BCI MINERALS LTD

Mardie Salt Project

Marine Turtle Monitoring Program 2024/25

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Synopsis

This report documents the outcomes of the Mardie Project's Marine Turtle Monitoring Program for the 2024/25 season, as conducted by Worley Consulting on behalf of BCI Minerals Ltd.

Disclaimer

PROJECT 311012-02345 - 311012-02345-EN-REP-0001: Mardie Salt Project - Marine Turtle Monitoring Program 2024/25

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1. Executive Summary

Mardie Minerals Pty Ltd (Mardie Minerals) is a wholly owned subsidiary of BCI Minerals Limited (BCI), and is the proponent developing the Mardie Salt and Potash Project, a greenfield high-volume salt production venture in the Pilbara region of Western Australia.

In accordance with best practice monitoring requirements, the Mardie Salt Marine Turtle Monitoring Plan (MTMP), and the Mardie Salt and Potash Project Illumination Plan, three field surveys were undertaken at suitable nesting habitat on mainland and island beaches in October 2024 (Field Survey 1; FS1), December 2024 (FS2) and March 2025 (FS3). The final survey, FS3, was initially scheduled to be conducted in February 2025, however, was postponed following the development of Severe Tropical Cyclone Zelia. The surveys were designed to target the peak nesting and hatching periods for hawksbill (*Eretmochelys imbricata*), flatback (*Natator depressus*) and green turtles (*Chelonia mydas*). Each field survey was 14 days in duration, to represent the mean inter-nesting period for marine turtles and the peak hatching period for green and flatback turtle hatchlings.

A daily track census was undertaken on the mainland to the east and west of Mardie Creek (i.e. the location of the proposed secondary seawater intake facility) and at Sholl and Long Islands. The remaining islands - Round, Middle Passage, Angle, Passage, Fortescue, Mardie, South Passage and Stewart – were surveyed a minimum of twice a week (i.e. minimum of four times within a survey). Nests encountered during FS1 and FS2 on Long and Sholl islands, or along monitored sections of the mainland, were systematically marked for excavation later in the season to quantify incubation success. Hatchling orientation data was recorded in FS2 and FS3, to coincide with the peak hatchling period for hawksbill turtles (December) and flatback and green turtles (March).

Flatback, hawksbill and green turtles were all observed to be nesting within the Mardie region during the 2024/25 nesting season. As in 2023/24, marine turtle nesting activity in 2024/25 was greatest at Sholl and Long islands during the December 2024 survey (FS2). Overall, flatback turtles were the most abundant nesters, followed by hawksbill and green turtles. At the mainland beaches and smaller, opportunistically monitored islands, marine turtle nesting activity was significantly lower, supporting the baseline evidence that indicates these sites provide less regionally significant nesting habitat than is available at Sholl and Long islands.

Varying patterns in nester abundance and nesting success relative to the previous season (i.e. 2023/24) and baseline were apparent for flatback (greater than 2023/24, but less than baseline) and hawksbill (less than both 2023/24 and baseline) turtles in 2024/25. The abundance of nesting marine turtles is known to vary temporally in response to the life history characteristics of the species (e.g. remigration intervals) as well as environmental conditions at their offshore foraging grounds. At present, it is difficult to quantify these patterns for the Mardie region as the 2024/25 season represents only the second year of monitoring post-baseline for the MTMP. Following the third year of data capture (i.e. 2025/26) closer examination of the significance of these species-specific trends in abundance may be possible.

Similarly, while specific distribution metrics were not available for marine turtle nesting activities at Long and Sholl islands in 2023/24, track census surveys undertaken in 2024/25 revealed little change in the distribution patterns of nesters across the Mardie region compared to those reported during the baseline period for the MTMP. The clustering reported for Sholl (West) in 2024/25 was the only notable difference to observations from the baseline period, when the distribution of tracks at this site was described as ‘dispersed’. Given the observation of tracks throughout entire Sholl (West) monitoring area, however, it is likely that this change is due to physical characteristics of the sub-tidal benthos and their influence on marine turtle emergence point selection, rather than any Project-attributable change in nesting habitat health.

Twenty-six nests (16 flatback; six hawksbill) were systematically marked across Long (n = 17) and Sholl (n = nine) islands during the 2024/25 season. As in 2023/24, no nests were marked on the mainland in 2024/25 because no new nests were observed. Eleven (42%) of the marked nests – all flatbacks – had fates considered to be complete, with the remaining 15 either being disturbed by other turtles nesting in the area (n = five), impacted by rainfall associated with Severe Tropical Cyclone Zelia (n = two), or lost (n = eight). Excavated, complete flatback clutches had an average clutch size of 45.9 eggs, which was slightly lower than the average clutch sizes reported previously for Long and Sholl islands, but within the range of previous observations across the Pilbara (Pendoley et al. 2014; Avenant et al. 2024). Hatch and hatchling emergence successes for 2024/25 (both 68.8%) were lower than those reported last season (2023/24; 81 and 80%, respectively), but similar to those observed during baseline (2021/22; 65% PENV 2023b). This reduction in success rates can be attributed to the severe weather systems that occurred across the Pilbara in 2024/25.

The results of the 2024/25 artificial light monitoring surveys were suitably analysed and compared to the baseline data (2021/22: offshore island, and 2022/23: mainland) to quantify any changes in sky brightness and identify new light sources, as outlined in the MTMP. In addition, artificial light monitoring was completed for the first time in the 2024/25 season on the mainland at Mardie Pool as per the Illumination Plan; the outcomes of which will serve as baseline for future seasons of monitoring at this site. A notable 55.6 % increase in WOS sky brightness was observed from Sholl Island (West), which was attributed to the newly constructed Mardie Onshore Facilities. This increase represented the greatest change to the artificial light-scape for the Project in 2024/25, however, fell below the whole-of-sky brightness levels predicted during light modelling studies for all Project-related facilities during operations.

While a trigger level spread angle (i.e. disorientation) exceedance was identified in hatchling orientation data collected at for Sholl Island (West) in 2024/25, this was not attributed to Project-associated lighting given: (i) the low sample size available (n = 2), (ii) the position of observed hatchling fans towards the southern-most spit of the island, and (iii) similarities in hatchling orientation patterns reported during the previous monitoring season (i.e. 2023/24), which occurred prior to the construction of the Mardie Onshore Facilities. It is recommended that monitoring of hatchling orientation at, and artificial light visibility from, Sholl Island (West) be continued in future seasons – as per the MTMP – and that the trigger and threshold values at this monitoring site be reviewed at the completion of the 2025/26 season, when a larger sample size is available for examination.

In conclusion, BCI was compliant with the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 with respect to marine turtle and artificial light monitoring undertaken as per the Mardie Salt Project MTMP and Illumination Plan in 2024/25.

No impacts attributed to the Project were reported across marine turtle abundance, distribution, incubation success, and hatchling orientation components of the MTMP, and artificial light monitoring using suitable light monitoring equipment was successfully conducted in accordance with the requirements of the Illumination Plan.

2. Glossary

Term	Definition
False crawl	When a female turtle crawls onto the beach and subsequently returns to the ocean without making a nesting attempt or laying.
Hatch success	The percentage of eggs in a clutch that produce live hatchlings.
Emergence success	The percentage of eggs in a clutch that produce live hatchlings that successfully leave the egg chamber.
Incubation period	The duration between the date a clutch was laid and the date a clutch hatched.
Nester abundance	Determined through successful nest counts over one complete inter-nesting period at the peak of the nesting season. Represents an estimation of the total number of females nesting at a particular beach for the season.
Nesting activity	Either a false crawl, nesting attempt, or successful nest made by a turtle.
Nesting attempt	When a female turtle crawls onto the beach and attempts to lay a clutch of eggs by digging a nest, or part thereof, but not actually depositing eggs.
Nesting success	The number of successful nests as a percentage of the total number of tracks recorded.
Thermal tolerance range	The range of suitable temperatures for marine turtle egg incubation, outside of which, embryo development is impaired.
Thermosensitive period	The middle trimester of development that determines the sex ration of a clutch.
Track census	The process of identifying marine turtle tracks and classifying the turtle species and nesting activity based on track characteristics and morphology.

