LITTLE PENGUIN ANNUAL MONITORING REPORT

Summary of Findings and reporting requirements

24 August 2026

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1 INTRODUCTION

This summary report has been prepared by RPS AAP Consulting Pty Ltd (RPS) to accompany the ***Little Penguin Annual Monitoring Report 2025/26*** prepared by Dr Belinda Cannell of University of Western Australia (UWA).

The Little Penguin Annual Monitoring Report 2025/26 has been prepared in accordance with the Little Penguin Monitoring and Management Plan (LPMMP) and satisfies Condition 12 of EPBC Act approval (Variation of Conditions attached to approval) 2024/10031. The report addresses the monitoring and reporting requirements associated with Environmental Outcome (EO): ***No measurable decline in little penguin population size attributable to the SRF-West Project landside and maritime construction works.***

The primary objective of the LPMMP is to outline the monitoring program that will facilitate detection of changes in little penguin behaviour, habitat use and population size during the construction of SRF-West approved Action works to inform adaptive management responses where necessary, ensuring that an acceptable EO is achieved.

In order to achieve the EO little penguin monitoring will record nesting behaviour, nest conditions, breeding success, numbers of breeding adults (as an index for population size) and environmental variables within expected ranges of variation and demonstrate little penguin population size changes are within normal ranges of variation (as compared to baseline population size between 2021–2024) or will provide evidence to demonstrate the influence of external factors.

Annual reports will include documentation of data collection and analysis methods, survey effort, monitoring results and interpretation of those results in the context of historical data. Specific reporting requirements include:

- Little Penguin activity, based on evidence such as faecal material, nesting material, feathers and birds;
- breeding activity and the locations of active nests, including mapping;
- the number of breeding attempts, successful and unsuccessful clutches, and the proportion of successful clutches, together with graphical comparison of current results against historical averages;
- analysis of the influence of five environmental variables—salinity, dissolved oxygen, sea temperature, turbidity and rainfall—on breeding performance;
- moulting activity and the locations of active moult sites;
- movement behaviour of tagged individuals, including spatial use, home and core ranges, tag details, breeding stage, deployment dates, trip duration and breeding status;
- assessment of population status using breeding numbers as an index of population size and comparison with previous years;
- assessment of whether observed changes in population size or behaviour during the SRF-West construction period are within the range of natural variability, attributable to external factors, or potentially influenced by construction activities;
- consideration of the timing and potential influence of construction activities, including underwater noise and vibration, and the adequacy of management controls and monitoring requirements; and
- assumptions, limitations and other factors relevant to interpretation of the monitoring results.

This summary provides an overview of the principal monitoring results and conclusions, a cross-reference between the annual reporting commitments and the relevant sections of the technical report and a summary of the information presented against each reporting requirement.

This document should be read together with the full technical report. It does not replace the detailed methods, results, statistical analyses, figures, maps, assumptions or limitations contained within that report.

2 KEY RESULTS AND CONCLUSIONS

The 2025/26 annual monitoring report concludes that the Environmental Outcome (EO LP 1) has been met for the reporting period. While monitoring identified a measurable decline in the number of breeding little penguins, particularly in Area C, the available evidence indicates that this decline was unlikely to be attributable to SRF-West landside or maritime construction works.

Breeding adult numbers, used as an index of population size, were lower in 2025 than in previous years, with the most pronounced decline occurring in Area C. However, other measures of breeding success were observed within the normal range. Breeding timing was similar to that recorded in 2023 and 2024, overall breeding success was marginally higher than in 2022– 2024, and the success of clutches laid between July and October 2025 was higher than in most recent years.

The report identified environmental and biological factors as the more likely contributors to the observed decline. Moderate to strong marine heatwave conditions occurred between December 2024 and April 2025 and were likely to have affected prey availability within Cockburn Sound. Other documented sources of adult mortality included hyperthermia during moult and predation by pythons and foxes (in previous breeding seasons).

Monitoring of construction-related noise, vibration and nest integrity did not provide evidence of a population-level impact associated with project activities and no notable change in behaviour to noise and/or vibration associated with construction activities that did not exceed any noise or vibration thresholds. Two breeding attempts in Area C failed around the time of noise and vibration exceedances. However, 13 other breeding attempts in the same area continued during this period, and the failures were considered unlikely to have been caused by construction activities. Nest integrity monitoring identified some structural failures associated with natural events. No reportable events were recorded during the reporting period.

On this basis, the annual report concludes that although a measurable population decline has occurred, the available monitoring data provide evidence that external environmental and biological factors, rather than SRF-West construction activities, are the likely drivers of the observed change. Currently there is no need for any revised management controls or monitoring requirements in association with the approved Action activities.

Key Findings

- The number of breeding penguins during the 2025/26 breeding season was estimated to be 124 individuals (excluding Area A and B), 26% fewer than the 2024 estimate and 20.5% decline from the minimum population baseline of 156.
- No evidence that the observed population decline was attributable to SRF-West landside or maritime construction works and likely related to environmental and biological factors.
- 262 nests showed evidence of nesting activity.
- 62 nests were confirmed to have breeding activity (i.e. eggs were laid). Second clutches were recorded in 9 nests resulting in a total of 71 breeding attempts.
- 68% of attempts with known outcomes successfully raised at least one chick.
- Breeding activity in Area C remained below the historical average, although breeding success in 2025 was slightly higher than in 2022–2024.
- Rainfall was the key environmental variable associated with breeding having a positive effect on hatching success, but no effect was observed for fledging success.

2.1 Summary of Little Penguin Monitoring Annual Report

Table 1: Summary of Information required for inclusion in Annual Report, summary of report findings and reference to location within report.

Annual Report Inclusion	Summary of report findings	Report reference
Data collection and analysis methods, survey effort	• Protocols for data collection, and analysis are detailed in the Report. • 370 and 392 potential, historical, and current nests were monitored each fortnight from April 2025 - March 2026.	Section 2 (pp 3-7) Section 3.1 (p11)
Little penguin activity	• Of 392 potential nests monitored, 262 shows evidence of activity including direct evidence (presence of adults, eggs or chicks) or other signs (faecal matter, feathers, nesting material). • Activity was recorded in 148 of 230 potential sites within Area B/C, 59 of 70 potential sites within area D/E, 33 of 73 potential sites within area F and all 21 potential sites within area A. • Patterns of activity were similar between zones with peak of activity recorded in October/November. • Figure of location of nests with observed activity presented	Section 3.1 (p11) Section 3.1 (p 11-12) Section 3.1 (p 11-12) Figure 4 (p14)
Breeding activity including maps that identifying the locations of all active nests. graphical displays showing number of breeding attempts, number of clutches (successful and unsuccessful), proportion of successful clutches. graphical displays to compare current breeding results with historical averages and interpretation of change	• Nests with breeding activity were recorded in all areas. Breeding Activity was highest in Area B/C followed by Area D/E, Area F, and Area A. • Figure of location of nests with observed breeding presented • 62 nests were confirmed to have breeding activity (i.e. eggs were laid). Second clutches were recorded in 9 nests resulting in a total of 71 breeding attempts. • Breeding success was calculated for 66 breeding attempts in 57 nests. • 68% of breeding attempts were considered successful (at least one successful fledgling). More successful clutches were observed for eggs laid in June and July. • Visual displays of breeding success are presented in Figure 7, Table 1 and Table 2 • Breeding data in Area C was used for comparison with historical data. • The number of breeding attempts observed in Area C during 2025 was lower than both the 2021 – 2024 average (approx. 40 nests) and historical average (approx. 78±10 nests). This was consistent across all laying months. • Breeding success within normal range	Section 3.2 (p 15) Figure 6 Section 3.2 (p 15) Table 3 Section 3.2 (p 15) Section 3.2 (p 15) Section 3.2 (p 18) Section 3.2 (p 18) Section 3.2 (p 18) Section 4(p 34)

Presentation of modelling results investigating the influence of 5 environmental variables (salinity, dissolved oxygen, sea temperature, turbidity and rainfall) on the breeding performance of the penguins.	• Modelling results showed rainfall was the most influential environmental variable predicting breeding outcomes. Rainfall was found to have a have significant positive effect on egg success but there was no significant effect found for rainfall or any other environmental variables on chick success.	Section 3.3 (p24) Table 7
Moulting activity, including maps that identify the locations of all active moult sites	• Moulting activity was observed from Mid-November through to early March. Moulting was observed in 108 sites across all areas. • All sites where moulting adults or signs of moulting was observed are presented in a Figure.	Section 3.2.3 (p20) Figure 9
Movement behaviour, including detail of all tagged individuals, mapping including home range and core range, tag ID and type, breeding stage, deployment date, trip duration and breeding status (egg incubation, hatching, chick fledging) from each nest site	• One satellite tag and one GPS tag were deployed during the 2025 season. • The satellite tag was attached to a male penguin (ID 21625481) on the 9th September 2026 during the egg incubation phase. The penguin carried out 2 daily foraging trips on the 10/09/2026 and the 11/09/2026. • The home range encompassed marine areas including. The core range was similar on both days that the tag was deployed and shown to be within the central basin of Cockburn Sound. The home range covered an area extending from the colony to the Central basin. A map detailing core range and home range are detailed in Figure 12. • A GPS tag was attached to a female penguin (ID 21625479) on the 10th August during the chick guard phase and recorded location data during 1 foraging trip on the 11th August. Data show the penguin initially heading southeast from the colony before heading northeast toward the central basin where remained for several hours. A map detailing the fine scale tracking data for this penguin is detailed in figure 13. • Movement was similar to previous tracking data observations.	Section 3.4 (p27) Table 8 Section 4 (p38)
Population status assessment, based on nest site data and any observed changes in the population. Breeding numbers will be used as an indicator of population size and compared with previous years. Discussion will include whether any changes in population size during the SRF-West construction period are within the natural range of variability or potentially influenced by construction activity	• The number of breeding penguins during the 2025/26 breeding season was estimated to be 124 individuals (excluding Area A and B), 26% fewer than the 2024 estimate and 20.5% decline from the minimum population baseline. • Whilst there was a measurable decrease in the little penguin population size, especially in Area C, it was not likely to have been attributable to the SRF-West Project landside and maritime construction works. Information to support this is discussed in detail in section 4	Section 3.2.5 (p23) Table 5 Table 6 Section 4 (p34 – 36)
Timing of construction activities, whether any changes in behaviour during the SRF-West construction period were potentially influenced by construction activity (such as underwater noise from piling activities) or commentary on	• Construction activities associated with the Action commenced in July 2025, with the annual report covering relevant activities through to mid-December 2025. • There was no notable change in behaviour to noise and/or vibration associated with construction activities that did not exceed any noise or vibration thresholds (RPS 2026b).	Section 4 (p 38) Section 4 (p 39)

sufficiency of management controls and monitoring requirements		
Assumptions, limitations and other contributing factors that influence the interpretation of results	Limitations include: - data gaps in location data during early afternoon periods - Population estimates represent minimum number of breeding adults and do no include juvenile or non-breeding adults.	Section 2.8 (p11)

Little Penguin Annual Monitoring Report (2025/26)

SRF-West Priority Infrastructure Works, Garden Island/Meeandip, Western Australia

Milestone Report
Dr Belinda L Cannell
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Executive Summary

Dr Belinda Cannell from the University of Western Australia (UWA) was commissioned by RPS AAP Consulting Pty Ltd (RPS) to provide this *Little Penguin Annual Monitoring Report (2025/26)* on behalf of Department of Defence (Defence) for the Submarine Rotational Force-West (SRF-West), Priority Infrastructure Works project (the Action). This document was developed in accordance with the *Little Penguin Monitoring and Management Plan* (LPMMP) (RPS 2026a), which outlines the little penguin monitoring and reporting arrangements required under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval 2024/10031.

This report documents the outcomes of the little penguin monitoring program carried out during the 2025/26 breeding period against the requirements of the LPMMP (RPS 2026a). Little penguin nest behaviour monitoring is considered separately in the Little Penguin Behaviour Characterisation report (RPS 2026b).

Between 370 and 392 potential, historical, and current nests were monitored each fortnight from April 2025– March 2026. Evidence of penguin activity was observed in 262 nests across the year. Whilst there was generally a similar pattern of activity between the areas with a peak of activity in October/November 2025, and an increasing trend from March to April 2026 that was greater than the preceding year, there were some spatial differences. The least number of nests with activity occurred in Area F, where only 45% of potential nests were used. This is likely influenced by previous predation events by foxes There were 71 breeding attempts recorded in Areas A – F in 62 nests. Of these, 66 breeding attempts in 57 nests had confirmed outcomes, with 68% attempts successful in raising at least one chick. A second clutch was laid in nine nests. Eggs were laid from May to October, with a peak in August. The success rate of clutches varied by month, with the highest success observed for eggs laid in July, and the lowest for those laid in May and October.

When compared to historical data, there were fewer breeding nests with known outcomes in 2021 – 2025 in Area C than the historical average of 78±10 nests (data from 2005 – 2019, Cannell unpubl. data). Overall, there has been a decline in breeding activity in Area C, not only compared to historical records, but also since 2022. In contrast, the number of breeding adults in Areas D and E initially increased from 2021 to 2023, before slightly decreasing from 2023 to 2025. The number of breeding adults in Area F drastically declined in 2023, due to predation by foxes, although numbers have since increased.

Environmental conditions within Cockburn Sound will have influenced the number of penguins attempting to breed. From December 2024 to April 2025, moderate to strong marine heatwave (MHW) conditions were present along the central to southwest coast, including near Cockburn Sound. However, higher rainfall later in the year, compared to the same time in previous years, was likely associated with a slightly higher breeding success than in previous years. The odds of an egg hatching in 2025 was significantly increased by 2.7% with every 1 mm of rain.

A satellite tag was deployed on one breeding penguin during the incubation stage of breeding, and a GPS tag was deployed on one breeding penguin during the guard stage. Both penguins remained within Cockburn Sound, using the central basin, western margin, southern basin and/or Kwinana Shelf. These areas were generally consistent with those from penguins previously tagged from Garden Island.

Mortality of two adults on Garden Island in 2025/26 occurred during the moult period. Thirteen chicks were found dead, 10 of which were likely to have died from starvation.

Nest integrity monitoring revealed some structural failures attributed to natural events, and threshold exceedances for vibration were not associated with nest integrity. Two breeding attempts in Area C failed around the same time as there were exceedances in noise and vibration. However, these were unlikely to have been associated with the penguins' abandonment of breeding attempts, given that another 13 breeding attempts in Area C continued.

