorded in 2014 compared with 60 days in 2016 (Table 1). The mean residency of unaccompanied adults was consistent across years and ranged from 13 days in 2014 to 18 days in 2015 and 2018 (Table 1).

Survey effort increased from 2016 with the additional use of UAV sightings data contributed from Murdoch University. Increase in effort was calculated in 2016 with an additional 777 sightings of females with a calf and 55 sightings of unaccompanied adults contributed from UAVs. Additional sightings including data from UAV effort resulted in a mean residency of 61 days (SD = 21, range = 2–99 days) for female and calf pairs and 15 days (SD = 12, range = 2–52 days) for unaccompanied adults. When using the UAV and cliff-based sightings, the mean residency is significantly greater ( $p < 0.001$ , SD = 22.43) for female and calf pairs and not significantly different for unaccompanied adults ( $p = 0.65$ , SD = 12.7), compared with using the cliff-based sightings alone. The contribution of UAV sightings resulted in a 12-day increase in the mean residency for female and calf pairs and 1.4-day increase for unaccompanied adults. While the whales move around and can be photographed throughout the season from the cliff-top vantage points, the use of UAVs enabled access to whales while they were occupying the shallow waters of the bay in the east of the study site that were inaccessible from the cliff-top vantage points. Based on significant difference in mean residency of female and calf pairs when using UAV and cliff-based sightings, years with additional UAV data are considered a more accurate estimation of residency.

The mean residency for female and calf pairs at HOB between 2016, 2019 and 2021 (years with UAV and cliff-based sightings) was 53.2 days (SD = 20.3, range = 2–99 days) and for unaccompanied adults was 13.8 days (SD = 14.0, range = 2–58 days) (Table 1). A one-way ANOVA was performed to compare the effect of year on mean residency. The interannual variation was significant for female and calf pairs ( $F(4, 390) = 9.049$ ,  $p < 0.001$ ). A Tukey’s Honest Significant Difference (HSD) Test for multiple comparisons revealed a significant difference in mean residency for 2016 compared with 2017 ( $p < 0.001$ ), 2016 with 2021 ( $p = 0.01$ ), 2018 with 2017 ( $p < 0.001$ ) and 2018 with 2021 ( $p = 0.042$ ). The interannual variation was also significant for unaccompanied adults ( $F(4, 134) = 2.59$ ,  $p = 0.04$ ), a Fisher’s Least Significant Difference (LSD) Test revealed a significant difference when comparing mean residency periods for 2018 with 2017 ( $p < 0.009$ ) and 2018 with 2019 ( $p = 0.022$ ). There was no significant difference between other years.

The combination of the two methods, cliff-based photo-ID and UAVs, for collecting photo-ID data post 2016 increased the effort and therefore introduced an observer bias. The inclusion of UAVs in 2016 resulted in 110% more sighting events which contributed significantly to the assessment of residency periods. The UAVs were able to capture 71% of the first-time sighting events of females with newborn calves that often occupy the shallow sandy habitat in the eastern end of the bay that is not accessible to the cliff-based team until the whales move into that area. The cliff-based team had a greater success capturing the last sightings of SRWs at the HOB due to the distribution of animals along the cliffs later in the season. The cliff-based team sighted 78% of animals on their final sighting.

### Site fidelity

Site fidelity was assessed for calving females (n = 554) with sighting histories available from at least two sightings in different years. Sighting history was available for individuals that were matched to individuals previously sighted at HOB in the long-term photo-ID catalogue (1984–2019). Site fidelity was displayed for 57.6% of reproductive females (319 out of 554). Calving site fidelity was displayed for 44.9% (249 out of 554) of the total reproductive females observed, or 78.1% of the females that showed fidelity to the site (n = 249). The mean number of calves recorded for all reproductive females was 2.16 (SD = 1.81). For females that displayed site fidelity (n = 249), the mean number of calves observed at HOB was 3.57 (SD = 1.92). The number of calves recorded at HOB for calving females that displayed calving site fidelity (n = 249) to the area ranged from 2–12 calves, with two being the most frequently recorded number of calves for each individual (n = 103 individual) after a single calf (n = 305) (Table 2, Fig. 2).