3. Introduction

Mardie Minerals Pty Ltd (Mardie Minerals) is developing the Mardie Salt and Potash Project (the Project), a greenfield high-volume salt production venture in the Pilbara region of Western Australia. The Project will produce salt via evaporation of seawater, with a proposed production of 5 million tonnes per annum of concentrated salt, and 140,000 tonnes per annum of Sulphate of Potash (SoP). Mardie Minerals is a wholly owned subsidiary of BCI Minerals Limited (BCI).

The Project will comprise a series of evaporation and crystalliser ponds extending over an area ~30 km long, built predominately over existing mud and salt flat habitat. It will also feature a processing plant, a bitterns disposal pipeline and outfall, a trestle jetty and supporting infrastructure to produce and export salt and SoP (Preston Consulting 2018). Bitterns will be the only waste product produced during operations.

The Project was originally referred to the Western Australian Environmental Protection Authority (EPA) in April 2018 and the Department of Climate Change, the Environment, Energy and Water (DCCEEW) in June 2018. The original Mardie project was approved by the State with conditions under Ministerial Statement 1175 in November 2021, and by the Commonwealth with conditions under EPBC 2018/8236 in January 2022.

Significant amendments to the original proposal have since been outlined within the Optimised Mardie Proposal (OMP), which was submitted to the EPA and DCCEEW in March 2022. The OMP was approved by the State with conditions under Ministerial Statement 1211 (which superseded MS 1175) in October 2023, and by the Commonwealth with conditions under EPBC 2022/9169 in September 2024. Subsequently, the previous Commonwealth approval (EPBC 2018/8236 (as varied) was amended to align with (or 'mirror') the new OMP conditions set in October 2024.

The BCI Illumination Plan (hereafter, 'The Plan'; BCI Minerals 2023) was developed in support of the Optimised Mardie Project and aligns with the requirements of Condition 9-1 and 9-4 of Ministerial Statement 1211, Condition 24 of EPBC 2018/8236 and Conditions 37 and 38 of EPBC 2022/9169. The purpose of The Plan is to avoid where possible, and otherwise minimise impacts of artificial light to fauna of conservation significance and their habitats. Condition 9-4 requires BCI to review, propose and submit any amendments to The Plan every 5 years.

The Ministerial Statement referred to above contain approval conditions pertaining to the protection of marine turtles from impacts due to artificial light associated with the Optimised Mardie Salt Proposal. Outcome-based indicators from The Plan that will be used to ensure that significant impacts from artificial light on marine turtles are minimised and managed include:

- The spatial distribution of marine turtle beach usage shows a statistically significant change in a single season compared to the baseline data for that site, and
- Marine turtle hatchling behaviour (i.e. nest fan metrics) displays a variation in spread and/or offset angles that exceed trigger and threshold metrics when compared to the baseline data.

The studies undertaken by Pendoley Environmental (PENV) in the austral summer of 2018/19 and 2021/22 identified that marine turtles utilise sandy beach habitat along the mainland coast and offshore islands in the vicinity of the Project for nesting activities (PENV 2019; 2022; 2023a). Flatback (*Natator depressus*), hawksbill (*Eretmochelys imbricata*) and green turtles (*Chelonia mydas*) were recorded nesting at offshore islands, and nests or nesting attempts were recorded for flatback and hawksbill turtles on mainland beaches to the east and west of Mardie Creek (PENV 2019; 2022). The data obtained from these studies provided the baseline data for the marine turtle monitoring that took place in 2024/25 (i.e. that is reported here).

3.1 Scope of Work and Objectives

This report details the outcomes of marine turtle and artificial light monitoring undertaken in 2024/25 to meet the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A).

As per the Mardie Salt Marine Turtle Monitoring Plan (hereafter 'MTMP'; PENV 2023b), the 2024/25 Marine Turtle Monitoring Program was designed to collect monitoring data over the entire breeding and hatching season of hawksbill, flatback, and green turtles utilising mainland and island beaches in the vicinity of the Project. Data was collected to meet the following objectives:

- Identify the species of turtles nesting on the beaches;
- Identify the abundance and distribution of adult tracks on the nesting beaches;
- Collect baseline data on the health of the nesting habitat;
- Collect baseline data on hatchling orientation; and
- Measure the intensity and extent of light sources visible from nesting beaches.

This report provides monitoring data to allow comparison with baseline data collected by PENV (2019; 2024).

The technical report detailing the outcomes of all artificial light monitoring works, including those at Mardie Pool, undertaken on behalf of BCI in 2024/25 is provided in Appendix D.

4. Methods

4.1 Survey Location and Schedule

Marine turtle nesting and hatching surveys were conducted at islands and along the mainland coast in the vicinity of the Project over the 2024/25 marine turtle nesting season (Figure 4-1). Three field surveys were undertaken between October 2024 and March 2025, including:

- **Field Survey 1 (FS1: 14th October – 2 November 2024):** Targeted the peak of the hawksbill turtle nesting season over one 14-day inter-nesting period (Commonwealth of Australia 2017).
- **Field Survey 2 (FS2: 30th November – 14th December 2024):** Targeted the peak green and flatback turtle nesting season over one 14-day interesting period and peak hawksbill hatching season (Pendoley et al. 2016; Fossette et al. 2021).
- **Field Survey 3 (FS3: 3rd – 17th March 2025):** Targeted the peak green and flatback hatching season (Pendoley et al. 2014, 2016).

Sandy beach habitat was surveyed by helicopter and by foot to determine the presence and abundance of nesting activity and survey areas were divided into two groups; those sites monitored daily, and those monitored opportunistically (i.e. at minimum rate of twice-weekly).

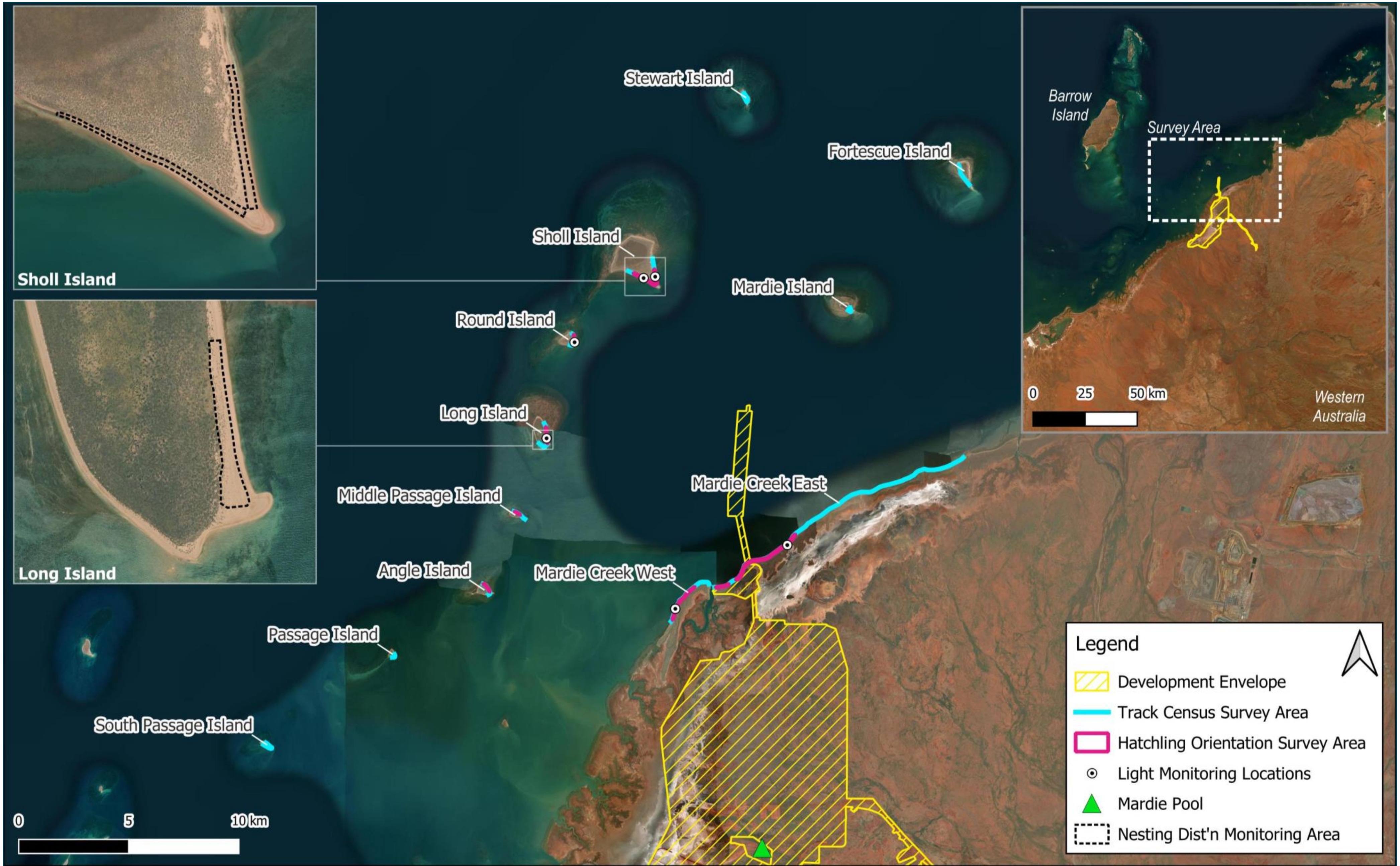
Survey areas along the mainland (i.e. east and west of Mardie Creek), as well as the survey beaches at Long and Sholl Islands, were surveyed daily (Figure 4-1). Survey areas at Angle, Fortescue, Mardie, Middle Passage, Passage, Round, South Passage, and Stewart islands were surveyed opportunistically.