In accordance with the Little Penguin Environmental Outcome, whilst there was a measurable decline in the little penguin population size, especially in Area C, it was not likely to have been attributable to the SRF-West Project landside and maritime construction works. This was demonstrated through the following performance criteria:

- Little penguin monitoring for 2025 showed that timing of egg lay was similar to that in 2023 and 2024.
- Breeding success was marginally higher in 2025 compared to 2022 – 2024.
- There was no difference in the breeding success between Areas.
- The success of eggs laid in July to October 2025 was higher than most other years.
- The decline in the numbers of breeding adults (as an index for population size), particularly in Area C, was likely as a result of the marine heatwave from mid December 2024-early April 2025, as well as other losses of adults in Area C from hyperthermia during moult in 2024/25, predation by a python in 2024, and fox predation in early 2023. Loss of adults from any cause can cause both short- and long-term impacts on the population.

Acronyms, abbreviations and definitions

Acronym or abbreviation	Description
EO	Environmental outcome
h	Hour
LPMMP	Little Penguin Monitoring and Management Plan
SRF-West	Submarine Rotational Force-West
UWA	University of Western Australia

Definitions of key terms

Term	Definition
Action area	Means the combined area encompassed by the Armament Wharf Action area and Careening Bay Action area (DCCEEW 2025).
Baseline population	Relates to the little penguin population and means data that measures the annual population size and overall trend prior to commencement of the Action, which can be used for later comparison to population data obtained after commencement of the Action.
Conditions	Means the Notification of approval decision Submarine Rotational Force – West, Priority Infrastructure Works, Garden Island, Western Australia [EPBC 2024/10031].
Environmental outcome	Environmental outcome/ Little penguin environmental outcome = No measurable decline in little penguin population size attributable to the SRF-West Project landside and maritime construction works. **Performance criteria** • Little penguin monitoring will record nesting behaviour, nest conditions, breeding success, numbers of breeding adults (as an index for population size) and environmental variables within expected ranges of variation, during construction and for a 6-year period following the completion of construction. • The little penguin monitoring data will demonstrate little penguin population size changes are within normal ranges of variation (as compared to baseline population size between 2021–2024) or will provide evidence to demonstrate the influence of external factors.
Correlated random walk	A statistical movement model where the direction of each step depends on the direction of the previous step
Guard stage	The period from the point of eggs hatching until the chicks are approximately 2-3 weeks old, during which time one parent penguin remains with the chick/s during the day
Little penguin	Means the EPBC Act-listed marine species little penguin (*Eudyptula minor*) (DCCEEW 2025).
Little penguin breeding period	Means the period when little penguins are laying and incubating eggs and rearing chicks, which typically commences in April and ends in mid-January.
Little penguin environmental outcome	No measurable decline in little penguin population size attributable to the SRF-West Project landside and maritime construction works. Performance criteria • Little penguin monitoring will record nesting behaviour, nest conditions, breeding success, numbers of breeding adults (as an index for population size) and environmental variables within expected ranges of variation, during construction and for a 6-year period following the completion of construction. • The little penguin monitoring data will demonstrate little penguin population size changes are within normal ranges of variation (as compared to baseline population size between 2021–2024) or will provide evidence to demonstrate the influence of external factors.
Little penguin moulting period	Means the period when little penguins are moulting, which typically commences during November and ends during February.
Little penguin nesting sites	Means the areas used by little penguins for breeding and moulting, and the known nesting sites identified in [EPBC Act approval 2024/10031] Appendix A Map 4b, under the legend title 'Nesting sites' and designated in the legend 'Colpoys Point', 'Diamantina/Parkes', 'Main Colony', 'Moresby Harbour', 'Outer rock wall' and 'Parkes/Oxley'.

Term	Definition
Little penguin population	Means the number and distribution of little penguins at Garden Island/*Meeandip*.
Microchipped	Insertion of a microchip, a permanent method of electronic identification. The chip itself is about the size of a grain of rice.
Monitoring data	Means the data required to be recorded under the conditions of approval EPBC 2024/10031, including sensitive biodiversity data.
Noise threshold level	Means the maximum threshold of acoustic sound measured in decibels (dB) that is considered safe to operate within the Action area without harming the local little penguin population (DCCEEW 2025).
Suitably qualified seabird conservation ecologist (Seabird Ecologist)	For the purpose of preparing and implementing monitoring programs to detect changes in little penguin population and correlating these changes with environmental variables, this means a person who has relevant professional qualifications and: • at least 5 years of work experience with little penguins • has an in depth understanding of little penguin ecology, threats to little penguins and their conservation • can give an independent, authoritative assessment and advice on the little penguin species and its habitat using relevant protocols, standards, methods and/or literature • has implemented monitoring programs and analysed and reported on monitoring results to better understand little penguin ecology, population dynamics and correlations between population/breeding success with environmental and other variables (DCCEEW 2025).
Suitably qualified acoustic expert (Acoustic Consultant)	Means a person who has relevant professional qualifications and has at least 3 years of work experience designing and implementing surveys and environmental management plans to manage the negative impacts of noise and vibration pollution in construction settings on native fauna (either in-air and/or underwater as relevant to the context) (DCCEEW 2025).
Vibration threshold level	Means the maximum threshold of vibrational sound measured in millimetres per second that is considered safe to operate within the Action area without harming little penguins.

Contents

1. Introduction

Dr Belinda Cannell from the University of Western Australia (UWA) was commissioned by RPS AAP Consulting Pty Ltd (RPS) to provide this *Little Penguin Annual Monitoring Report (2025/26)* on behalf of Department of Defence (Defence) for the Submarine Rotational Force-West (SRF-West), Priority Infrastructure Works project (the Action). This document meets the requirements for protection of little penguin nesting on Garden Island as described in the *Little Penguin Monitoring and Management Plan* (LPMMP) (RPS 2026a), which outlines the little penguin monitoring arrangements required under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval 2024/10031.

In accordance with the LPMMP (RPS 2026a), monitoring was undertaken with the overarching aims of:

- monitoring the little penguin population to facilitate detection of changes in population size and breeding success
- observing and assessing little penguin foraging behaviour during the breeding season to detect behavioural changes that may be occurring because of construction activities and to inform adaptive management measures
- documenting any changes in little penguin habitat through nest integrity monitoring
- monitoring environmental variation over time to understand the influence on breeding success and population size of little penguins
- providing estimates of the number of breeding adults as an index of population size (per Cannell 2025), comparing with baseline estimates (pre-Action) and tracking any changes over time
- providing evidence to support compliance reporting against the approved Action conditions, specifically to demonstrate that the little penguin Environmental Outcome is achieved (RPS 2026a).

This report documents the outcomes of the little penguin monitoring program carried out during the 2025/26 breeding period against the requirements of the LPMMP. The results from the monitoring report will be used to inform the need for any revised management controls and monitoring requirements for the approved Action activities.

2. Methods

2.1 Study area

The study area for the monitoring program covered all known nesting areas ('nesting sites') for the little penguin on Garden Island/*Meeandip*, per RPS (2026a), from Moresby Harbour to Colpoys Point (Areas A – F respectively, Fig. 1).

Fig. 1. The location of monitored little penguin breeding sites on Garden Island, Western Australia, 2025.

2.2 Penguin monitoring team and handling permits

All capture, handling, microchipping, and tracking of little penguins was undertaken as per the LPMMP (RPS 2026a).

2.3 Breeding population monitoring

To monitor penguin activity and determine breeding outcomes, including timing of breeding, peak egg laying periods and breeding success, and facilitate comparison with historical data, all potential natural and artificial nests within the colony were monitored once a fortnight across 1 – 1.5 days. Nests were grouped into spatially discrete areas (represented by Areas A to F). Potential natural nest sites are rock crevices that have either been used by a penguin for breeding or moulting, have had evidence of visitation but no breeding, or have features similar to other used nests but may have never been used. All potential nests are verified by Dr Cannell. The number of potential nest sites in each area varied between years and monitoring areas, due to loss (e.g. rock movement during storm events and high tides) or gain (e.g. penguins using crevices previously unused) of some nest sites, and variation in monitoring history.

During each monitoring visit, the following data were recorded:

- nest ID
- nest Area (A – F)

- nest activity (adults, eggs/chicks, moulted feathers, faecal matter, nesting material, unknown, empty)
- number of adults (0,1,2, unknown), noting if an adult is moulting, or dead. Dead penguins assessed for presence of microchip, if possible
- number of eggs (0,1,2, unknown)
- number of chicks (0,1,2, unknown), noting if dead
- general condition of chicks (nestboxes only) and identity once microchipped
- identity from microchip and body condition of adults (nestboxes only).

Nest contents and activity were determined by visual inspection using a torch or a burrowscope. For deep or structurally complex nest burrows where complete nest contents could not be directly observed, additional evidence indicating activity was recorded. This included the presence of fresh faeces, nesting material, footprints, chick down, ants or fleas, penguin vocalisations and adult moult feathers.

As it is not always possible to observe the number of eggs laid (i.e. one or two), or the number of fledged chicks (i.e. one or two), for each breeding attempt, two breeding success variables were determined - a binary Successful/Unsuccessful outcome for both egg success (i.e. whether at least one egg hatched) and fledging success (i.e. whether at least one chick successfully fledged). Where the outcome for a breeding attempt was not discernible, the outcome was classed as unknown and not used in any final analyses of breeding success.

Month of egg lay was back calculated either by:
1) estimating the age of an observed chick and subtracting 35 days (average length of incubation), or
2) if chicks did not hatch, the month the eggs were first observed in the nest.

To assess spatial and temporal variation in the nest sites visited by penguins, the number of nests sites with any evidence of activity was determined for each area on each monitoring date. This metric indicates penguin presence in an area and includes breeding nests, likely breeding nests, nests which may be used prior to breeding, nests used for moulting, and nests used for loafing but not breeding.

To assess whether breeding outcomes during the 2025/2026 breeding season fell within the expected range of variation, breeding success and timing were compared to data collected through the little penguin monitoring program (2021- 2024, Cannell 2022, Cannell 2024 and Cannell 2025a) and historical data collected between 2005 and 2019 through independent research (Cannell unpubl. data). However, due to variation in monitoring frequency and the spatial extent of the colony monitored prior to 2021, only data collected in Area C was available for direct comparison. The historical data sets used comprised monitoring records from both nestboxes and from natural nests and include only nesting attempts where the breeding outcomes were known.

2.3.1 Breeding population and comparison to baseline breeding population estimate

As required by the conditions of approval and described in the LPMMP, a baseline population estimate range was set, based on breeding data collected between 2021 and 2024 (Cannell 2025b). The estimated number of breeding adults was derived from the count of all nests within the study area with known breeding and those with likely breeding monitored over four seasons (2021 to 2024) and assumes that each nest represents a pair of penguins. Likely breeding activity is determined when an egg and/or chick has not been observed but other signs and expert knowledge deem breeding has occurred. Additionally, a breeding nest was included even if the success of the breeding was not confirmed.

The estimate ranged from 156 to 226 breeding adults for Areas B – F, noting that Area B was not monitored in 2021 or 2022 and historical data were not available for Area A as it was added to the monitoring program in April 2025. For the purposes of setting a baseline population estimate, 156 breeding adults stands as the minimum population size that can be compared to population size estimates during and for six years post construction of the Action in Areas B – F (Cannell 2025b). It is possible that a small percentage of nests deep within rock wall cavities are missed. Therefore, the population estimate represents a minimum number of breeding adult penguins per year. Additionally, the total population size was not known, as the number of non-breeding adults (i.e. individuals taking a sabbatical from breeding in any one year), immature and juvenile birds in the population were not included and could not be reliably measured.

Breeding population size was determined as the number of unique nests with confirmed or likely breeding activity in the 2025 breeding year (i.e. March/April 2025 – February 2026) in Areas B – F, and multiplied by two, assuming two penguins per nest. The 2025/26 estimate was compared with the baseline population size of 156 – 226 individuals (Cannell 2025b).

In the event that the number of estimated breeding adults in 2025/26 was lower than the baseline estimate, a review of compliance records, along with the environmental indicators and biologging data will be used to assess the potential underlying cause of the reduction in breeding adults during the 2025/26 monitoring period.

2.4 Environmental variables influencing breeding

The influence of six variables identified as having the potential to influence breeding performance of penguins was investigated. These variables were:

- salinity (psu)
- dissolved oxygen (mg/L)
- sea surface temperature (°C)
- turbidity (nephelometric turbidity units)
- rainfall
- the area (i.e. Area A – F) in which the nests were located.

Salinity, dissolved oxygen, sea surface temperature and turbidity data were obtained from the Water Information Reporting (WIN; 2026). Hourly data obtained from two collection buoys in 2025 (CS11 and CS13) (Fig. 2) were summarised to extract monthly means, as this is typical for investigating the influence of environmental variables on fish composition and abundance (e.g. McInness et al. 2017, Yeoh et al. 2025), which ultimately can influence penguin breeding. Furthermore, due to the asynchronous breeding of the penguins, not all will be foraging within Cockburn Sound on the same day, or for the same duration, and thus it is more appropriate to use monthly mean data. The monthly means were obtained using the package 'dplyr' (Wickham et al. 2023) in R, a free computer programming language (R Core Team 2018, 2021, 2022). In addition, total monthly rainfall was obtained from the Bureau of Meteorology website at the Perth Airport (http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_startYear=&p_c=&p_stn_num=009021).