The introduction of UAVs as a method for capturing photo-ID data did not significantly change the site fidelity results. The UAVs contributed an additional 4% of reproductive females. The cliff-based team had 55% greater success capturing unaccompanied adults than the UAV team due to the location of the unaccompanied adults along the cliffs and the no-fly zones around raptor nests preventing the UAV team from accessing those areas at the western end of the study site.

Table 2  
Number of Southern Right Whale calving events for reproductive females at Head of Bight, South Australia, 1984–2019 (36 years).

No. calves	1	2	3	4	5	6	7	8	9	10	11	12
# (n = 554)	305	103	51	31	24	16	13	5	4	0	1	1
%	55.1	18.6	9.2	5.6	4.3	2.9	2.3	0.9	0.7	0.0	0.2	0.2

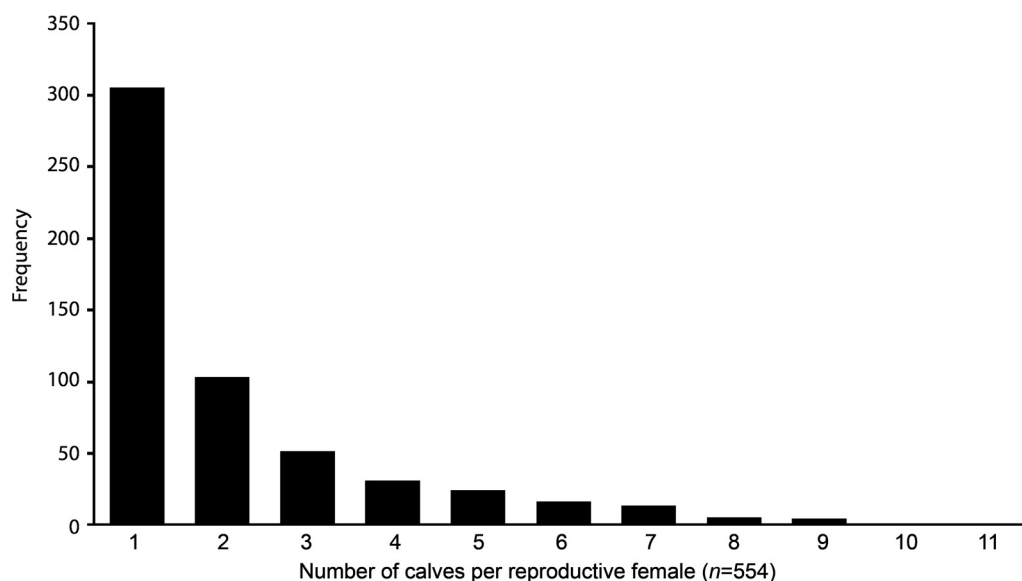


Figure 2. Frequency distribution of number of Southern Right Whale calves produced at Head of Bight, South Australia by known reproductive females (n = 554).

Reproductive females migrate to Australian wintering grounds outside of calving years. A third of reproductive females were observed in non-calving years at HOB (29.6%,  $n = 164$ ). Reproductive females were observed outside calving years (including a calf, yearling, juvenile or adult) on average 1.66 times (SD = 1.22, range = 1–8) at HOB.

Site fidelity for unaccompanied adults (non-reproductive females) was observed for 21% ( $n = 215$  out of 1,019) and, on average, unaccompanied adults were resighted at HOB 1.35 times (SD = 0.9, range = 1–13).