A summary of the survey schedule for the 2024/25 nesting season is provided in Appendix B.

4.2 Work Scopes

4.2.1 Work Program

An overview of the work scopes conducted for each field survey is provided in Table 4-1, with methodology detailed in the following sections. A daily location schedule for each field survey is provided in Appendix B.



Mardie Project: Marine Turtle and Artificial Light Monitoring 2024/25

Figure 4-1 Marine turtle and artificial light monitoring locations for 2024/25. Dist'n = distribution

*Table 4-1 Field survey work program for the 2024/25 monitoring season. * = Hatchling orientation not monitored due to all nesting habitat occurring on, or adjacent, to the spit*

Monitoring location	Monitoring component											
	Track census			Incubation success			Hatchling orientation			Light monitoring		
	FS1	FS2	FS3	FS1	FS2	FS3	FS1	FS2	FS3	FS1	FS2	FS3
Surveyed daily												
Sholl Island	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Long Island	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Mardie Creek East	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Mardie Creek West	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Opportunistically surveyed twice weekly												
Round Island	✓	✓	✓					✓	✓			
Middle Passage Island	✓	✓	✓					✓	✓			
Angle Island	✓	✓	✓					✓	✓			
Passage Island*	✓	✓	✓									
Mardie Island	✓	✓	✓					✓	✓			
South Passage Island	✓	✓	✓					✓	✓			
Stewart Island	✓	✓	✓					✓	✓			
Fortescue Island	✓	✓	✓					✓	✓			

4.2.2 Nesting Habitat: Track Census

A track census involves recording the type of marine turtle nesting activity and species derived from tracks encountered on a nesting beach. A track census could be of one of the following:

- A one-off, opportunistic survey: for sites that were not frequently monitored, but where there was a need to determine the presence/absence of nesting activity. The age of tracks recorded during a snapshot survey typically cannot be determined.
- A routine survey: for sites that were monitored daily or three times per week throughout a survey. All visible tracks are marked during a 'line-in' day (i.e. first day of each survey) prior to the commencement of the track monitoring to ensure only new tracks from overnight nesting activity are recorded on subsequent survey days.

On each survey day, marine turtle nesting activity was identified by walking sections of suitable sandy beach on each of the islands and mainland. Overnight activity was confirmed from fresh tracks left in the sand since the previous day's survey. Marine turtle species and nesting activity (false crawl, attempt, or nest) were determined using track and nest characteristics, including track width, shape and orientation of flipper marks, trail drag marks, displaced sand, and the depth of the nest pit and associated mound (CCG 2015). All identified tracks were marked with a line in the sand to prevent recounts on the following survey days.

Predator activity was identified by tracks, scratchings, and holes dug in the sand in the vicinity of a nest, which may have resulted in eggshells being scattered at the sand surface.

4.2.3 Nesting Habitat: Incubation Success

4.2.3.1 Nest Marking

When nests were identified during the track census on islands surveyed daily during FS1 and FS2, they were marked (Table 4-1). Each clutch was located by gentle digging into a fresh nest and locating the eggs at the top of the nest. A Hobo temperature logger (model: UA-001-64; accuracy 0.53 °C; resolution 0.14 °C; weight 18 g) tethered to a marking post was placed amongst the eggs at the top of the nest to record the temperature profile during incubation at 30-minute intervals.

Control temperature loggers were also deployed during FS1 to track the sand temperature during the incubation period of marked nests. Control loggers were buried in sand at 500 mm depth, and recorded temperature at 30-minute intervals.

4.2.3.2 Nest Excavation

Marked clutches were excavated by removing and sorting the contents of each egg chamber during FS3 (Table 4-1). The timing of FS2 and FS3 ensured that all clutches marked during FS1 were able to hatch prior to excavation. Egg chamber contents were sorted into the following categories:

- Live hatchlings
- Dead hatchlings
- Pipped eggs
- Hatched eggs
- Partially developed embryos (dead)
- Fully developed embryos (dead)
- Undeveloped embryos

In addition to marked clutches, opportunistic clutches were also excavated during FS2 and FS3. Recently emerged nests on routinely monitored islands were identified and excavated 48 – 36 hours after no new hatchling activity was observed at the nest cone. Opportunistic clutches were excavated with caution to avoid disturbance to any remaining live hatchlings within the clutch or to developing embryos that may not yet have hatched. The contents of the egg chamber were sorted into the same categories as the marked clutches.

4.2.4 Hatchling Orientation

A nest fan was recorded if five or more hatchling tracks were sighted from a hatched clutch. Hatchling tracks fan out from a localised depression in the sand which marks the point of emergence. A sighting compass was used at the point of emergence to measure the bearing of the outermost tracks of the nest fan (vectors A and B, Figure 4-2) and the bearing of the most direct route to the ocean (vector X, Figure 4-2). Bearings were measured at the point where the track crossed the high tide line, or five metres from the clutch emergence point (whichever distance was shortest). Any tracks more than 30° outside of the main fan defined by vectors A and B were considered outliers, and the bearing of outlying tracks was recorded separately.

Two metrics were used to track fan spread and offset:

- **Spread angle**: this describes track dispersion from the emergence point, capturing the spread of all hatchling pathways toward the ocean. A larger value indicates greater dispersion or variation in ocean finding bearings and may indicate disruption to natural hatchling sea finding ability.
- **Offset angle:** this describes the degree of deflection of tracks from the most direct route to the ocean. A smaller value indicates a more direct route (i.e., less deviation from the most direct route) and a larger value demonstrates greater deviation from the most direct route, which may indicate disruption to natural hatchling sea finding ability.