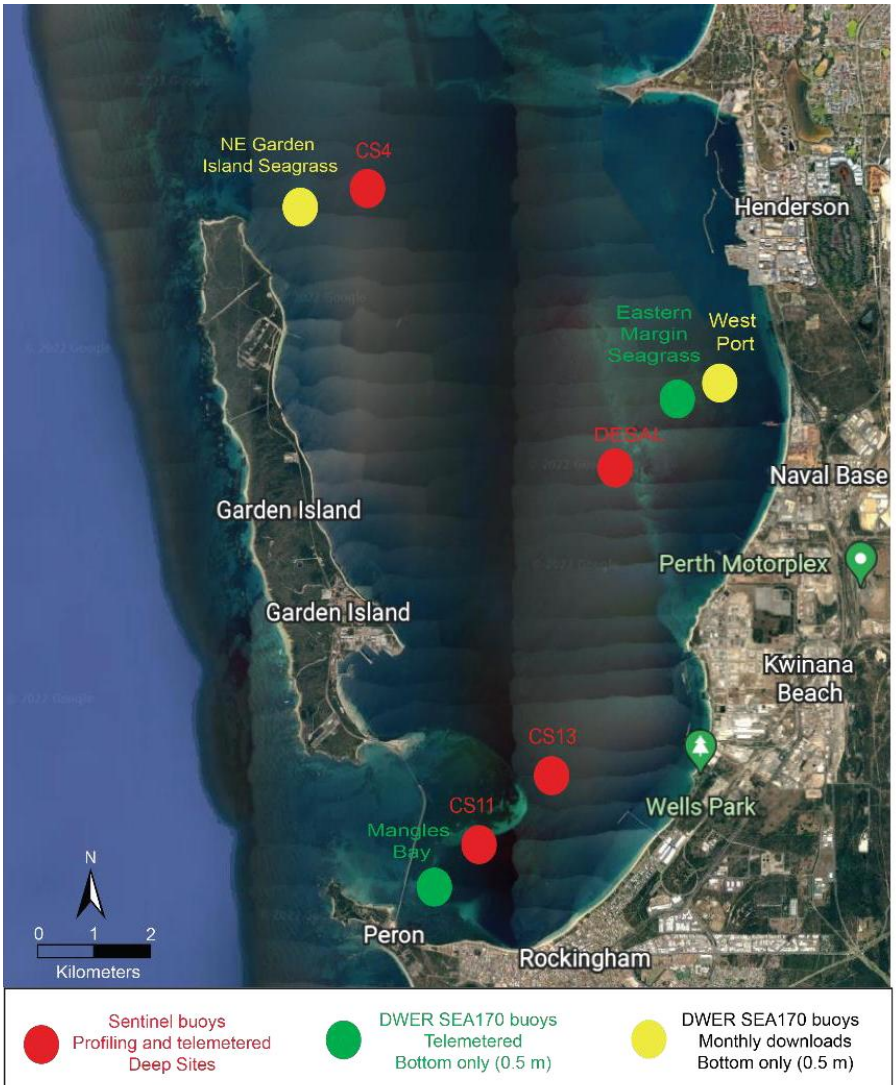

Fig. 2. The location of in-situ buoys from which hourly environmental variables (salinity (psu), dissolved oxygen (mg/L), sea temperature (°C) and turbidity (NTU)) were collected in 2025 (C11 and C13 only). Data and map supplied by Department of Water and Environmental Regulation, Water Information section, Perth Western Australia.

2.5 Analyses

All analyses were performed using multiple packages in 'R' versions 3.5.0 (for analysis of single day trip data from satellite tag deployment), 4.1.3, or 4.2.3 (R Core Team 2018, 2021, 2022). Mean ± one standard deviation is reported unless otherwise stated. Candidate models were compared using Akaike's Information Criterion (AIC), with ΔAIC < 2 considered to indicate comparable support between models (Burnham & Anderson, 2002; Symonds & Moussalli, 2011).

2.5.1 Spatial and temporal variation of penguin presence in each area

The number of nests with activity was determined on every monitoring visit for Areas A, B and C combined, D and E combined, and F. Areas B and C were combined as they represent those nests on the eastern edge of Careening Bay and Moresby Wharf and would both encounter movements of small and occasionally larger vessels in and out of Careening Bay. Areas D and E were combined as they represent the areas between Diamantina – Oxley wharves and thus would encounter large vessel movements. A nest site is regarded as active on any given monitoring session and is not influenced by the previous monitoring.

2.5.2 Environmental variables influencing breeding

In all models, salinity, dissolved oxygen, sea surface temperature (SST), turbidity, rainfall, Area, and Month were initially considered as potential fixed effects. For each breeding attempt, the mean value of each environmental variable was calculated for the month in which the eggs were laid. As these environmental variables were calculated as monthly means and assigned to each breeding attempt based on the month in which eggs were laid, Month was structurally confounded with all environmental predictors, with one-way ANOVAs confirming near-total dependence between Month and each variable (all $F > 1 \times 10^{28}$, $p < 0.001$; residual variance ≈ 0).

Generalised linear mixed models (GLMMs) incorporating nest identity as a random intercept were initially attempted for both egg success and chick success (both area binary response variable) using the function *glmer* in the R package “lme4” (Bates et al. 2015). Prior to modelling, pairwise correlations between predictor variables were examined, and variables with high collinearity ($r > 0.7$) were not included in the same model. Therefore, two separate candidate models were constructed using ecologically non-redundant predictor sets to avoid multicollinearity: Model 1 (salinity, SST, and turbidity) and Model 2 (dissolved oxygen, turbidity, rainfall). Full GLMMs, which included the appropriate environmental predictors as well as Area, Month, and the random intercept, failed to converge, with the fixed-effects model matrix found to be rank deficient. This was due partly to Month and the environmental variables essentially giving the model the same information twice since the environmental values were calculated as an average for each month. Additionally, some combinations of Area and Month had no data at all, leaving the model unable to work out whether a pattern was due to the location or the time of year.

Simplified models retaining only Area and the random intercept for nest identity did converge, but returned a singular fit, meaning the estimated variance of the random effect was essentially zero. This indicated that nest identity wasn't explaining any meaningful variation once Area was accounted for. This was because 48 of 61 nests were represented by only a single observation, with a further nine contributing just two. Random effects require repeated observations within each group to estimate how much groups genuinely differ from one another — with almost every nest represented by a single data point, there was essentially no information available for the model to detect nest-to-nest variation, even if it existed.

Given these convergence and estimability issues, generalised linear models (GLMs) were used in place of GLMMs to identify the variables associated with variation in the breeding success. As the vast majority of nests contributed only one observation each, the risk of pseudoreplication from treating observations as independent is considered minimal. The models were applied using the functions *glm* in the R base package “stats”. A GLM with a binomial error distribution and logit link function was used to model the success vs failure of eggs hatching or chicks fledging. The response variable is a binary variable indicating whether or not at least one egg in a given nest successfully hatched or at least one chick in a given nest was successfully raised. To determine the influence of environmental variables on the proportion of eggs laid each month, a GLM with a quasibinomial error distribution and logit link function was used.

For the analysis of at least one egg hatching in a nest, two initial full models were fitted, 1) including the categorical variable area along with salinity, SST and turbidity and 2) categorical variable area along with dissolved oxygen, turbidity, rainfall. For each full model, single-term deletions were performed on the full model using the function *drop1* in the package ”lme4” (Bates et al. 2015), and likelihood ratio tests (χ^2 test) to assess the individual contribution of each predictor while controlling for the others. The *drop1* function assesses the effect of removing each predictor individually from the full model and compares the change in the model deviance. As area did not contribute significantly to model fit for either of the models ($p>0.05$), and did not meaningfully improve AIC, it was removed from subsequent models. The *drop1* function was then re-run on the reduced models, and the most parsimonious model was used for the presentation of model coefficients and visual representation of variable effects. For Model 1, this process kept salinity, SST and turbidity. For Model 2, the backward elimination showed that dissolved oxygen, and turbidity did not contribute significantly to the model (all $p > 0.05$), while rainfall remained highly significant at each step ($p < 0.001$).

The final reduced models for each set of variables were compared using AIC, McFaddens Pseudo R^2, and k-fold cross validation. McFaddens Pseudo R^2 was calculated using the package *“*pscl” (Jackman 2024), to provide an additional measure of the proportion of deviance explained by each model relative to the null model, i.e. the simplest model where there are no predictors. The k-fold cross validation was determined using the function *cv.glm* in the package “boot” (Canty and Ripley 2021), with k=11. This is a resampling technique where the dataset is randomly split into k equal groups (in this case 11), the model is trained on 10 of the 11 groups and tested on the group that is left out. This is then repeated 11 times, each time a different group is held out for testing. A final delta value is the average prediction error across all 11 rounds.

For the analysis of at least one chick being successfully raised to fledging, the same modelling approach was applied to the two candidate predictor sets. The contribution of each term was assessed using single-term deletions, using *drop1* with likelihood ratio tests.

As the proportion of clutches laid each month relative to the total number of clutches laid annually, was modelled using a GLM with a quasibinomial error distribution and logit link function, the *drop1* function was used with F-tests, not likelihood ratio tests, appropriate for quasibinomial models.

2.5.2 Population change

To determine the breeding population, nests with known breeding activity were counted. Additionally, in a few nests, the eggs and chicks were never observed. If one or more of the indications of nesting activity were noted on more than one monitoring date for a nest, then the nest was classed as having a likely breeding attempt.

To calculate the rate of population change between time periods (λ-lambda) we used the equation

$$\lambda_i = N_{i+1}/N_i$$

where N_{i+1} is the count in year i +1 and N_i is the count in year i (Williams et al. 2002).

The rate of population change used the counts of breeding adults from Areas C – F only, as these were the only areas with data available across the full time period.

2.6 Behaviour monitoring- movement at sea

To study the at-sea movements of the penguins two different types of tags were deployed on the penguins:

- satellite tags (Kiwisat PTT 202 K2G 173A, 32g, 60 x 27 x 17 mm, Antenna angle 45°, duty

cycle 1900-1400 UTC, repetition rate 35s, or Kiwisat PTT K4G 154, 17g, 74 x 21 x 11 mm, Antenna angle 45°, duty cycle 1900-1400 UTC, repetition rate 35s) deployd during incubation
- GPS tags (Axy-Trek Marine, 26g, 56 x 23 x 12 mm), which obtain GPS positions at a very high frequency, deployed during the chick-guard phase.

All tags were deployed on penguins inhabiting the nestboxes within Area C in 2025. Tags can only be deployed on penguins in the nestboxes as it is difficult to remove penguins from the natural burrows without potentially injuring the penguin or collapsing the burrow. Each breeding parent can be deployed with either a satellite tag or a GPS tag, but satellite tags are not deployed on both parents during incubation (due to the potential energetic costs on the bird due to the tag during a protracted incubation period at sea). Generally, a satellite tag will be deployed on one parent, and a GPS tag will be deployed on the other parent. However, tags can only be deployed on penguins that meet mass criteria and do not display overt stress during the attachment process, and chicks, if present, are gaining adequate mass.

Data from the satellite tags were collected by Argos and obtained from the Argos website (https://www.argos-system.org/). In contrast, the GPS tags are archival, and hence data were downloaded from the GPS upon retrieval of the tags. All the tags were removed from the penguins after one or two foraging trips. The battery life of a satellite tag is approximately 292 days, whilst that of the GPS tags is dependent on the frequency at which location data are obtained but was approximately 3 days when obtaining locations every 30 seconds, the frequency used in this study. The GPS tags are rechargeable.

Location data were analysed using different methodologies, dependent on:
a) the type of tag deployed on the penguins, and
b) if the fitted model adequately described the data, as validated by plotting the predicted residuals, i.e. the differences between the observed and predicted values of the x and y locations.

Satellite tags
The location data from the single day trips obtained during this breeding season were initially analysed using a Bayesian State-space model (SSM) to account for location uncertainty (Jonsen et al. 2005, Patterson et al. 2008). Four models were fitted to the SSM - a correlated random walk model with one- or two-hour time steps, and a random walk model with one- or two-hour time steps. A correlated random walk is where movement is random and correlated in direction and magnitude, whereas movement is random in direction and magnitude in a random walk (Jonsen et al. 2023). The models were fit using the R (R Core team 2023) package “aniMotum” (which superseded the package “foieGras” used for the analysis of the data collected in 2021) (Jonsen et al. 2020, Jonsen et al. 2022, Jonsen et al. 2023). The 50% kernel density area represents the area where there is a 50% chance of finding that animal and generally represents core foraging habitat. However, for this colony of penguins, it can also include the area when the penguins first depart from the colony and move very slowly, spending much time preening and floating on the surface, as well as the area where they raft offshore in the evening before returning to the island. The 95% kernel density area represents home range.

Data from satellite tags deployed on penguins that completed foraging trips but could not be analysed using the SSM (due to poor fit in the model outputs), were analysed separately. The study area was gridded into 500 m x 500 m square grids, and the total time spent in each grid cell was determined using the ‘trip’ package (Sumner & Luque, 2015) in R (R core team 2019). To represent spatial use, the grid cells were ranked in order of time spent in each cell, and the relative proportion of the time spent in each cell was then determined by dividing the time spent in each cell by the total time the penguin was at sea (Soanes et al. 2013, Ferreira et al. 2020). The core area was represented by the cells which covered the first 50% of the cumulative frequency distribution and home range was represented by cells which covered the top 95% of the cumulative frequency (Soanes et al. 2013). Choropleth maps, i.e. the colour-coded grid cells, were produced in ArcGis Pro (v 3.2) to visualise the variation of the time a penguin spent in each grid. Data were initially classified using the Jenks natural breaks optimization algortithm, which identifies natural groupings in the data by minimizing within-class variance and maximizing between-class variance. The number of classes was set to 5. As this method suggested time periods with the minutes set to six decimal places, the classes were then manually changed to the nearest whole number representing a multiple of 5 (e.g. 15, 20,…,45 minutes). As the data for the time spent in each grid cell are different between trips, so too are the classes of time spent for each grid cell per trip.

Satellite tags turn on once wet, therefore the initial transit path from the island could not be identified from the Argos data. However, it was modelled by using the colony as the start point.

GPS tags

As the data from the GPS tags had greater position accuracy, and the locations were obtained at a much higher frequency rate, the raw data were analysed without preprocessing. However, due to this high frequency rate of location detection, the data are autocorrelated, and conventional kernel density estimation tends to underestimate the space used for home range (Fleming et al. 2015). Therefore, only the 50% kernel density area is determined using the hplugin value implemented in the function “kde” of the R package “ks” (Duong 2025). As noted above, the 50% kernel density area can represent both the foraging area as well as the at-sea departure and arrival areas. Mapping was conducted in ArcGIS Pro 3.2. A single trip was measured from the time the bird leaves the colony until it returns. Birds can undergo either multiple single day trips, or a multi-day trip. Given the generally high temporal resolution of the GPS data, a line was also drawn between each point to indicate likely area covered by the penguins between each location.

2.7 Nest integrity monitoring

Little penguin nesting habitat condition assessments were completed as part of the breeding population monitoring and all current, historical or possible burrows were visited each fortnight. Any obvious degradation of burrows or changes to the rock wall from the baseline state were documented, photos taken and changes were reported to the Site Environment Officer (SEO) if the changes were related to construction activities, as per the requirements outlined in the LPMMP (RPS 2026a). Any changes in nest integrity related to natural events, such as storms, rainfall and high tides, were noted in the appropriate monthly and quarterly reports.