### Natal site fidelity

Natal site fidelity was displayed for 24 of the 75 calves that were resighted at HOB after their year of birth. The number of calves recorded for individuals that displayed natal site fidelity ranged from one to six, with a mean of 2.5 calves (SD = 1.6). Individuals that displayed natal site fidelity were also sighted returning to the site as juveniles. For example, of the calves that displayed natal site fidelity, 33% returned to HOB as yearlings and 50% returned to HOB as juvenile in their first six years after birth.

### Date of calving

The date of calving was estimated for 63 individuals between 2014 and 2021 (excluding 2020) that were sighted as an unaccompanied adult (pregnant) and later sighted in the same season with a calf (Table 3). The minimum number of days between sightings as pregnant and then with a calf was one day, providing evidence that at least some SRWs must calve within the HOB study area. The mean date of calving was 24 July (SD = 14.7). The last sighting of a pregnant female occurred on 8 August.

Table 3

Mean date of calving for female southern right whales at Head of Bight, South Australia ( $n = 63$ ), using the average date between the last sighting of female unaccompanied (UA) and the first date of sighting with a calf (Cow Calf = CC). For each year the mean date last sighted as UA, mean date first sighted as CC and the range was calculated.

Year	<i>N</i>	Mean date last sighted as UA and range	Mean date first sighted as CC and range
2014	1	25 Jun	20 Jul
2015	7	3 Jul (25 Jun–19 Jul)	7 Aug (1 Jul–27 Aug)
2016	11	4 Jul (19 Jun–30 Jul)	20 Jul (1 Jul–22 Aug)
2017	7	21 Jul (12 Jul–25 Jul)	12 Aug (31 Jul–25 Aug)
2018	16	9 Jul (23 Jun–8 Aug)	25 Jul (26 Jun–28 Aug)
2019	13	15 Jul (2 Jul–2 Aug)	1 Aug (14 Jul–21 Aug)
2021	8	12 Jul (26 Jun–26 Jul)	3 Aug (9 Jul–29 Aug)
<b>Mean 2014–21 (excl. 2020)</b>		10 Jul (19 Jun–8 Aug)	30 Jul (26 Jun–29 Aug)

## DISCUSSION

This study examined residency, site fidelity and calving timing of SRWs at the HOB, SA – one of the most important reproductive BIAs in Australia. Using three decades of photo-ID mark-recapture data (1991–2021), we found that calving females remained at the site for up to 3.5 months, whereas unaccompanied adults were significantly more transient. Mean within-year residency for calving females declined over the study period, and site fidelity was evident in over half of reproductive females, consistent with earlier reports (Burnell, 2001).

Our hypothesis that residency and site fidelity have decreased compared to 1992–1994 (Burnell & Bryden, 1997) was supported. Mean residency of unaccompanied adults dropped from 20.4 to 13.8 days, and for females with calves from 70.9 to 53.2 days. These trends may partly reflect methodological differences (e.g., a 14-day longer field season in the 1990s) but are also likely driven by increased population size and associated habitat dispersal (Charlton *et al.*, 2019a; Kemper *et al.*, 2022; O’Shannessy *et al.*, 2025).

Spatial density and conspecific attraction are potential drivers of shifting habitat use and reduced residency (Carroll *et al.*, 2014; Charlton *et al.*, 2019a). In years of high abundance, photo-ID success exceeded daily whale counts, suggesting substantial within-season movement. Calving females tended to stay longer during low-abundance years, while crowding during peak years may prompt dispersal. This is supported by reports of ‘packing density’ thresholds (Charlton *et al.*, 2019b; O’Shannessy *et al.*, 2025), and by shorter residency at smaller

sites, such as Fowlers Bay, SA (mean 23 days for mothers, two for adults) and Encounter Bay, SA (47 and 12 days, respectively) (Charlton *et al.*, 2019a; Kemper *et al.*, 2022). Collectively, these patterns suggest that established sites like HOB support longer stays, while emerging sites reflect increasing population dispersal.