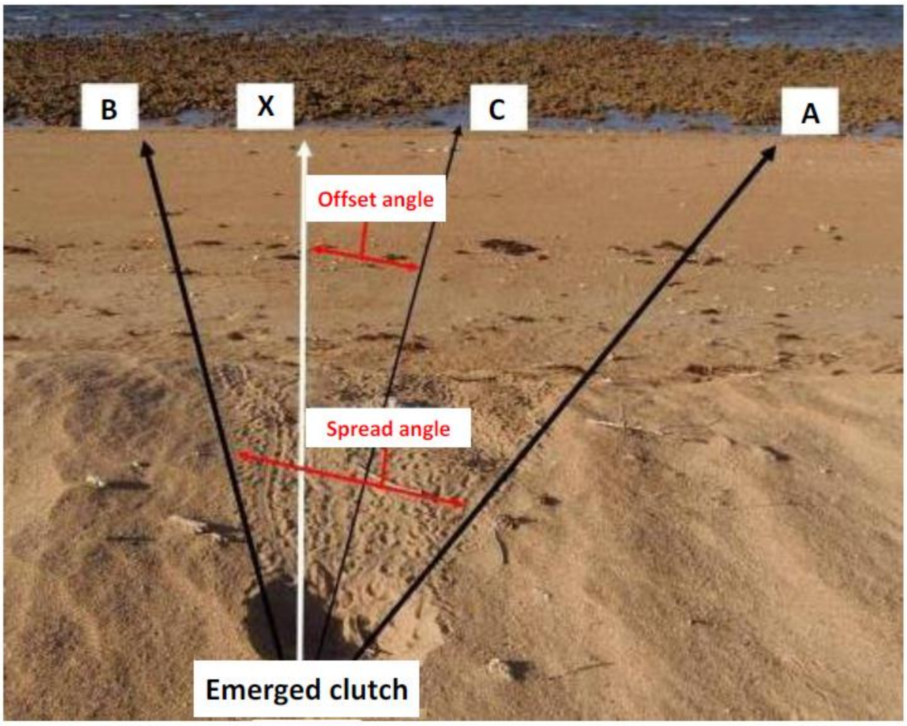


Figure 4-2 Hatchling orientation indices measured from the emergence point identified as the nest cone. A and B: the outermost bearings of the main fan, X: the bearing of the most direct route to the sea and C: offset angle

4.2.5 Artificial Light Monitoring

Sky42 light monitoring cameras were deployed on the mainland at Mardie Creek West and Mardie Creek East as well as at the following offshore locations: Sholl Island West, Sholl Island East, Long Island, Middle Passage Island, Round Island. Additional deployments were also completed on the mainland at Mardie Pool as per outcome-based provision Number 4 of the Illumination Plan (see page 52; BCI Minerals 2023).

All deployments were completed during FS2 and FS3 (Table 4-1) over the new moon period and, where required due to logistical constraints (i.e. in FS3), the five following days. Images of night-time light emissions on a 360° horizon were captured automatically by the cameras at 10-minute intervals between sunset and sunrise. All cameras were placed level on the ground, above the spring high tide line towards the base of the dune system. Deployment locations are presented in Figure 4-1.

Table 4-2: Light monitoring schedule for the 2024/25 monitoring season. Shaded cells = survey nights. FS = Field Survey.

FS	Date	Survey Day #	Mardie Creek (West)	Mardie Creek (East)	Sholl (West)	Sholl (East)	Long (East)	Middle Passage	Round Island	Mardie Pool
FS2	30 Nov 2024	1								
	1 Dec 2024	2								
	2 Dec 2024	3								
	3 Dec 2024	4								
	4 Dec 2024	5								
	5 Dec 2024	6								
	6 Dec 2024	7								
	7 Dec 2024	8								
	8 Dec 2024	9								
FS3	3 Mar 2025	1								
	4 Mar 2025	2								
	5 Mar 2025	3								
	6 Mar 2025	4								
	7 Mar 2025	5								
	8 Mar 2025	6								
	9 Mar 2025	7								

4.3 Data Analysis

4.3.1 Nesting Habitat: Abundance & Distribution

Descriptive statistics describing abundance (mean ± standard deviation, range and sample size) were generated for the following parameters for each species and each site monitored daily across all field surveys:

- overnight nests, and
- overnight tracks (includes false crawls and nesting attempts).

Nesting success, calculated as the number of successful nesting events as a percentage of the total number of overnight tracks, was also determined by census beaches (surveyed daily or a minimum of bi-weekly) and turtle species. It is important to note that a successful nesting event was only confirmed by a visual sighting of the eggs if the nest was selected for the incubation study. All other nesting events were determined from a visual assessment of the completed nest and was not confirmed by excavation and sighting of the eggs. Consequently, this parameter is an estimate only.

The distribution of nesting activities across monitoring areas at Long and Sholl (East and West; see Figure 4-1) islands was quantified using the heatmap tool in QGIS 3.36.0. Heatmaps considered all nesting activity records captured on track census days (i.e. excluding line-in days) and were generated using a Kernel Density Estimation with a quartic interpolation function and a search radius of 20 m around each activity record. A nearest neighbour spatial analysis was then used to quantify the level, or lack, of clustering of nesting attempts within each of these monitoring areas in 2024/25. This analysis involves the measurement of the distance between each track and the next nearest sighting. It then averages all these nearest neighbour distances. If the average distance is less than the average for a hypothetical random distribution, the distribution of the sightings is considered clustered. If the average distance is greater than a hypothetical random distribution, the sightings are considered dispersed. The nearest neighbour index is calculated as the actual mean distance divided by the expected mean distance (with expected mean distance being based on a hypothetical random distribution with the same number of sightings covering the same total area). High levels of clustering in nesting activity was indicated by large, negative Z-scores. Distribution patterns were compared to those provided for the baseline dataset.

4.3.2 Nesting Habitat: Incubation Success

4.3.2.1 Clutch Fate

Clutch fate was classified as one of four categories:

- Complete: If a clutch was not lost, inundated, disturbed or predated – i.e. it had been left undisturbed for the entire incubation period.
- Lost: If a clutch could not be located by the field team. This could be due to excessive sand deposition, erosion, disturbance from predators or other nesting turtles, or displacement of marking equipment.
- Inundated: If the temperature profile of a clutch showed a sudden substantial drop below the control temperature.
- Disturbed or predated: If the temperature profile of a clutch showed a sudden substantial increase in temperature.

4.3.2.2 Hatch and Hatchling Emergence Success

Hatch success was calculated by dividing the number of hatched eggs by the total number of eggs in the clutch. Hatchling emergence success (the percentage of hatchlings successfully leaving the nest) was calculated by subtracting the number of live and dead hatchlings encountered in the egg chamber from the number of hatched eggs, and then dividing by the total number of eggs in the clutch.

4.3.2.3 Incubation Period

The incubation period (IP) is the duration between the date a clutch was marked and the date the clutch hatched. The hatch date of each marked clutch was determined by comparing the clutch temperature profile to the control temperature profile. Specifically, a rapid drop in temperature in the clutch profile following a previously increasing temperature was identified that indicated the nest had hatched and emerged on that date.

4.3.2.4 Thermal Environment: Clutch Temperature

Following identification of the hatch date for each clutch, descriptive statistics were generated to describe the incubation environment of each clutch, including:

- Mean clutch temperature for the incubation period,
- Mean clutch temperature during the Thermosensitive Period (TSP), which represents the middle trimester of development and determines the sex ratio of a clutch (Yntema & Mrosovsky 1980, 1982; Hewavisenthi & Parmenter 2002), and
- the proportion of the incubation period where the mean daily temperature >33°C. This temperature is considered the lower bound of the upper thermal tolerance range (TTR) for marine turtle incubation, above which embryo development is impaired (Ackerman 1997, Van Lohuizen et al. 2016, Tanabe et al. 2020).

4.3.2.5 Thermal Environment: Sand Temperature

Temperature loggers deployed at control sites on each beach section were retrieved during FS3. Control logger temperatures were used to calculate the mean daily temperature for the entire incubation period of marked clutches.

4.3.2.6 Thermal Environment: Air Temperature and Rainfall

To facilitate comparison of the above metrics with the environmental conditions experienced across the monitoring period, air temperature and rainfall data for the Mardie weather station (ID: 005008) was accessed from the Bureau of Meteorology (BoM) website on 20 May 2025 (BoM 2025a).

4.3.3 Hatchling Orientation

Offset and spread angles were calculated for bearings measured from each nest fan (Figure 4-2) to determine the spread of hatchling tracks from the point of emergence (angle between vector A and B; Figure 4-2), and the degree to which hatchlings diverged from the most direct route to the ocean (angle between vector X and C, whereby C is the mid-point between vectors A and B; Figure 4-2).