2.8 Quality assurance and quality control

Quality assurance and quality control requirements were carried out in accordance with Section 8 of the LPMMP (RPS 2026a).

2.9 Limitations and assumptions

Regarding movement behaviour, there are no satellite passes over the Perth region, including Cockburn Sound in the early afternoon. Therefore, there are no location data for this period. As such the movement patterns potentially represent a limited foraging range.

Regarding population assessments, it is possible that a small percentage of nests deep within rock wall cavities are missed. Therefore, the population estimate represents a minimum number of penguins per year. Additionally, a population is not only composed of breeding adults, but also nonbreeding adults and juvenile penguins. The latter two groups of penguins will likely intermittently visit the colony, but it is not known how long they remain at the colony. It is not possible to get the counts of these two groups by counting nests with breeding activity.

3. Results

3.1 Spatial and temporal variation in penguin presence

Between 370 and 392 potential, historical, and current nests were monitored each fortnight from April 2025— March 2026. The number varied due to new nest sites being used by penguins, particularly in Area A where monitoring only began in April 2025. Evidence of penguin activity was observed in 262 nests across the year. Whilst there was generally a similar pattern of activity between the areas with a peak of activity in October/November 2025, and an increasing trend from March to April 2026 that was greater than the preceding year, there were some spatial differences.

There was generally an increasing trend in the number of nests with activity in Areas B and C from April to October, although there was a decrease in June, and a lesser decrease in August (Fig. 3). The decrease in activity at these times was unexpected. This is because the penguins' breeding season typically extends from April to November, and there often is a peak of eggs laid in June and a second peak in September, and therefore an increase in the number of active nests before, during and after these peaks is expected. The maximum number of active nests occurred in late October, with 51 active nests (Fig. 3). Although there was a maximum of 51 active nests on any one visit, 148 of the potential 230 nest sites in Areas B and C (i.e. 64%) had evidence of activity over the monitoring period (Fig. 4).

Whilst the activity followed a similar pattern in Areas D and E from March to early June, the downward trend was longer in both June and August (Fig. 3). A peak of 28 nests with evidence of activity was found in early October 2025 (Fig. 3). A total of 59 different nest sites of the potential 70 between the Diamantina and Oxley wharves (i.e. 84%) were found to have evidence of activity. (Fig. 4). There was no monitoring between Diamantina and Parkes wharves in mid-November 2025 for security reasons. As a result of this, the total number of active nests between all three wharves was not graphed, even though the nests between Parkes and Oxley wharves were monitored. As such, it is unknown if the number of nests with activity decreased from the early November count, as it did for Areas B and C, and F, or if it increased, as it did in Area A.

The pattern of penguin activity in Area F was similar to Areas B – E, although the decline in activity was slightly later, occurring later in June and continued through to July. Thereafter there was an increasing trend in activity, and unlike Areas B – E, there was no decline in August (Fig. 3). However, the maximum number of nests with activity on any visit, 14 nests, was in November. There were 33 nest sites of the potential 73 (i.e. 45%) with evidence of activity across the whole year (Fig. 4).

Monitoring of the nests in Area A began in April 2025. Peak activity occurred in 12 nests in mid-July and thereafter declined until late August. Activity again peaked in mid-November (12 nests), later than in the other areas (Fig. 3). All of the 21 nests within this area (i.e. 100%) had evidence of activity across the whole year (Fig. 4).

For all areas any increase in activity across the summer months (December to February) represented the penguins' moulting period, when either moulting birds or evidence of moulting birds, were observed. The decline following the typical moult period is expected as the penguins depart the colony and generally remain at sea until pre-breeding, which usually begins March/April. This was evidenced with the increased numbers of nests with activity in early and late March, Notably, the numbers of nests with activity were substantially higher in March 2026 compared to March 2025, in all areas (not including Area A where monitoring did not begin until April 2025).

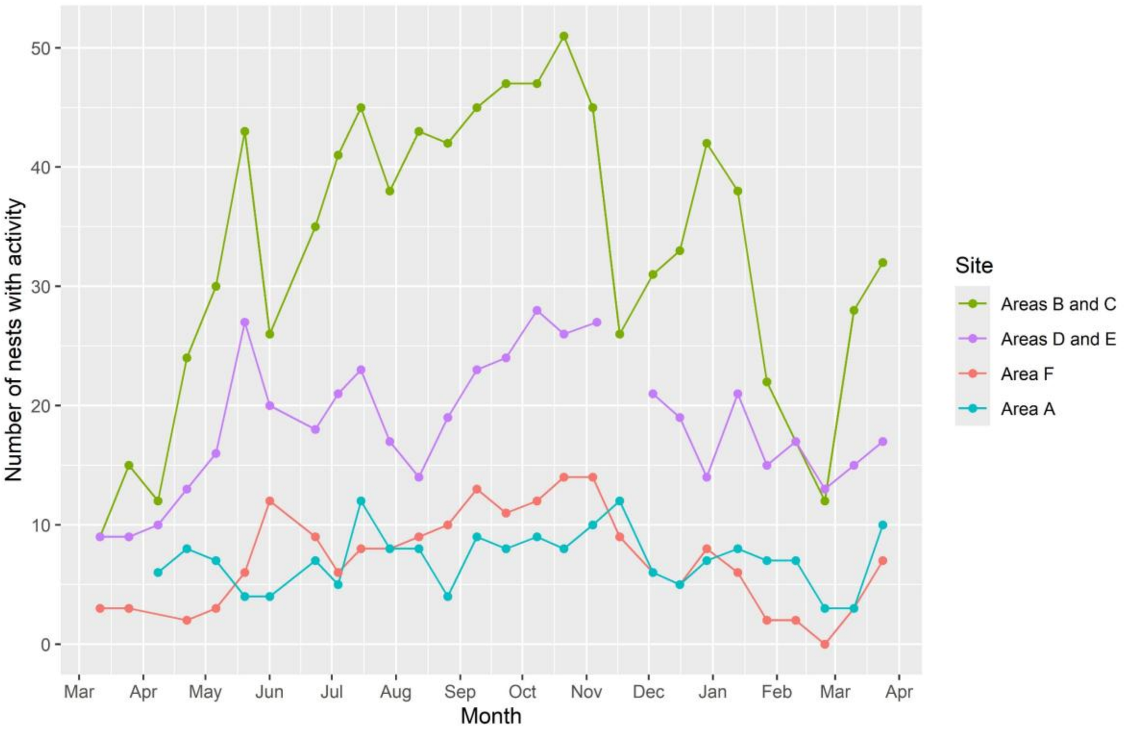

Fig. 3. The number of nests with activity in Areas B and C, D and E, F and A, on Garden Island, Western Australia, from April 2025 to March 2026. The gap in data for Areas D and E represents a date when monitoring was not allowed due to security reasons. Monitoring in Area A did not begin until April 2025.

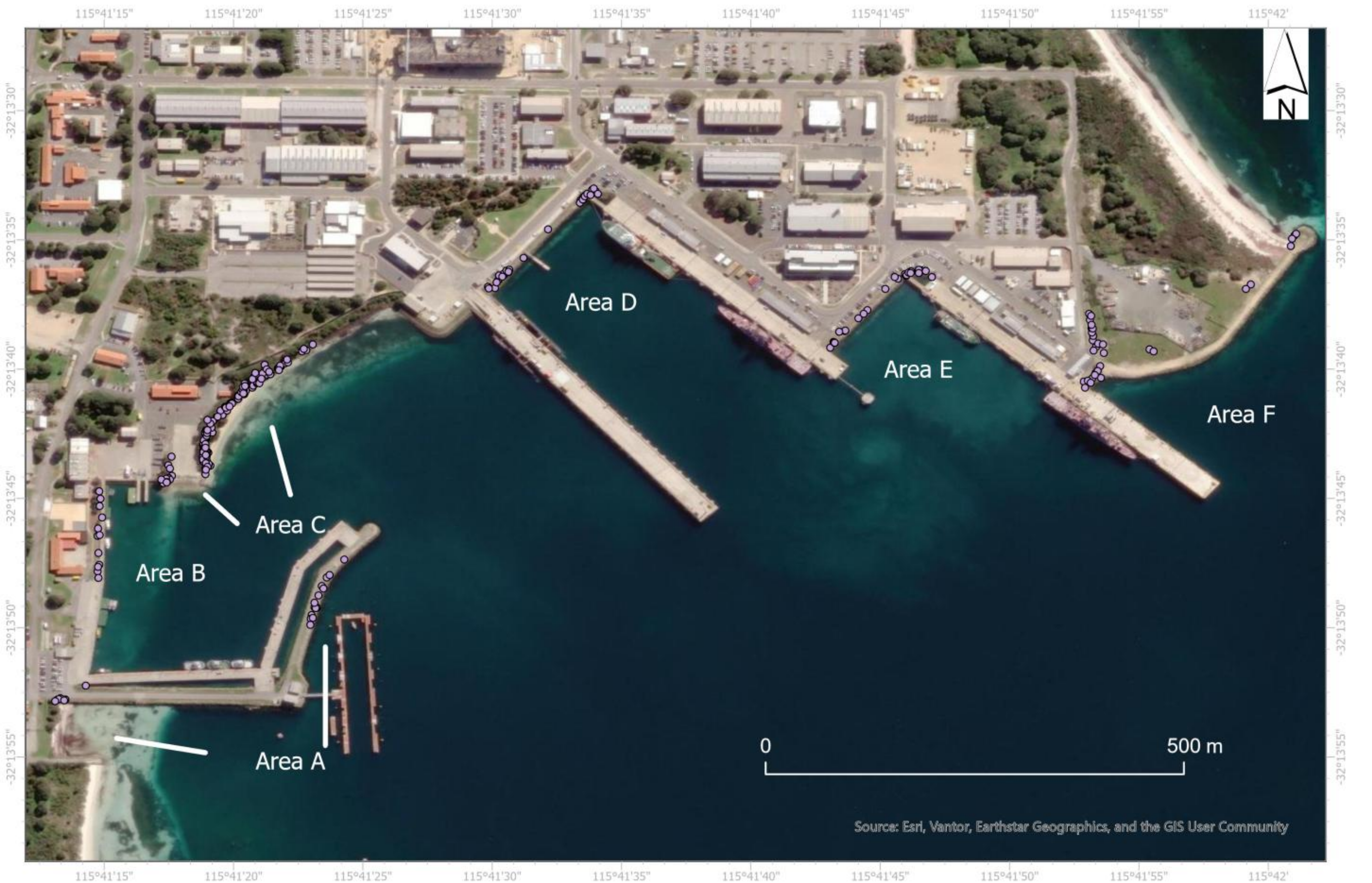

Fig. 4. Location of the nests with signs of little penguin activity Areas A-F on Garden Island, Western Australia, April 2025 – March 2026. The burrows are represented by purple dots.

3.2 Breeding population monitoring

There were 71 breeding attempts (i.e. eggs laid) across Areas A – F on Garden Island in 62 nests (Fig. 5), with known outcomes (including known month of egg lay) for 66 attempts in 57 nests. Second clutches (i.e. two breeding attempts within the same nest), occurred in nine nests. Of the 66 breeding attempts with known outcomes, 68% were successful, i.e. raised at least one chick to fledging from at least one egg.

For those nests in which breeding activity was observed and the outcomes were known, eggs were laid in every month from May to October, with a peak of clutches laid in August 2025 (Table 1). The proportion of successful clutches with known outcomes was highest for those eggs laid in June and July and lowest for those laid in May and October.

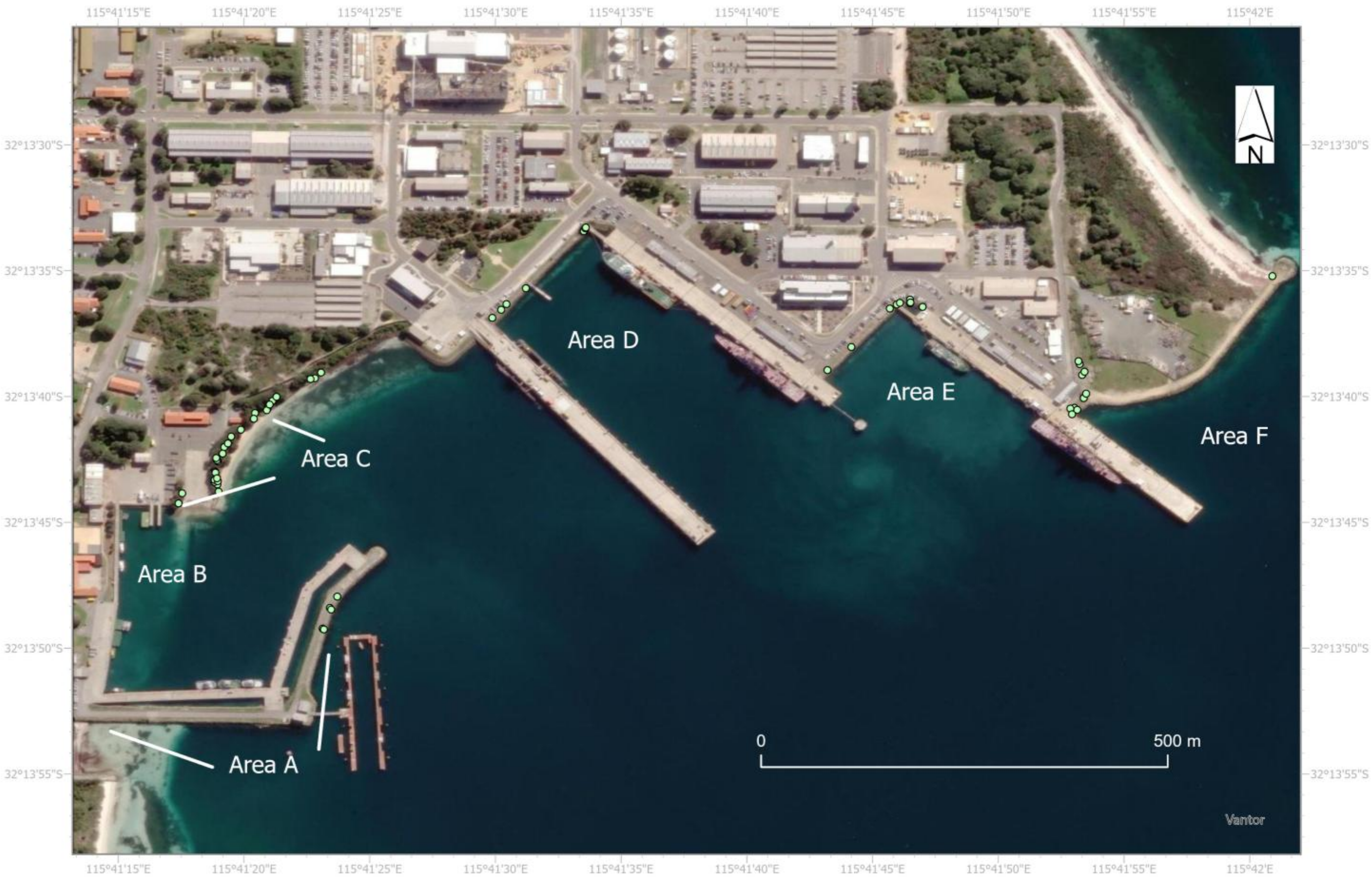

Fig. 5. Location of the burrows with known little penguin breeding activity, including those with unknown outcomes, on Garden Island, Western Australia, 2025. The burrows are represented by green dots. This does not include those burrows with likely breeding activity, where egg laying could not be confidently determined).