Despite this, site fidelity to HOB remains consistent: 57.6% of females identified between 1984–2019 ( $n = 319$ ) were resighted in multiple years. However, females may shift calving areas based on individual choice, environmental pressures or crowding (Carroll *et al.*, 2014; Charlton, 2017; Watson *et al.*, 2021). With a mean intercalving interval of four years (Charlton *et al.*, 2022), females were recording calving up to 13 times. The mean number of calves per female was 2.16, suggesting frequent movement across Australia's core use area and possible site shifts. Notably, females previously calving at HOB were documented shifting to adjacent areas, such as Fowlers Bay, likely in response to high density or habitat saturation (Charlton, 2017; O'Shannessy *et al.*, 2025). Shifts in preferred calving habitat were also observed between south-eastern Australia and HOB (Watson *et al.*, 2021). Similar habitat dispersal has been recorded in SRW populations in South America, South Africa and New Zealand (Rowntree *et al.*, 2001; Carroll *et al.*, 2011, 2014; Barendse & Best, 2014; Danilewicz *et al.*, 2016; Seyboth *et al.*, 2016).

The number of new individuals at HOB has increased annually, accompanied by greater intra-seasonal immigration and emigration (Charlton *et al.*, 2019b). HOB's relative contribution to the total western SRW population has declined over time (O'Shannessy *et al.*, 2025), reflecting range expansion. While female-calf pairs dominate the aggregation (80%), unaccompanied adults are common (20%) and highly transient, averaging 1.47 sightings and 20-day stays. A significant proportion of females (30%) were also observed at HOB in non-calving years, underscoring the site's importance for non-calving behaviours, including mating, socialising and resting.

This study provides the first evidence of natal site fidelity for SRWs in Australia, with 24 known-age whales photographed in their birth year and later resighted at HOB. Most (60%) returned within six years, and 43% were seen as yearlings, suggesting early return may predict long-term site fidelity. However, this is constrained by challenges in identifying calves before the development of callosity patterns at three months. These individuals offer rare long-term demographic insights spanning four decades.

Calving timing was consistent, with a mean date of 24 July – closely matching historical estimates of 26 July (Burnell & Bryden, 1997). This consistency validates the current timing of long-term surveys and supports their use in population monitoring (Charlton *et al.*, 2019b). Calving seasons vary globally, peaking later in South Africa and Argentina, possibly due to geographic and migratory differences, as well as climate and thermoregulatory factors (Payne, 1986; Best & Scott, 1993; Burnell & Bryden, 1997; Christiansen *et al.*, 2020).

This study highlights the critical role of coastal BIAs in supporting SRW recovery in Australia. Legislative protection through marine protected areas and application of the precautionary principle are essential to safeguard critical habitats and life stages. Strong national management, along with effective mitigation of human impacts, is urgently needed to secure the population's long-term recovery. These outputs are already being used by State Government departments in South Australia and Western Australia to inform updates to proposed MPAs and the refinement of BIA boundaries, serving as key tools for environmental impact assessment under the EPBC Act. This research directly contributes to legislative and policy development, supporting national recovery targets and advancing the global goal of protecting and conserving natural ecosystems through initiatives such as protecting 30% of land and sea by 2030. Continued long-term research and monitoring of long-lived marine mammal species, such as SRWs, is essential for detecting changes over time and informing effective management. The southern Australian dataset represents one of the most comprehensive long-term datasets globally and is critical for understanding population trends and emerging threats across the species' range.

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# Supplementary Material

Table S1

Mean date of calving for female Southern Right Whales at Head of Bight, South Australia (n = 63), using the average date between the last sighting of female unaccompanied (UA) and the first date of sighting with a calf (Cow Calf = CC). Table includes HOB code for known individual, the year that the female was sighted as pregnant, the date of last sighting as a UA and date of first sighting with a calf (CC).