A Kruskal-Wallis test was performed in R (version 4.4.1; R Core Team 2024) on the spread and offset angles to determine if there was a significant difference between islands.

To identify significant differences in hatchling orientation this season (i.e. 2024/25) compared with that recorded during baseline monitoring, the exceedance values of spread and offset that were considered statistically significant from baseline were set to when they exceed the baseline mean + 2*StDev (i.e. trigger value) and the baseline mean + 3*StDev (i.e. threshold value). This approach was selected given the small number of hatchling fans recorded in 2024/25 and to allow for direct comparisons to the monitoring outcomes reported in 2023/24 (PENV 2024) to be drawn.

4.3.4 Artificial Light Monitoring

4.3.4.1 Identification of Potential Light Sources

Potential sources of artificial light captured by the Sky42 cameras were identified using Google Earth and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite imagery (Elvidge et. al, 2021; available at: https://eogdata.mines.edu/products/vnl/).

4.3.4.2 Data Processing

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that are affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

Following quality checks, all suitable images were processed using specialised software to determine "whole-of-sky", "horizon" and "zenith" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image, horizon is the mean value of sky glow within the 60° – 90° across the horizon, and zenith is the mean values of sky glow within the 0° – 30° directly overhead. Nights with the clearest imagery and least amount of cloud cover were then selected for presentation within this report. It should be noted that the colour-coding used in these images represents sky brightness (described below) and is not indicative of how the visible light would be perceived by humans or wildlife.

Sky brightness is measured in units of visual magnitudes per square arcsecond (Vmag/arcsec^2); a standard unit that is used in astronomical measurements and is emerging as a standard for sky glow monitoring globally. The Vmag/arcsec^2 unit quantifies light intensity on an inverse logarithmic scale, where higher values represent lower intensity light, and lower values represent higher intensity light. Qualitative descriptions of the WOS values used to classify the night sky at each monitoring location are presented in Table 4-3.

Table 4-3: Qualitative description of Sky42 whole-of-sky (0 - 90°) brightness (Vmag/arcsec^2). Use as a guide only.

Whole-of-sky brightness (Vmag/arcsec^2)	Description
21.5 – 22.0	Ideal natural dark night sky
21.0 – 21.5	Rural night sky
20.0 – 21.0	Semi-rural night sky
19.0 – 20.0	Suburban night sky
18.0 – 19.0	Urban night sky
< 18.0	Urban/industrial night sky

4.3.4.3 Measuring Changes in Sky Brightness

In order to measure changes in WOS sky brightness between the present season (i.e. 2024/25) and baseline (i.e. 2021/22 for the offshore islands; 2022/23 for the mainland) as per the requirements of the MTMP, WOS sky brightness values – measured in logarithmic units of $Vmag/arcsec^2$ – were first converted to a linear scale. Changes in sky brightness were then presented as a percentage change in these converted metrics at each monitoring site. Where baseline data was not available, the change in brightness was calculated from the first year of available data for that monitoring site.

5. Results

5.1 Nesting Habitat: Characteristics

Islands monitored during the field program predominantly occur in a north-south orientated island chain off the coast of Mardie, and all share similar morphologic features (Figure 5-1). They typically feature a dynamic sand spit on the southern or south-eastern extent, a moderately wide and sloped intertidal zone, a wide supratidal zone, and vegetated dunes adjacent to sandy nesting habitat (Figure 5-1).

Figure 5-1 Examples of nesting habitat on Passage (top) and Angle (bottom) islands.

Mainland beaches, including those to the east and west of Mardie Creek, are long and low energy beaches with broad and shallow intertidal zones, narrow supratidal zones, and permanently vegetated dunes set back from the beach (Figure 5-2). Sections of the mainland coast are occupied by extensive mangrove forests, such as stretches to the west of Mardie Creek and at creek mouths. Beach sediment is typically dark brown or red in colour, and ranges in composition from stones and gravel to medium-coarse sand.

Figure 5-2 Example of nesting habitat on the mainland (Mardie, Western Australia).

5.2 Nesting Habitat: Track Census

5.2.1 Survey Effort

The completed survey effort across all beaches is presented in Table 5-1. In alignment with the MTMP, the two mainland sites (Mardie Creek West and East), Long Island, and Sholl Island were surveyed daily. Fortescue, Stewart, Mardie, Angle, Round, Passage, Middle Passage, and South Passage islands (see Figure 4-1) were all surveyed between three and eight days opportunistically per survey, but at a minimum rate of twice weekly as per the MTMP (Table 5-1).

It should be noted that while one day of survey on the mainland was missed due to logistical constraints associated with the helicopter (FS1, Mon 21 October 2024), no new nesting activity was recorded along the mainland on the subsequent survey day. Given the calm weather conditions experienced over the two days and the known level of turtle track retention observed within the sand at these sites (e.g. helicopter skid marks, human footprints), it is considered highly unlikely that any nesting activity records were missed between 20 and 22 October 2024.

Table 5-1 Track census survey effort for 2024/25

Field Survey	Track Census Type	Mainland* (MCW & E)	Long*	Sholl*	Mardie	Fortescue	Stewart	Round	Middle Passage	Angle	Passage	South Passage
Number of survey days												
FS1	Line-in	1	1	1	1	1	1	1	1	1	1	1
	Survey	12	13	13	4	4	4	8	7	6	5	4
FS2	Line-in	1	1	1	1	1	1	1	1	1	1	1
	Survey	13	13	13	3	3	3	4	4	4	3	3
FS3	Line-in	1	1	1	1	1	1	1	1	1	1	1
	Survey	13	13	13	3	3	3	6	5	4	4	4
	Total	41	42	42	13	13	13	21	16	19	15	14

*MCW & E = Mardie Creek West and East. *denotes sites surveyed daily*

5.3 Nester Abundance

5.3.1 Track Counts

A total of 890 turtle tracks (i.e. nesting activity records) were recorded across all beaches and field surveys in 2024/25 (Table 5-2). Flatback turtles were responsible for the majority of nesting attempts (54 %; *n* = 479), followed by hawksbill (30 %; *n* = 110) and green (12 %; *n* = 110) turtles. The remaining 4% of tracks were unable to be identified to species level. Of the full set of records captured, 155 (17%) were recorded during line-in days.

When both line-in and census day data were considered together, approximately one third (32%; *n* = 287) of activities were associated with nests, with the remaining 603 tracks consisting of unsuccessful nesting attempts (52%; *n* = 466) or false crawls (15%; *n* = 137; Table 5-2). Flatback turtles were responsible for over half of all nests (56%; *n* = 160), with 91 (32 %) attributed to hawksbill turtles, and 32 (11 %) to green turtles. The remaining four nests were unable to be identified to species level. Twenty percent of all nests were recorded during line-in days (*n* = 58).

Table 5-2 Total marine turtle nesting activity records recorded per field survey across all monitored sites in 2024/25

Field Survey	False Crawl	Attempt	Nest	Grand Total
FS1	42	110	64	**216**
FS2	95	351	221	**667**
FS3	0	5	2	**7**
Total	**137**	**466**	**287**	**890**

Note: Includes tracks recorded on line-in days

5.3.1.1 Mainland

Mainland beaches were accessed *via* helicopter and surveyed by helicopter and on-foot, as required, during each field survey. The helicopter survey covered ~10 km of coastline to the east and west of Mardie Creek, although ~7 km of the surveyed coastline to the west of Mardie Creek was occupied by mangrove forests and vast intertidal flats (i.e. not suitable for turtle nesting; Figure 8). Both east and west transects were surveyed daily during FS1, FS2 and FS3 to record overnight tracks (Appendix B).

The total number of tracks recorded at mainland beaches are provided in Table 5-3. No old or new marine turtle nests were recorded on mainland beaches throughout the entire 2024/25 monitoring season. In total, three nesting attempts were observed. These included one green turtle attempt and one hawksbill false crawl (both recorded in FS2), and nesting attempt made in FS1 that could not be attributed to a species. All of these aforementioned tracks were observed on Mardie Creek (East).