Table 1. The month and number of breeding attempts with known outcomes (i.e. at least one egg laid) in Areas A – F and the percentage in which at least one chick successfully fledged.

Month	N breeding attempts	Percentage (%) of successful breeding attempts
May	6	50
June	9	89
July	13	85
August	15	60
September	12	67
October	11	54

Breeding activity per Area 2025

Of the 57 nests with breeding activity and known outcomes, the highest proportion of breeding activity occurred in Areas B and C, and the lowest in Area A (Fig. 6). Six nests were in Area A (with a second clutch laid in one nest), there was no breeding in Area B, 25 nests were in Areas C (with second clutches laid in four nests), 16 nests were in Areas D and E (with second clutches laid in four nests), and 10 nests were in Area F (no second clutches laid). Breeding started in May in Areas B – E, and in June in both Areas A and F (Table 2).

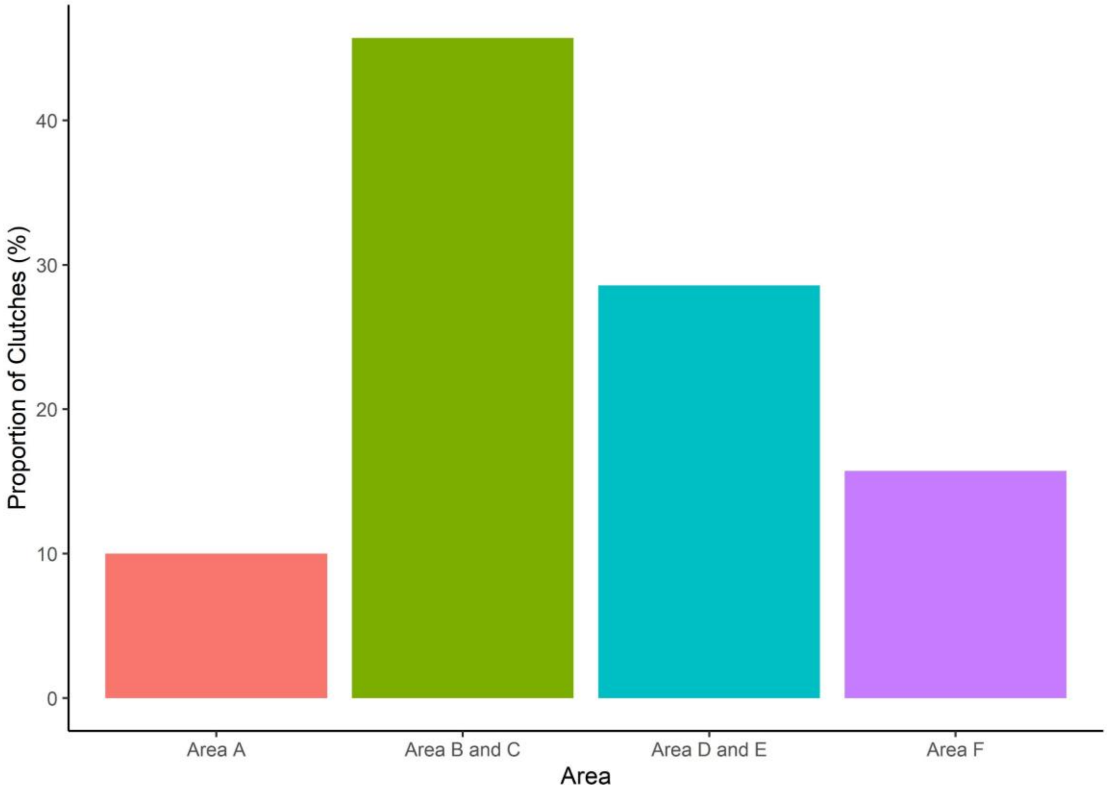

Fig. 6 The proportion of all breeding attempts, including those with unknown outcomes, in 2025 in each Area on Garden Island, Western Australia,

Table 2. For the nests with known breeding outcomes, the month of egg lay (as determined from chick age or when eggs were first sighted) and the number of nests with eggs in Areas A, B and C, D and E, and F, Garden Island, Western Australia, in 2025. The number of successful clutches, where at least one chick was raised to fledging, is indicated in parentheses. Note that second clutches were laid in some nests.

Month Laid	Area A	Areas B and C	Areas D and E	Area F
May	0	2 (1)	4 (2)	0
June	1 (1)	4 (4)	2 (2)	2 (1)
July	2 (1)	4 (4)	4 (4)	3 (2)
August	0	8 (6)	3(2)	4 (1)
September	2 (2)	7 (3)	3 (3)	0
October	2 (1)	4 (1)	4 (3)	1 (1)

Comparison with historical data

There were far fewer breeding nests with known outcomes in Area C in each year from 2021 – 2025 (Table 3), compared to the historical (2005 – 2019) average of 78±10 nests. Historically, the mean number of clutches laid was greater in each month, with the only exceptions being July 2022 and 2023, October – December 2021 and November 2022. Notably in both 2024 and 2025, the number of clutches in every month was below the historical monthly average (Fig. 7).

Table 3. The number of breeding nests in Area C only, with known breeding outcomes, and in Areas B and C (from 2023 –2025) with known breeding outcomes.

Year	Area C known outcomes only	Areas B and C, known outcomes only
2021	40[a]	
2022	51[b]	
2023	33	35
2024	35	38[c]
2025	25	25

[a] This had previously been reported as 42 nests as this had included those nests where the outcome was unknown (Cannell 2022)
[b] This had previously been incorrectly reported as 55 nests with known breeding activity, however the 55 breeding nests included four nests where the outcome was unknown (Cannell 2024).
[c] This was previously reported as 37 nests (Cannell 2025), but one nest had been incorrectly removed from the analysis.

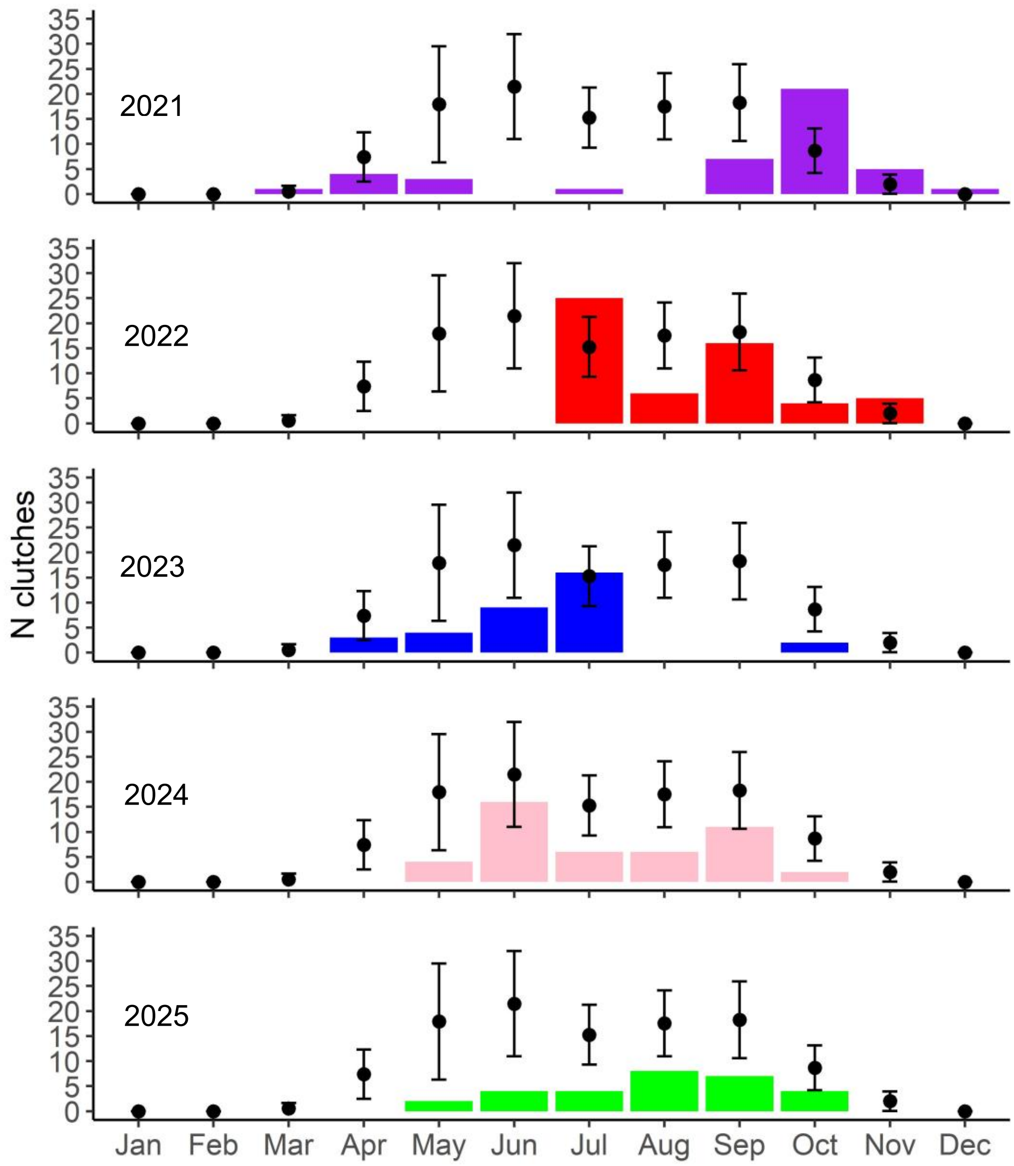

Fig. 7. The number of clutches laid by little penguins in Area C on Garden Island in 2021 (purple), 2022 (red), 2023 (blue), 2024 (pink), and 2025 (green) and the historical (2005 -2019) average number of clutches laid in each month (black dots).

3.2.3 Moulting Activity

Moulting penguins, or feathers in nests, were observed from mid-November 2025 (a moulting adult in a nest) through to early March 2026. Nests were used for moulting in Areas, A – F (Fig. 8), including a site under Oxley wharf, adjacent to where it meets land. A total of 108 nests/sites were used for moulting.

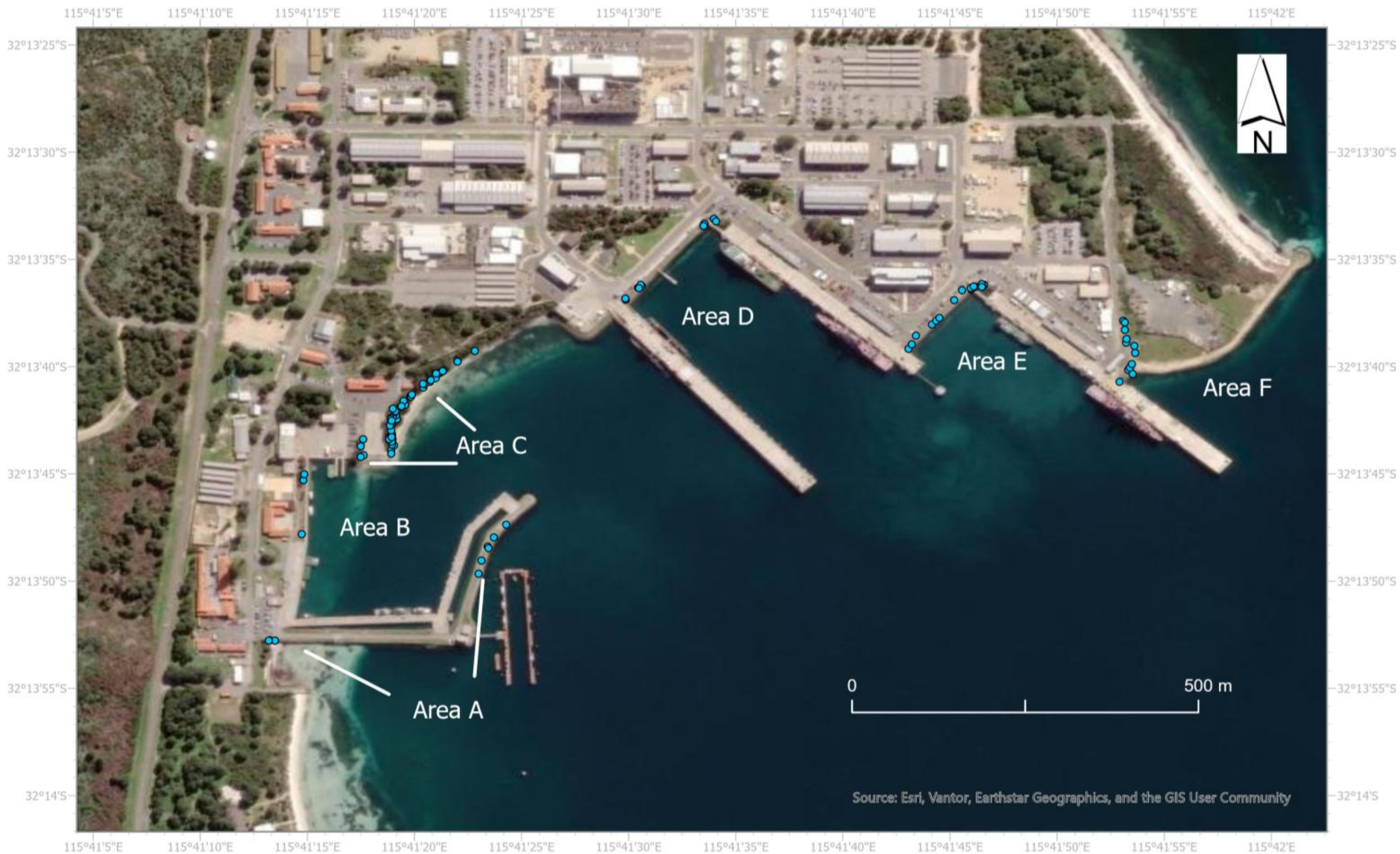

Fig. 8. The location of nests observed with either moulting penguins, or moulted feathers, on Garden Island, Western Australia, from November 2025- March 2026.