Code	Year	Date last sighted UA	Date first sighted CC	Estimated date of calving
H9357	2014	25-Jun	20-Jul	7-Jul
H0807	2015	25-Jun	31-Jul	13-Jul
H1507	2015	2-Jul	7-Aug	20-Jul
H1509	2015	1-Jul	15-Aug	23-Jul
H1510	2015	9-Jul	16-Aug	28-Jul
H1511	2015	19-Jul	17-Aug	2-Aug
H0451	2015	2-Jul	27-Aug	30-Jul
H1501	2015	27-Jun	1-Jul	29-Jun
H1608	2016	25-Jun	1-Jul	28-Jun
H0150	2016	25-Jun	3-Jul	29-Jun
H1611	2016	25-Jun	2-Jul	28-Jun
H1613	2016	2-Jul	19-Jul	10-Jul
H9401	2016	19-Jul	20-Jul	19-Jul
H0945	2016	29-Jun	14-Jul	6-Jul
H0703	2016	29-Jun	6-Jul	2-Jul
H1622	2016	8-Jul	3-Aug	21-Jul
H1625	2016	19-Jun	3-Aug	11-Jul
H1628	2016	18-Jul	4-Aug	26-Jul
H1638	2016	30-Jul	22-Aug	10-Aug
H0953	2017	22-Jul	31-Jul	26-Jul
H1717	2017	21-Jul	15-Aug	2-Aug
H0424	2017	23-Jul	11-Aug	1-Aug
H1438	2017	25-Jul	13-Aug	3-Aug
H0607	2017	22-Jul	12-Aug	1-Aug
H9572	2017	22-Jul	12-Aug	1-Aug
H1723	2017	12-Jul	25-Aug	3-Aug
H1170	2018	24-Jul	3-Aug	29-Jul
H9375	2018	24-Jun	4-Jul	29-Jun
H1805	2018	12-Jul	18-Jul	15-Jul
H0910	2018	23-Jun	26-Jun	24-Jun
H1218	2018	16-Jul	18-Jul	17-Jul
H9116	2018	26-Jun	4-Jul	30-Jun
H1029	2018	25-Jun	8-Jul	1-Jul
H0758	2018	26-Jun	8-Jul	2-Jul
H1809	2018	26-Jun	21-Jul	8-Jul
H1208	2018	16-Jul	17-Aug	1-Aug
H1468	2018	4-Jul	12-Jul	8-Jul
H1317	2018	20-Jul	31-Jul	25-Jul
H1816	2018	10-Jul	28-Aug	3-Aug
H1437	2018	12-Jul	16-Aug	29-Jul
H9319	2018	25-Jul	19-Aug	6-Aug
H1830	2018	8-Aug	20-Aug	14-Aug
H9144	2019	3-Jul	14-Jul	8-Jul
H1115	2019	2-Jul	15-Jul	8-Jul
H0929	2019	3-Jul	16-Jul	9-Jul
H0807	2019	9-Jul	19-Jul	14-Jul
H1163	2019	16-Jul	3-Aug	25-Jul
H1909	2019	9-Jul	1-Aug	20-Jul
H1910	2019	24-Jul	3-Aug	29-Jul
H1911	2019	19-Jul	1-Aug	25-Jul
H0577	2019	16-Jul	12-Aug	29-Jul
H1502	2019	1-Aug	12-Aug	6-Aug
H1673	2019	31-Jul	13-Aug	6-Aug
H1913	2019	9-Jul	13-Aug	26-Jul
H9308	2019	2-Aug	21-Aug	11-Aug
H1611	2021	26-Jun	9-Jul	2-Jul
H9401	2021	18-Jul	25-Jul	21-Jul
H2108	2021	13-Jul	25-Jul	19-Jul
H1710	2021	3-Jul	28-Jul	15-Jul
H1013	2021	19-Jul	8-Aug	29-Jul
H2110	2021	19-Jul	16-Aug	2-Aug
H1161	2021	5-Jul	8-Aug	22-Jul
H2112	2021	26-Jul	29-Aug	12-Aug