Table 5-3 Nesting activity summary for Mardie Creek (East; MCE) in the 2024/25 monitoring season. No nesting activity was recorded at Mardie Creek (West)

Survey	Species	Nesting Activity			Total
		False Crawl	Attempt	Nest	
FS1	Flatback	0	0	0	**0**
	Green	0	0	0	**0**
	Hawksbill	0	0	0	**0**
	Unknown	0	1 (MCE)	0	**1**
FS2	Flatback	0	0	0	**0**
	Green	0	1 (MCE)	0	**1**
	Hawksbill	1 (MCE)	0	0	**1**
	Unknown	0	0	0	**0**
FS3	Flatback	0	0	0	**0**
	Green	0	0	0	**0**
	Hawksbill	0	0	0	**0**
	Unknown	0	0	0	**0**
	Total	**1**	**2**	**0**	**3**

FS = Field Survey

5.3.1.2 Daily Islands

Following the line-in day, track census surveys were undertaken at Sholl and Long Island on each survey day (Table 4-1). The total number of nesting activities recorded during track census surveys (i.e. excluding line-in data) is presented in Table 5-4 and Appendix C.

A total of 586 turtle tracks were recorded at Long and Sholl Islands across the three field surveys. Of these, 56 % were flatback tracks (n = 324), 30 % were hawksbill tracks (n = 177) and 14 % were green turtle tracks (n = 81). Thirty percent (n = 177) of all activities across both islands were associated with nests, with the remaining 407 activities consisting of false crawls (n = 102) or nesting attempts (n = 307). The majority of nests were reported at Long Island (n = 118; 67 %), with the remaining third reported at Sholl Island (n = 59).

Table 5-4 Nesting activity summary for track census surveys (i.e. excluding line-in data) at Long and Sholl islands in 2024/25

Island	Field Survey	Species	Nesting Activity			Total
			False Crawl	Attempt	Nest	
Long	FS1	Flatback	10	15	14	**39**
		Green	0	0	0	**0**
		Hawksbill	10	20	14	**44**
		Unknown	0	0	0	**0**
	FS2	Flatback	11	101	52	**164**
		Green	4	33	13	**50**
		Hawksbill	14	39	25	**78**
		Unknown	0	0	0	**0**
	FS3	Flatback	0	1	0	**1**
		Green	0	0	0	**0**
		Hawksbill	0	0	0	**0**
		Unknown	0	0	0	**0**
Subtotal			*49*	*209*	*118*	*376*
Sholl	FS1	Flatback	5	8	7	**20**
		Green	0	0	0	**0**
		Hawksbill	8	7	5	**20**
		Unknown	0	0	1	**1**
	FS2	Flatback	15	56	31	**102**
		Green	10	14	7	**31**
		Hawksbill	15	12	8	**35**
		Unknown	0	1	0	**1**
	FS3	Flatback	0	0	0	**0**
		Green	0	0	0	**0**
		Hawksbill	0	0	0	**0**
		Unknown	0	0	0	**0**
Subtotal			*53*	*98*	*59*	*210*
Grand Total			**102**	**307**	**177**	**586**

5.3.1.3 Opportunistic Islands

Angle, Fortescue, Mardie, Middle Passage, Passage, Round, South Passage, and Stewart islands were all surveyed opportunistically during FS1, FS2 and FS3 (Table 5-1). These islands were surveyed between four and eight times per field survey, but at a minimum rate of twice weekly. The total nesting activity for these islands is presented in Appendix C and in Table 5-5, alongside a comparison to nesting records from the 2023/2024 season.

Angle Island was surveyed six times in FS1, and four times in both FS2 and FS3 (Table 5-1). There was evidence of nesting activity for flatback, hawksbill and green turtles, with a total of 18 nests (11 flatback, 4 green, and 3 hawksbill) recorded across the 52 observed tracks (35 % of total nesting activity; Table 5-5).

Fortescue Island was surveyed four times in FS1, and three times in both FS2 and FS3. There was evidence of hawksbill, green and flatback nesting activity, with two hawksbill nests recorded across the ten observed tracks (20 % of total nesting activity; Table 5-5).

Mardie Island was visited four times in FS1 and three times in both FS2 and FS3. Mardie Island recorded the lowest nesting activity across the opportunistic islands, with zero nesting attempts recorded across the 2024/2025 season on track census days (Table 5-4).

Middle Passage was not surveyed during the 2023/24 season, however surveying occurred over seven, four and five days for FS1, FS2 and FS3, respectively, during 2024/25 (Table 5-1). There was evidence of hawksbill, green and flatback nesting activity with a total of 16 tracks being recorded between FS1 and FS2. Of these, two were associated with flatback nests, one green turtle nest and two hawksbill nests (31 % of all nesting activity; Table 5-5). No tracks were observed in FS3.

Passage Island was surveyed five times in FS1, three times in FS2 and four times in FS3 (Table 5-1). There was evidence of flatback, green and hawksbill nesting activity on the island (Table 5-5). A total of 23 turtle tracks were recorded over the 2024/25 season, including four flatback turtle nests (17% of all activity). All other tracks were associated with nesting attempts (*n* = 4) and false crawls (*n* = 15; Table 5-5).

Round Island was not surveyed during the 2023/24 season. However, it was surveyed during all field surveys in 2024/25, with efforts totaling 18 days (Table 5-1). There was evidence of flatback, hawksbill and green turtle activity across the island (Table 5-5), with eight nests recorded in total (62 % total nesting activity). Of these, five nests were identified as hawksbill and the remaining two were green turtle nests. The remaining tracks were associated with false crawls (*n* = 2) and attempts (*n* = 3).

South Passage Island was surveyed four times during FS1, three times during FS2 and four times during FS3 (Table 5-1). A total of seven turtle nests were recorded for the season – consisting of three flatback nests, one green nest, and three hawksbill nests – representing 41 % of nesting activity at the island. The remainder of tracks were associated with false crawls (*n* = 1) and attempts (*n* = 9; Table 5-5).

Stewart Island was surveyed 10 times throughout the 2024/25 season (Table 5-1). Tracks indicated that flatback and hawksbill turtles' nest on the island, with a total of seven hawksbill nests and one unknown nest being observed (53 % total nesting activity; Table 5-5). The remaining tracks were associated with false crawls (*n* = 6) and an attempt (*n* = 1), and hawksbill turtles were the most abundance nesters, with tracks representing attributing to 86% (*n* = 13) of all activity (*n* = 15).

Across for all species across all opportunistically monitored islands, nester abundance was greater in 2024/25 than in 2023/24 (Table 5-5).

Table 5-5 Marine turtle nesting activity recorded during opportunistic surveys in 2024/25 and compared to records from 2023/24. Asterisk = excludes unknown turtles; blue shading = previous season data; NA = not available