3.2.4 Dead, sick or injured penguins

Since April 2025, 15 penguins have been found deceased. Two of the deceased penguins were adults and 13 were chicks. They were found from July 2025 to January 2026. Ten of the chicks were considered to have died from starvation, one chick appeared to have become caught under a stick at the front of its burrow, while another was suspected to have fallen out of its nest and was found below the nesting site. An additional healthy, partially fledged chick was found at the entrance of its nest (see RPS 2025), while its sibling remained alive within the nest. The cause of mortality for this individual is unclear, and a laceration was observed on the body adjacent to its flipper (Fig. 9), could have been caused post- mortem by the parents or surviving chick attempting to get in or out of the burrow. This supposition is based on the highly abraded nature of the feathers (Fig. 9), just four days after it had last been observed alive, in addition to much digging around the entrance and the dead chick.

Both adult mortalities were individuals in moult (Table 4). Hyperthermia was unlikely to have contributed to the mortality of either individual. Pedal hyperaemia (i.e. dark pink feet and an indicator of hyperthermia, Cannell et al. 2016) was not observed in one penguin. Whilst this could not be discerned in the other penguin, and despite a maximum daytime temperature of 38.8°C on Garden Island two days prior to the discovery of the penguin, 19 km/h SE winds in the afternoon would have likely reduced the temperature within the burrow. Furthermore, there were 22 other burrows with moulting penguins that would have been present on the same day, none of which succumbed to the high temperature.

Table 4 The date and location of dead penguins found on Garden Island, Western Australia, from March 2025-March 2026. Each entry is for a specific nest. (2): two chicks found dead in the one nest.

Date	Adult/Fledgling/Chick	Area
15/07/25	Chick	C
15/07/25	Chick	D
29/07/25	Chick (2)	F
9/09/25	Chick	A
23/09/25	Chick	D
5/10/25	Chick	A
5/10/25	Chick (2)	A
5/10/25	Chick	A
21/10/25	Chick (2)	F
17/11/25	Chick	F
16/12/25	Adult	C
13/01/25	Adult	F

Warning: A photograph of a dead chick appears on the next page

Fig. 9 Dead partially fledged chick found in the entrance of nest 45B in Area C, Garden Island, Western Australia, on 5/10/2025. Note the laceration on its body near the flipper and the abraded feathers, likely caused by parents and/or its live sibling trying to get in and/or out of the nest site

3.2.5 Population change

In 2025, a record low of breeding adults was observed in Areas C – F (n=124 individuals), compared to 2021 – 2024 (range: 150 – 226 individuals, Table 5). There was a 26% decline in the number of breeding individuals compared to 2024 (Table 6), and a 45% decline from the maximum number of breeding individuals estimated in 2022. It should be noted that monitoring data for Area B were unavailable in 2021 and 2022 and therefore breeding adults nesting in this area were not included in totals for those years.

Breeding adult numbers also reached a record low across Areas B – F in 2025 compared to 2023 and 2024 (Table 5).

Although fewer breeding individuals were recorded in 2025, the largest decline in the annual rate of population growth occurred from 2022 to 2023, with a growth rate of 0.66, equivalent to a 34% decline. The greatest annual increase occurred from 2021 to 2022, with a growth rate of 1.33, equivalent to a 33% increase (Table 6).

Table 5. The number of adults observed breeding, and likely breeding, in Areas C – F and in Areas B – F on Garden Island, in each year from 2021 to 2025. This includes all breeding attempts, including those where the outcome was unknown. Note that no data were collected in Area B in 2021 and 2022.

Year	N breeding adults Areas C – F	N adults likely breeding, Areas C – F	Total N breeding adults Areas C – F	N breeding adults Area B	N adults likely breeding, Areas B – F	Total N breeding adults Areas B – F
2021	136	34	170	-	34[a]	
2022	190	36	226	-	36[a]	
2023	128	22	150	4	24	156
2024	142	26	168	8	28	178
2025	112	12	124	0	12	124

[a]No data available for Area B

Table 6. The rate of population change (λ) in Areas C – F from 2021 – 2025, and the% change in growth compared to the previous year, on Garden Island, Western Australia

Year	λ	% change
2021		
2022	1.33	+33
2023	0.66	-34
2024	1.12	+12
2025	0.74	-26

3.3 Environmental variables influencing breeding

Comparison metrics of the final two models predicting egg success showed that the model with rainfall only outperformed the model with salinity, SST and turbidity (Table 7). For each 1 mm increase in rainfall, there was a 2.7% increase in the odds of egg success (Fig. 10).

None of the other predictors (as defined in Section 2.4) had a statistically significant effect (all $p > 0.05$) on the likelihood of chicks successfully fledging, or the proportion of eggs laid in each month

Table 7 Summary of candidate GLMMs and GLMs for each response variable, including predictors, distribution, AIC, number of parameters (k), residual degrees of freedom, and significant predictors. Note that AIC are not defined for quasibinomial models due to the lack of a true likelihood function; significance was instead assessed using F-tests from single-term deletions. The final model is indicated in bold.

Response Variable	Predictors	Distribution	AIC	k (parameters)	Residual df	Significant predictors
Egg Success	area,month, dissolved oxygen, turbidity, rainfall + nest identity as random effect	Binomial GLMM				Failed to converge
Egg Success	Area + nest identity as random effect	Binomial GLMM				Converged but singular fit (random effect variance ≈ 0)
Chick Success	area,month, dissolved oxygen, turbidity, rainfall + nest identity as random effect	Binomial GLMM				Failed to converge
Chick Success	Area + nest identity as random effect	Binomial GLMM				Converged but singular fit (random effect variance ≈ 0)
Egg success	area, dissolved oxygen, turbidity, rainfall	binomial	56.95	7	59	Rainfall (p=0.00772)
Egg success	**rainfall**	**binomial**	**49.07**	**2**	**64**	**Rainfall (p=0.00288)**
Egg success	area, salinity, SST, turbidity	binomial	58.156	7	59	SST (p=0.0151) Turbidity (p=0.0945)
Egg success	salinity, SST, turbidity	binomial	53.82	4	62	SST ($p < 0.001$), Salinity ($p = 0.047$); Turbidity retained despite non-significance ($p = 0.076$) based on ΔAIC and ecological relevance
Chick success	area, dissolved oxygen, turbidity, rainfall	binomial	54.833	7	48	None
Chick success	Area, salinity, SST turbidity	binomial	55.347	7	48	None
Proportion of eggs laid per month	dissolved oxygen, turbidity, rainfall	Quasi-binomial	NA	3		None
Proportion of eggs laid per month	salinity, SST, turbidity	Quasi-binomial	NA	3		None

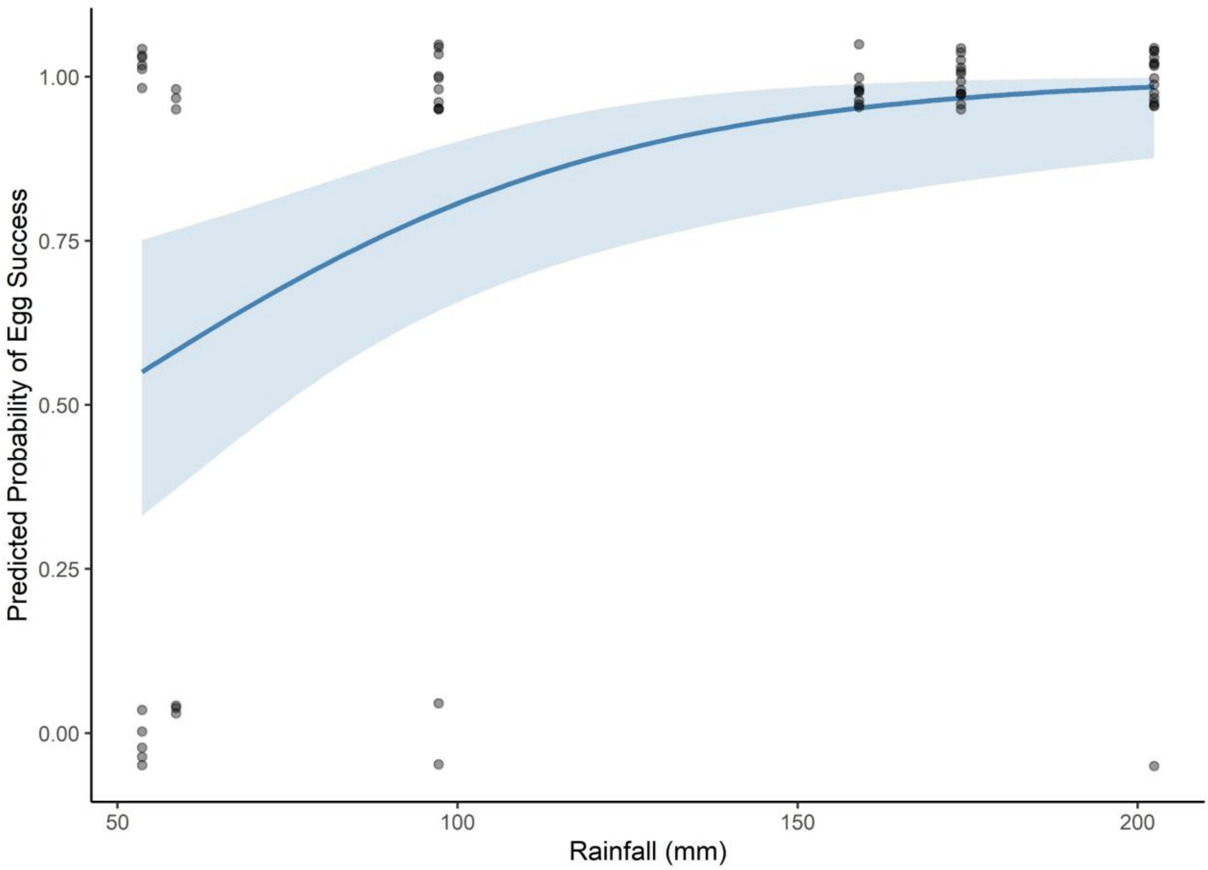

Fig. 10 The probability of eggs hatching on Garden Island with increasing rainfall (as measured at the Perth airport), 2025. Shaded areas represent 95% confidence intervals. Note that there were 66 breeding attempts, and the points have been slightly offset vertically to aid in visualisation.

3.4 Behaviour monitoring - Movement at sea

There were three breeding attempts in the nestboxes in 2025, all in Area C. A satellite tag was deployed on one incubating adult only. This was because the adults in the other nestboxes were either too light or had lost a significant amount of mass between two monitoring dates, indicating that either the parents were not regularly swapping their incubation shifts and/or prey abundance was limited.

A GPS tag was deployed on only one adult guarding chicks. This was because the chicks in one of the nestboxes had died when just a few days old. In the other nestboxes, one adult was too light, and the other adult had not only lost a significant amount of mass from early incubation to guard phase but was also displaying behaviour that was indicative of increased stress during an attempt to deploy the tag. In another nestbox, the chicks' mass had not markedly increased between checks and did not show abdominal fullness consistent with sufficient feeding, indicating that the parents were not swapping regularly and/or prey abundance was limited.

The tags were deployed in August and September (Table 8). Data were obtained from both deployments. The incubating adult conducted two single day foraging trips, but due to the low number of locations on each day, all four of the models obtained using the SSM did not fit the data well. Thus, the time spent in each grid cell was determined for each day. The adult guarding the chick conducted a single day foraging trip (Table 8). The penguins remained within Cockburn Sound, using the central basin, western margin, southern basin and/or Kwinana Shelf (Figs. 11 and 12).

For the incubating adult, the core areas, where the penguin spent 50% of its time, are represented by the grid cells with the dots (Figs. 11 a and b). The core foraging areas, represented by the red grid cells with the dots, were in very similar areas on both days, in the central basin (Figs. 11 a and b). This area is only approximately 1 km from the footprint of the Stage 3 Preferred Option for the Westport Port. The grid cells with the dots close to the island represent the core areas where the penguin spent longer periods of time when it first left the colony (Figs. 11 a and b). The penguins' home range on both days are represented by the grid cells with the dots (Figs 11 c and d). Its home range on the first day covered an area from the colony to the central basin (Fig. 11c), and on the second trip closer to the footprint of the Stage 3 Preferred Option for the Westport Port on the second foraging trip (Fig. 11d). The penguin travelled a maximum distance of 4.8 km from the colony on its first day, and 6.4 km from the colony on its second day.

The penguin guarding chicks initially headed SE before heading NE towards the central basin (Fig. 12). The penguin then spent several hours foraging, identified by areas of high residence and sinuosity often interspersed by slower travel between areas within the central basin (the 50% KDE areas, Fig. 12). However, there was a period of more rapid travel identified when the penguin swam from the central basin to another core area in the southern basin. During such travel, there is little time on the surface. This often leads to few locations and can be seen as a straight line on the map, though in reality it is unlikely to be this straight. The size of the core areas combined was 1.13 km^2.

Table 8. Trip information including sex, tag type, duration of trip and breeding success. Duration of multiple trips listed. Breeding stage: Inc - incubation, Guard - guard stage, when one parent remains in the nest to guard the chick. Tag type: Sat- satellite tag.