Island	Nesting Activity	Turtle Species								Total	
		Flatback		Green		Hawksbill		Unknown			
		23/24	24/25	23/24	24/25	23/24	24/25	23/24	24/25	23/24	24/25
Angle	Attempt	24	18	0	5	0	7	NA	0	24*	30
	False Crawl	8	1	0	1	0	2	NA	0	8*	4
	Nest	11	11	0	4	0	3	NA	0	11*	18
	Total	*43*	*30*	*0*	*10*	*0*	*12*	*NA*	*0*	43*	*52*
Fortescue	Attempt	2	2	0	1	1	3	0	2	3	8
	False Crawl	0	0	0	0	1	0	0	0	1	0
	Nest	1	0	0	0	0	2	0	0	1	2
	Total	*3*	*2*	*0*	*1*	*2*	*5*	*0*	*2*	*5*	*10*
Mardie	Attempt	0	0	0	0	0	0	0	0	0	0
	False Crawl	0	0	0	0	0	0	0	0	0	0
	Nest	0	0	0	0	0	0	0	0	0	0
	Total	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*
Middle Passage	Attempt	18	2	1	1	0	0	NA	1	19*	4
	False Crawl	1	4	0	1	2	2	NA	0	3*	7
	Nest	3	2	0	1	0	2	NA	0	3*	5
	Total	*22*	*8*	*1*	*3*	*2*	*4*	*NA*	*1*	*25**	*16*
Passage	Attempt	9	16	0	1	0	2	0	0	9	4
	False Crawl	0	0	0	0	0	0	0	0	0	15
	Nest	1	4	0	0	0	0	0	0	1	4
	Total	*10*	*20*	*0*	*1*	*0*	*2*	*0*	*0*	*10*	*23*
Round	Attempt	11	0	0	0	1	3	NA	0	12*	3
	False Crawl	3	1	1	0	3	1	NA	0	7*	2
	Nest	4	0	1	2	2	5	NA	1	7*	8
	Total	*18*	*1*	*2*	*2*	*6*	*9*	*NA*	*1*	*26**	*13*
South Passage	Attempt	3	8	0	1	0	0	1	0	4	9
	False Crawl	1	1	0	0	0	0	0	0	1	1
	Nest	4	3	0	1	0	3	0	0	4	7
	Total	*8*	*12*	*0*	*2*	*0*	*3*	*1*	*0*	*9*	*17*
Stewart	Attempt	3	0	0	0	0	1	0	0	3	1
	False Crawl	3	1	0	0	0	5	0	0	3	6
	Nest	0	0	0	0	0	7	0	1	0	8
	Total	*6*	*1*	*0*	*0*	*0*	*13*	*0*	*1*	*6*	*15*
Total		**110**	**74**	**3**	**19**	**10**	**48**	**1**	**5**	**124**	**146**

NA = site not surveyed

5.3.1.4 Track Census

Following line-in surveys at each of the monitored islands, subsequently recorded tracks represented new nesting activity records for each of the monitoring periods. These track census records (i.e. excluding line-in data) for the 2024/25 season are presented below.

1. Field Survey 1

A total of 125 turtle tracks were recorded during track census surveys (i.e. excluding line-in days) at Long and Sholl islands (Figure 5-3) and the mainland beaches (Mardie Creek East and West; Figure 5-4) in FS1 (i.e. October 2024). The majority of tracks were observed on the offshore islands collectively (*n* = 124; 99%) with only one attempt being observed on the mainland, which could not be assigned to species-level (Mardie Creek (East); 1%). Hawksbill tracks (*n* = 64; 51%) slightly outnumbered flatback tracks (*n* = 59; 47%) across these sites, with the remaining two tracks unable to be identified to species level (Figure 5-5).

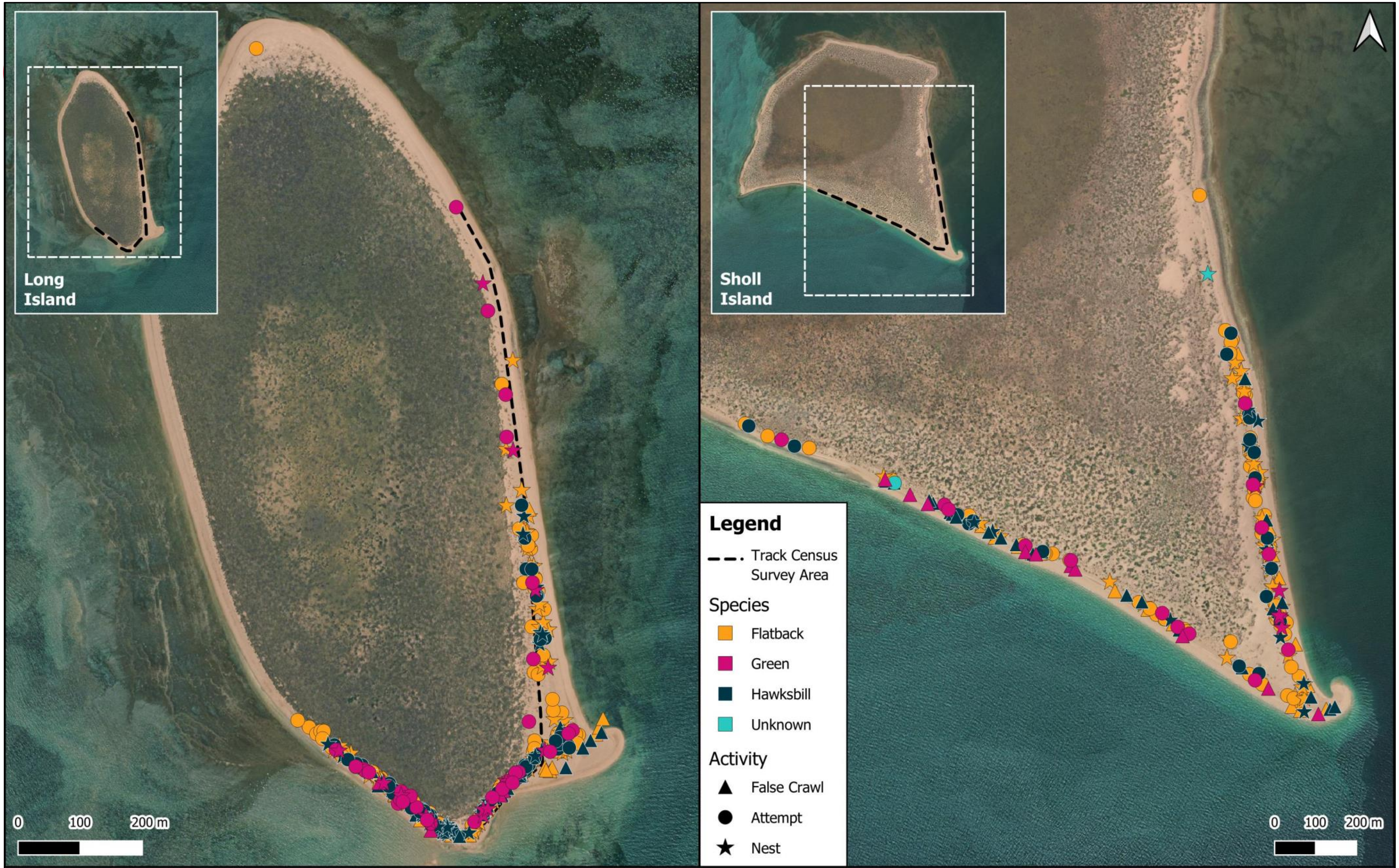
Nests were recorded at Long (*n* = 28; 68%) and Sholl (*n* = 32%) islands (total nests = 41) and of these, 21 were flatback turtle nests (51%), 19 were hawksbill turtle nests (46%), and one was unable to be identified to species level (2%). The remaining 84 tracks were associated with nesting attempts (*n* = 51; 41%) and false crawls (*n* = 33; 26%) (Appendix C).

The track census surveys (i.e. excluding line-in data) at the opportunistic islands recorded 38 marine turtle tracks (Figure 5-6; Figure 5-7). Of these, 24 were hawksbill (63%) tracks, ten were flatback tracks (26%), one was a green turtle track (3%), and the remaining three could not be identified to species level (8%; Figure 5-8).

2. Field Survey 2

The overnight track census survey (i.e. excluding line-in data) at Long, Sholl and the mainland beaches recorded a total of 461 marine turtle tracks (Figure 5-3; Figure 5-4). Flatbacks were the most abundant nesters, with 266 tracks being recorded (57%), followed by hawksbills (*n* = 114; 25%), and green turtles (*n* = 82; 18%; Appendix C). Only one track could not be identified to species level (Figure 5-5).