ID	Gender	Breeding stage	Tag type	Deployment date	Date of departure	Trip duration (days)	N eggs hatch	N chicks successful
21625481	Male	Incubation	Sat	8/9/25	10/9/25	2 x 1 day	2	0
21625479	Female	Guard	GPS	10/8/25	11/8/25	1	2	2

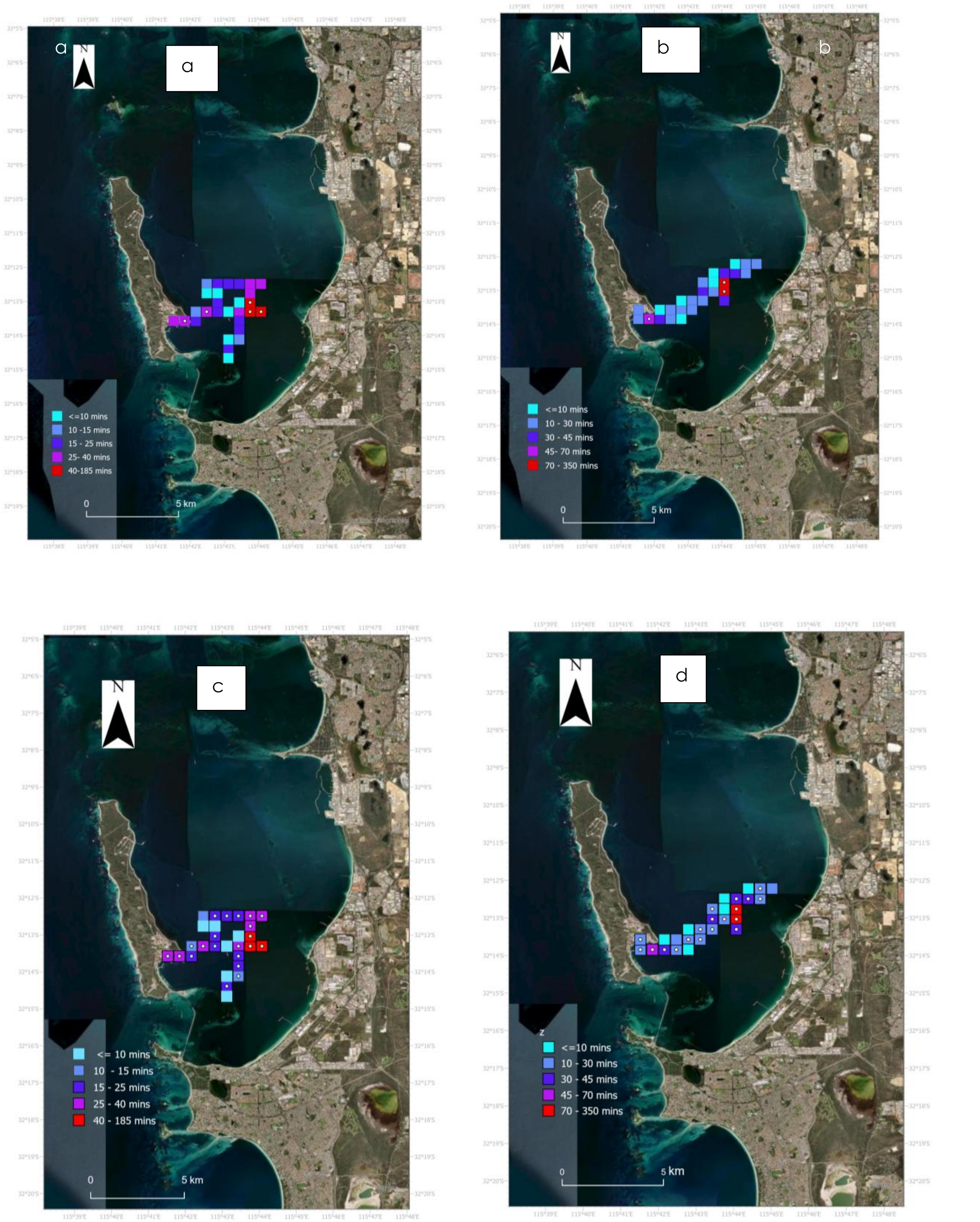

Fig. 11 The total time spent in gridded cells (mins) by one little penguin incubating eggs from Garden Island, during its first (a and c) and second (b and d) single day foraging trip in 2025. The cells with the dots represent the core areas where the penguin spent 50% (a and b) or 95% (c and d) of its time. The tag was deployed in September.

Fig. 12. The GPS locations and core habitat (50% KDE) of one little penguin from Garden Island during the chick guard stage of breeding in 2025. A line has been drawn between all the consecutive GPS locations.

3.5 Nest integrity monitoring

The bottom of one nest site in Area C collapsed, as observed on 26/8/2025. This site was not used for breeding in 2025. Note that a penguin was observed at the bottom of the nest site on 26/8/2025, which was the first observation of a penguin in this site for 2025 (Fig. 13). The degradation coincided with high tides and storm events, and as the nest was close to ground level, it is assumed that natural events were the likely cause.

Another change in the integrity of a nest was observed in Area C (Fig. 14), following 100 mm of rainfall recorded on Garden Island on 28 March 2026. There was successful breeding in the nest from July to October 2025, but there have been no signs of activity on any monitoring dates this year. The collapsed area has been covered over to prevent any future adults or chicks falling in the gap.

Fig. 13 A penguin observed in the bottom of a nest site in Area C 26/8/2025. The bottom of the nest had collapsed some time between 12/08/2025 and 26/08/2025. The collapse was most likely due to high tides and storm events

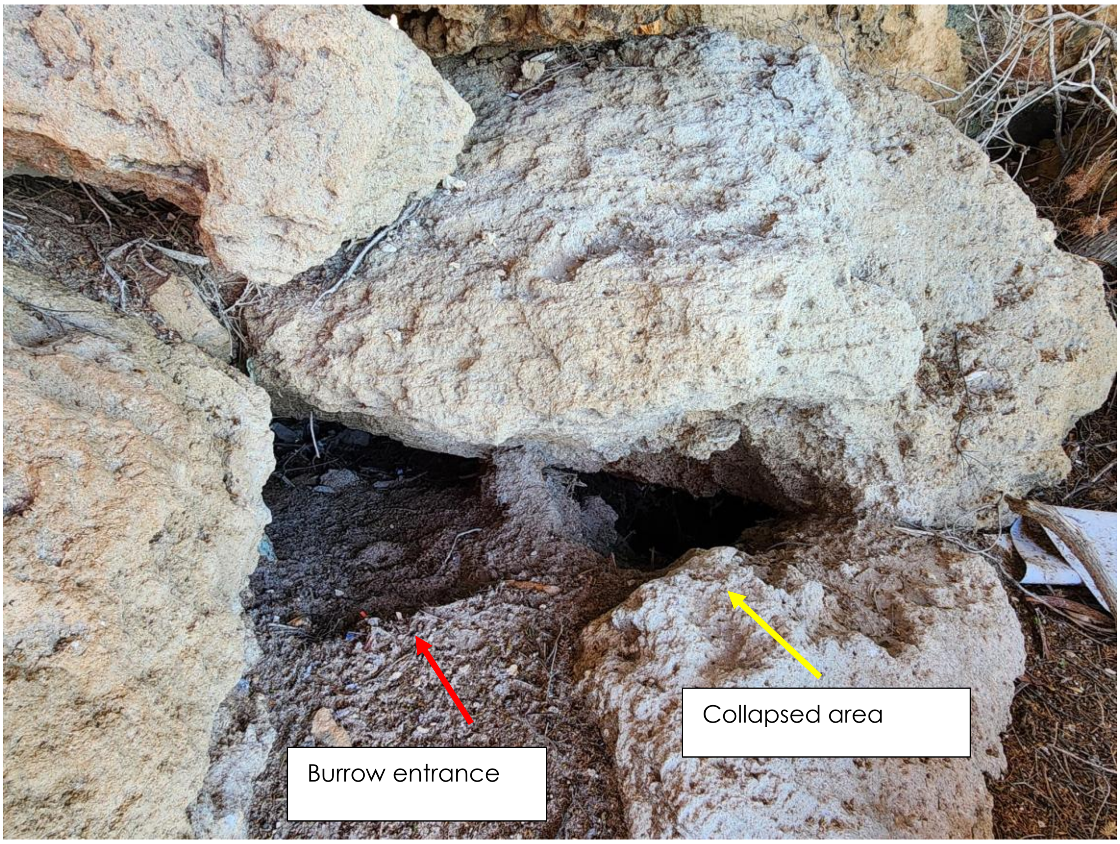

Fig. 14 Nest site in Area C with collapsed section just north of the entrance, following 100 mm of rainfall on 28 March 2026 at Garden Island, Western Australia.

4. Discussion

This report details the activity, breeding performance, movement patterns at sea, moult cycle, mortality events and population assessment of little penguins on Garden Island from April 2025 – March 2026. The integrity of their nest sites following exceedance thresholds and other natural events was also determined.

Nest monitoring

Comparing the number of nests with signs of activity from 2021 – 2024 with that in 2025, there was not a consistent trend in the number of nests with activity within or between each area. In Area C (i.e. Main colony), there were more nests recorded with activity in 2025 compared to 2022 (148 and 136 nests respectively, Cannell 2024) but fewer than in 2021 (N=185), 2023 (N=156; Cannell 2024) and 2024 (N=158; Cannell 2025a). However, for all years except 2021 and 2022, this included active nests in Area B (i.e. parallel to Moresby wharf). In Areas D and E (i.e. between the wharves), there were more nests with activity in 2025 (N=59) compared to 2022 (N=36; Cannell 2022), 2023 and 2024 (N=54 in both years; Cannell 2024, 2025a), but less than 2021 (N=62). The number of nests with activity in Area F (i.e. Colpoy's Point) has continued to decline annually, from

64 nests in 2022 (Cannell 2024) to 33 nests in 2025. The decline of activity in Area F is likely due, in part, to the large number of penguins that were killed by fox/es in this area in 2023 (see Cannell 2025b for further explanation of the potential delayed impact on activity in this area).

The magnitude and direction of change in the number of nests with activity between months in Area C was not consistent between years. For example, a decrease in active nests from May to June was only observed in 2022 and 2025, an increase from June to July was only observed in 2025, and there were more nests with activity in early July 2025 compared to all years from 2021 – 2024. A decrease in the number of nests with activity from July to August only occurred in 2021 and 2025, but there was an increase in the number of nests with activity from November to December in 2023 and 2025 only. Overall, fewer penguins were generally visiting the colony from January to June in 2025 compared to 2021 – 2024, and from August to October 2025 compared to 2022 and 2023.

There was more breeding activity in 2022 compared to 2021, 2023, 2024 and 2025 (Cannell 2022, Cannell 2024, Cannell 2025a), but the number of nests with breeding in all five years was lower in most months compared to historical data, except for October 2021 and July 2022. Overall, there has been a decrease in breeding activity in Area C since 2022. In contrast, the number of breeding adults using Areas D and E initially increased from 2021 to 2023 (N breeding nests = 13, 17 and 18 in 2021, 2022 and 2023 respectively, Cannell 2022, Cannell 2024), before slightly decreasing from 2023 to 2025 (N breeding nests = 17 and 16 in 2024 and 2025 respectively, Cannell 2025a, this report). The number of breeding adults in Area F drastically declined in 2023 (N breeding nests = 12, 21 and 4 in 2021, 2022 and 2023 respectively, Cannell 2022, Cannell 2024), following the large number of adults killed by foxes that year (Cannell 2024). Whilst it has more than doubled since then, it has remained steady in 2024 and 2025 (N breeding nests = 10 in both 2024 and 2025, Cannell 2025a, this report). Overall, the decrease in breeding adults in Areas D and E was smaller than in Areas C and F, highlighting the importance of Areas D and E to the ongoing success of the colony.

Whilst fewer penguins participated in breeding in 2025, the success of breeding attempts with known outcomes was similar to that in 2022 – 2024 (i.e. 63%, 62%, 65% Cannell 2024, Cannell 2025a), and higher than that in 2021 (47%, Cannell 2022). Furthermore, the success of clutches laid in July 2025 was greater than those laid in the same month in any other year from 2021 – 2024, greater for those laid in August 2025 compared to August 2023 and 2024, and greater for those laid in September and October 2025 compared to those laid in the same months in 2022 – 2024 (Cannell 2022, Cannell 2024, Cannell 2025a). The greater success of those clutches laid in July – October 2025 is presumably related to increased prey availability compared to the same months in other years.

Population change

The estimate of breeding penguins in Areas B – F on Garden Island in 2025 has decreased below the baseline level of 156 penguins to 124 penguins. The number of breeding penguins has decreased in Areas B and C, (the latter adjacent to the infrastructure changes), but only marginally in Areas D and E, and with no change in Area F since 2024, it is possible that the infrastructure changes associated with the SRF-West project could have influenced the penguins returning to breed in Area C. However, there are several other factors that will have influenced the number of penguins observed breeding in this area in 2025, including:

- Recent mortality events, including predation of four penguins by foxes in 2023 (Cannell 2024)
- Three adults that died from hyperthermia in early 2025 (Cannell 2025a)

- A large carpet python observed on multiple occasions in Area C during 2024, with penguin feathers in its faeces indicating likely predation of an unknown number of penguins. (Cannell 2025a).

  Any losses of adults will impact the immediate population estimate, as well as chick production, which would then have a longer-term impact on the recruitment of juveniles back into the population two to three years after the event e.g. 2025 – 2026 for the fox predation event in 2023. Additionally, even if only one of a pair has been removed from the population, the surviving mate may not find another breeding partner immediately. There will also be a longer-term impact, based on the lost breeding effort over multiple years from those penguins that were killed, and those juveniles who themselves would have become breeding adults.

Other factors which may influence the change in the number of breeding penguins between areas in any year include:

- Potential differences in the age structure between which may influence the number of penguins in each area. For example, if there were a greater proportion of older birds in Area C, they may have died or reached breeding senescence, which would influence the number of breeding penguins for that area. However, to assess this, it would be necessary to microchip chicks from all areas, but it is too difficult to remove the penguins from their nest sites. Furthermore, to obtain enough data to discern any differences in age structure, this would have to be conducted over many years due to the likely high mortality rate of juveniles, as observed in other colonies (Dann & Cullen 1990, Sidhu et al. 2007, Agnew et al. 2016).
- Poorer quality individuals may be over-represented in certain areas of the colony, which could result in poorer breeding success or the production of poorer quality offspring, and hence a longer-term reduced recruitment back into that area.
- There is the possibility that a small percentage of birds may move to another area of the colony between years. For example, in a 20-year study on the breeding penguins within several study areas on Phillip Island, approximately 3% of birds were not recorded for 2–6 years, reappearing with the same mate, and approximately 9% of birds were not recorded for 2–8 years and then reappeared with different mates (Nisbet & Dann 2009). Additionally, it is possible that a small percentage of birds that hatched in Area C recruit to other areas on Garden Island. In the same study by Nisbet & Dann (2009), approximately 26% of birds were not found breeding in the colony until they were 4 years or older. As little penguins begin breeding when they are 2 to 3 years old, it was surmised that some of these birds likely bred elsewhere in the intervening years (Cannell 2025b).

Additionally, environmental conditions within Cockburn Sound will have influenced the number of penguins attempting to breed. From December 2024 to April 2025, moderate to strong marine heatwave (MHW) conditions were present along the central to southwest coast, including near Cockburn Sound (Fig. 15). MHWs on the west coast of Australia in 1999 and 2011 were associated with fewer little penguins attempting to breed on Penguin Island (Cannell et al. 2024) and Garden Island (2011 only, as no data for 1999- Cannell unpubl. data). Furthermore, MHW conditions in SE Tasmania from November 2024 to January 2025 were linked with fewer penguins returning to feed their chicks (Hobday et al. 2026 and references within). The changes in penguin presence is likely due to reduced prey availability (Cannell et al. 2024, Cannell unpubl. data). Indeed, some of the baitfish species that the penguins from Garden Island prey on, Australian sardine (*Sardinops sagax*), southern garfish (*Hyporhamphus melanochir*) and sandy sprat (*Hyperlophus vittatus*) (Cannell et al. 2025), are at severe risk of being negatively impacted by climate change (Mitchell et al. 2024).

Furthermore, changes in the primary productivity in Cockburn Sound are likely associated with decreasing commercial landings (fish caught and brought ashore for sale for commercial purpose) of these species as well as Australian anchovy (*Engraulis australis*) and scaly mackerel, *Sardinella lemuru*), which also compose significant proportions of the penguins' diet (Lawrie, Chaplin & Cannell, in draft, Cannell et al. 2025). Notably, sandy sprat were not identified in samples collected from the penguins from 2009 – 2018 (Lawrie, Chaplin & Cannell, in draft), but there was an elevated frequency of occurrence in their diet in 2021 (Cannell et al. 2025). This was associated with an exceptionally high abundance of juvenile sandy sprat in spring 2021 (Yeoh et al. 2025) following unprecedented winter rainfall.

Therefore, environmental conditions influence the abundance of different baitfish species in Cockburn Sound, and it is likely that there was a lower abundance of baitfish species in the pre-breeding season during the MHW. This would influence the body condition of the penguins, and hence their decision to breed. Thus, fewer penguins would likely attempt to breed.

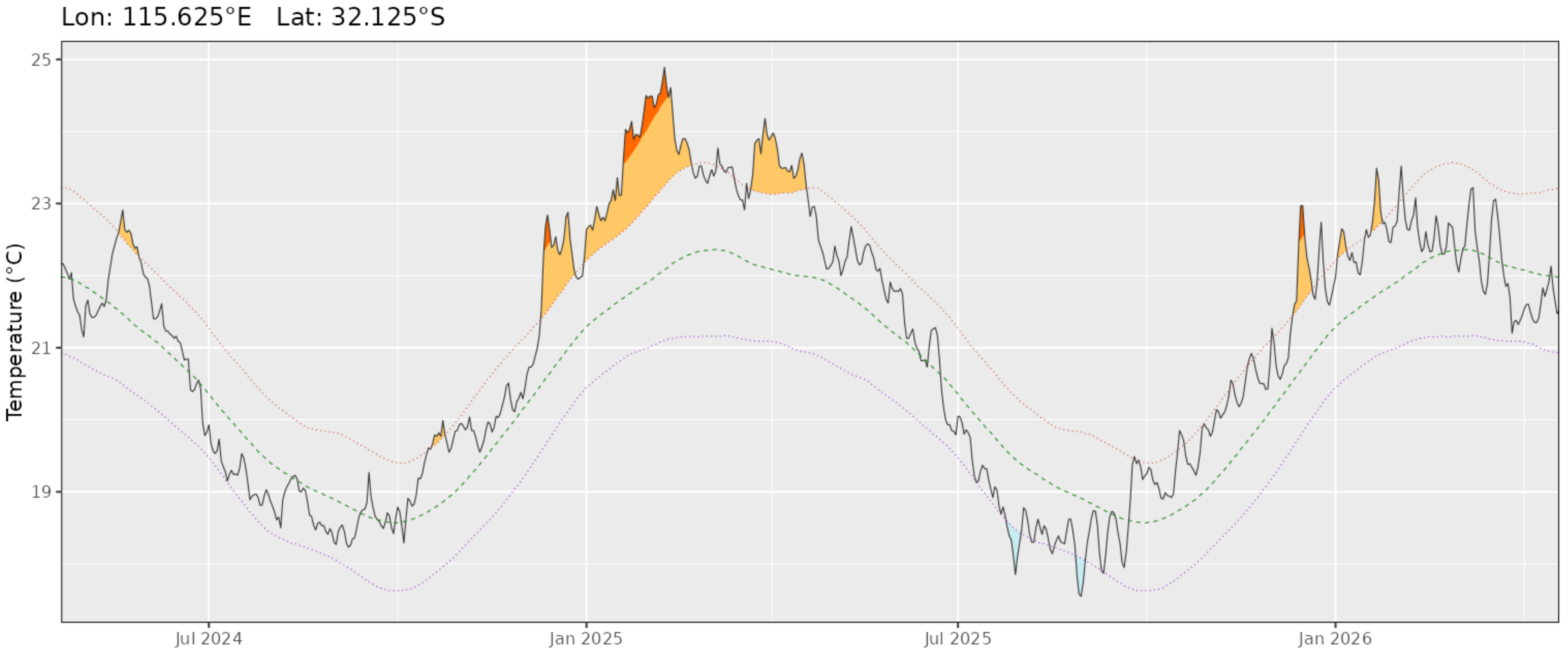

Fig. 15 Identification of a marine heatwave from late December 2024 to early April 2025, and also December 2025. The orange areas represent moderate marine heatwave conditions, and the red areas represent severe marine heatwave conditions. Green dotted lines plot daily long-term sea surface temperature climatology, the purple dotted line plots the 10th percentile, and the orange dotted line plots the 90th percentile Source https://www.marineheatwaves.org/tracker.html

Environmental variables influencing breeding

In 2025, eggs were more likely to successfully hatch when rainfall increased. Indeed, monthly rainfall in July and 2025 was greater compared to that in 2022, 2023 and 2024, when breeding success of eggs laid in these months was lower. Rainfall in August, September and October 2025 were greater than the same months in 2023 and 2024, and October 2022, and again breeding success was comparatively higher for these months in 2025. Increased rainfall is likely to reflect increased nutrients flowing into Cockburn Sound from riverine inputs, and hence more phytoplankton and zooplankton, i.e. food resources for fish (Yeoh et al. 2024). This would then increase the abundance of fish prey available to the penguins. Interestingly, unprecedently high rainfall fell in July 2021, the year that egg success decreased with increased turbidity (Cannell 2022). The high rainfall was associated with high tannin and chlorophyll levels, and hence turbidity, in Cockburn Sound (Cannell 2022). This suggests that the relationship between rainfall and penguin breeding success is unlikely to be straightforward, with the benefits of increased food availability potentially offset by the negative effects of turbidity on foraging efficiency and hence egg outcomes.

In years when the environmental conditions are considered poor for prey availability and penguin breeding such as the MHW early in the year, it is the more experienced penguins with better foraging abilities that are more likely to attempt to breed (Saraux and Chiaradia 2022). These birds are also better able to capitalise on the improved local resources associated with the increased rainfall in the later months.

Behaviour monitoring- Movement at sea

The core foraging areas of both the penguins during the incubation stage and the chick-rearing stage in 2025 was generally similar to that for penguins in 2021 – 2024 (Cannell 2022, 2024, 2025a). The penguins utilised the central and southern basins in all years, including areas either adjacent to, or within the Kwinana Shelf. In previous years, when tags were deployed on multiple penguins at the same breeding stage within a year, there was variation in the foraging areas, including use of the more shallow areas such as in Mangles Bay. This reflects the dynamic state of schools of penguin prey within Cockburn Sound.

A recent study of the spatial and temporal variation of fish assemblage composition in Cockburn Sound found that distance to seagrass beds was one of the environmental variables influencing the spatial variation of the fish assemblages. More species were found in shallow sites that included, or were adjacent to, seagrass (Yeoh et al. 2025). However, the fish fauna composition associated with the seagrass beds only includes a few fish species occasionally eaten by the penguins, such as leatherjackets (monocanthids) and sea mullet (*Mugul cephalus*) (Cannell et al. 2025). Juvenile anchovy, sandy sprat and blue sprat, and adult blue sprat, were typically found in shallow nearshore waters. Anchovy and sandy sprat adults were found in the deeper waters of Cockburn Sound (Yeoh et al. 2025). The deeper basins were also where pelagic schools of sardines and yellowtail scad (*Trachurus novaezelandiae*, another occasional prey of the penguins; Cannell et al. 2025) were found (Yeoh et al. 2025). Thus, the foraging habitat of the two tagged penguins in 2025 is consistent with what is known about spatial patterns of fish assemblages in Cockburn Sound.

Adaptive management and mitigation

Construction activity of the Action began in July 2025, with current access to a timetable of activity available through to the mid-December 2025 (at the time of writing this report). There was no notable change in behaviour to noise and/or vibration associated with construction activities that did not exceed any noise or vibration thresholds (RPS 2026b).

On 3 October 2025, exceedances of the vibration 'review' threshold were recorded at the SRF-West noise and vibration monitor no. 2 (V2) on Garden Island (see RPS 2026b). The exceedances were attributed to SRF-West construction activity, specifically a roller operating on the eastern side of the site being prepared for the controlled industrial facility (T. Forgie, GHD, pers. comm). The 'review' threshold exceedances were recorded at 08:00, 08:02, 08:21, 08:23 and 08:24 during vibro-roller works (T. Forgie, GHD, pers. comm.).

An inspection of 18 nests in Area C with known breeding activity was conducted on 5/10/2025, with the following findings:

- Three nesting attempts had failed in Area C since the previous fortnightly monitoring undertaken on 23 September 2025. For two of the attempts, it could not be confirmed if the failures were associated with the trigger event. The third failure occurred before the trigger event.
    - One nest, approximately 172 m from V2, previously with an adult and eggs, was empty; no eggs or adults were observed. Cause of abandonment unknown.
    - One nest, approximately 118 m from V2, had one dead chick that is likely to have died between 30 September and 4 October 2025, based on the assumed age of chick, although the chick could not be extracted from the burrow due to burrow structure. A second chick was not observed, but neither chick was observed during the previous monitoring, when the adult was observed. Based on the adult's behaviour during monitoring on 23 September, and the duration over which eggs had been observed, the parent was likely to be guarding chicks when monitored on this date (see Little penguin incident report_20251005_25J). Cause of death unknown.
    - One nest, approximately 26 m from V2, had two dead chicks. Based on their likely age when they died, these individuals are estimated to have been abandoned on 27 – 29 September 2025 (see Little penguin incident report_20251005_nb7), i.e. before the incident. Cause of death unknown.
- Chicks from an additional two nests, approximately 30 m and 119 m from V2 could not be observed due to burrow structure. However, there was evidence of breeding activity, and subsequent monitoring confirmed that at least one chick was alive in one nest from direct sighting (unable to confirm if a second chick was present or not), and there was continued evidence of breeding in the other nest.
- 13 nests (with distances varying from 25 m to 185 m from V2) still had confirmed breeding on 5 October 2025, including Nest 45B in which one dead chick was found at the burrow entrance on this day. Apart from a laceration above its left flipper, the bird appeared to have good body condition. Cause of death unknown, but it did not appear to be related to construction activity.

Whilst the cause of mortality of the chicks in the nests could not be ascertained from the 'review' triggered by the vibration threshold exceedance, it is likely that the adults abandoned the chicks and they died of starvation. It cannot be determined why the adults abandoned their breeding attempts. However, as breeding continued in 13 other nests immediately following the exceedance, it is unlikely that the penguins abandoned their breeding attempts because of the exceedance.

On 10 March 2026, between 10:31am and 10:34 am there were exceedances of the 'review' threshold for vibration at monitor V2. These 'review' threshold exceedances have been determined attributable to SRF-West construction activities. During on-site monitoring at the southern end of the colony at least 150 m from V2 at 10:30 am, no vibrations were detected. Nor was any unusual penguin activity in Area C observed. The only occupied nest closest to V2 had two penguins in it, both before and after the exceedance. On 11 March 2026 a vibration 'review' was triggered at 12:02 pm at monitor V2. There were no penguins in any nest sites near this area when monitored on 24/3/26, but varied attendance at nests is typical for the pre-breeding period. No changes in little penguin behaviour were identified from camera monitoring.

Conclusions

In accordance with the LPMMP (RPS 2026a), colony monitoring was undertaken and achieved the overarching aims of:

- Monitoring the little penguin population to facilitate detection of changes in population size and breeding success
- Observing and assessing little penguin behaviour during the breeding season to detect behavioural changes that may be occurring because of construction activities and to inform adaptive management measures
- Documenting any changes in little penguin habitat through nest integrity monitoring
- Monitoring environmental variation over time to understand the influence on breeding success and population size of little penguins
- Recording little penguin nest numbers and breeding adult pairs over the breeding season as an index for population size
- Providing the evidence to support compliance reporting against the approved Action conditions, specifically to demonstrate that the little penguin EO is achieved.

Environmental Outcome

In accordance with the Little Penguin Environmental Outcome, whilst there was a measurable decrease in the little penguin population size, especially in Area C, it was not likely to have been attributable to the SRF-West Project landside and maritime construction works. This was demonstrated through the following performance criteria:

- Little penguin monitoring for 2025 showed that timing of egg lay was similar to that in 2023 and 2024.
- Breeding success was marginally higher in 2025 compared to 2022 – 2024.
- The success of eggs laid in July to October was higher than most other years.
- Egg success was related to rainfall, with a 2.7% increase in the odds of an egg successfully hatching with each 1 mm increase in rainfall.
- The decline in the numbers of breeding adults (as an index for population size), particularly in Area C, was likely as a result of the marine heatwave from mid December 2024-early April 2025, as well as other losses of adults in Area C from hyperthermia during moult, predation by a python, and predation by fox/foxes in early 2023. Loss of adults from any cause can cause both short- and long-term impacts on the population.

The results from the monitoring in 2025/26 suggest that currently there is no need for any revised management controls or monitoring requirements in association with the approved Action activities.

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