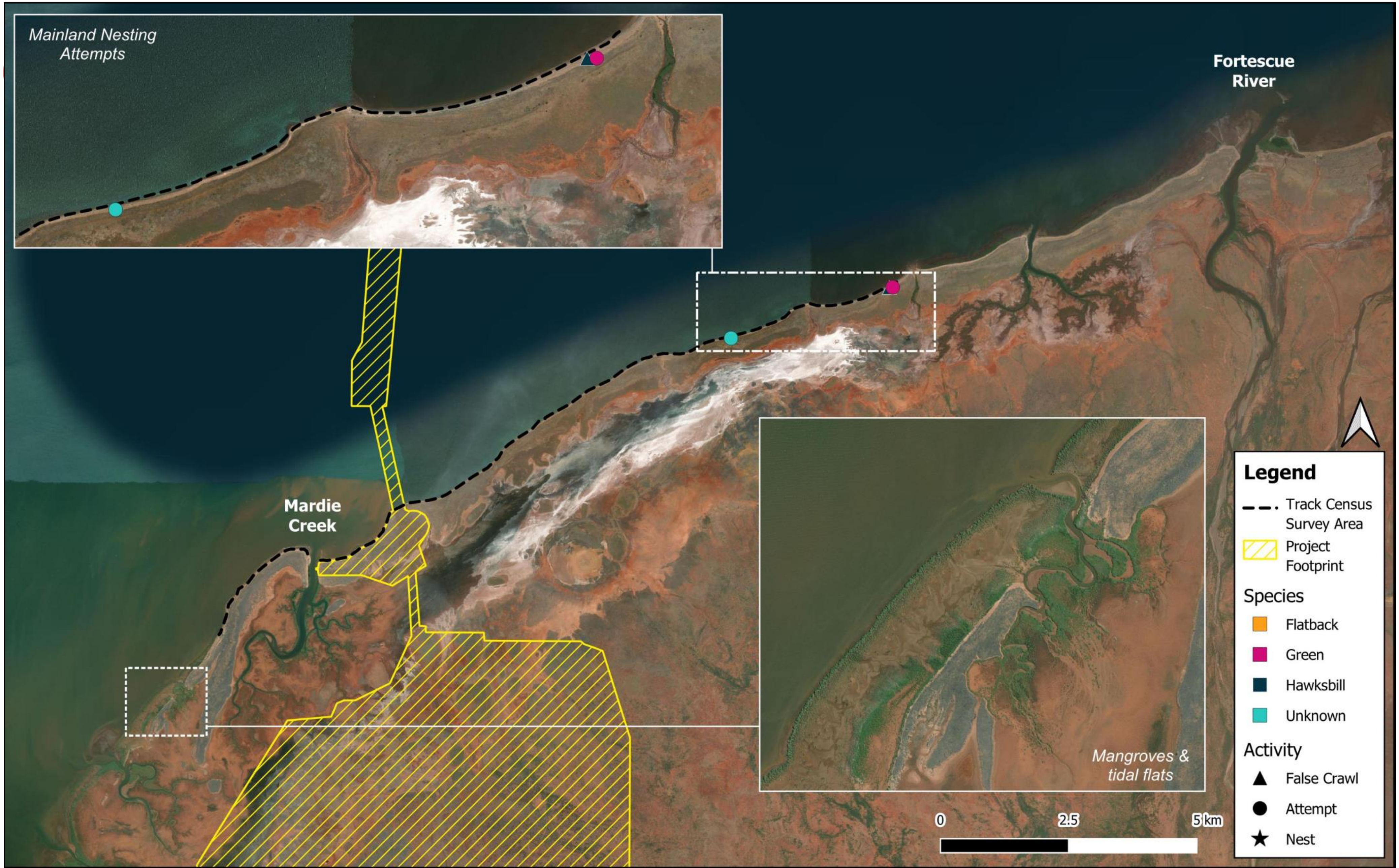
As in FS1, nests during FS2 (*n* = 136) were only recorded at Long (*n* = 90; 66%) and Sholl (*n* = 46; 44%) islands, with no nests being recorded at either of the mainland sites. Only one nesting attempt (green) and one false crawl (hawksbill) were recorded on the mainland during FS2, with both of these occurring at Mardie Creek (East; Figure 5-4). The greatest number of nests were laid by flatbacks (*n* = 83; 61%), followed by hawksbill (*n*= 33; 24%), and green (*n* = 20; 15%) turtles. The remaining 327 tracks across Long and Sholl Islands were associated with 256 nesting attempts and 69 false crawls (*n* = 173 and 29, and 83 and 40, for each island, respectively).



Mardie Project: Marine Turtle and Artificial Light Monitoring 2024/25

Figure 5-3 Track census records at Long (left) and Sholl (right) islands during the 2024/25 monitoring season

worley



Mardie Project: Marine Turtle and Artificial Light Monitoring 2024/25

Figure 5-4 Track census records at the mainland (Mardie Creek East and West) during the 2024/25 monitoring season

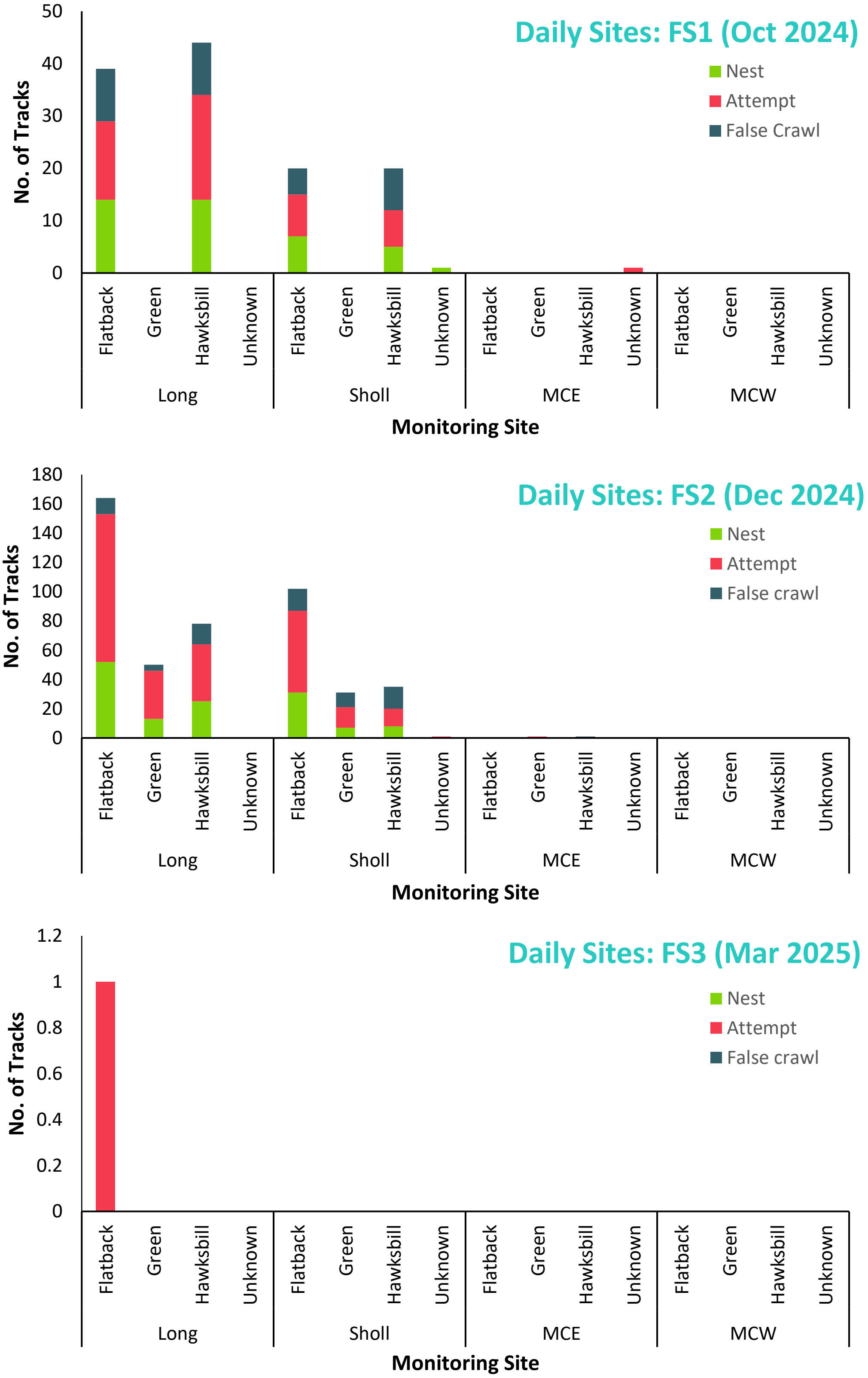
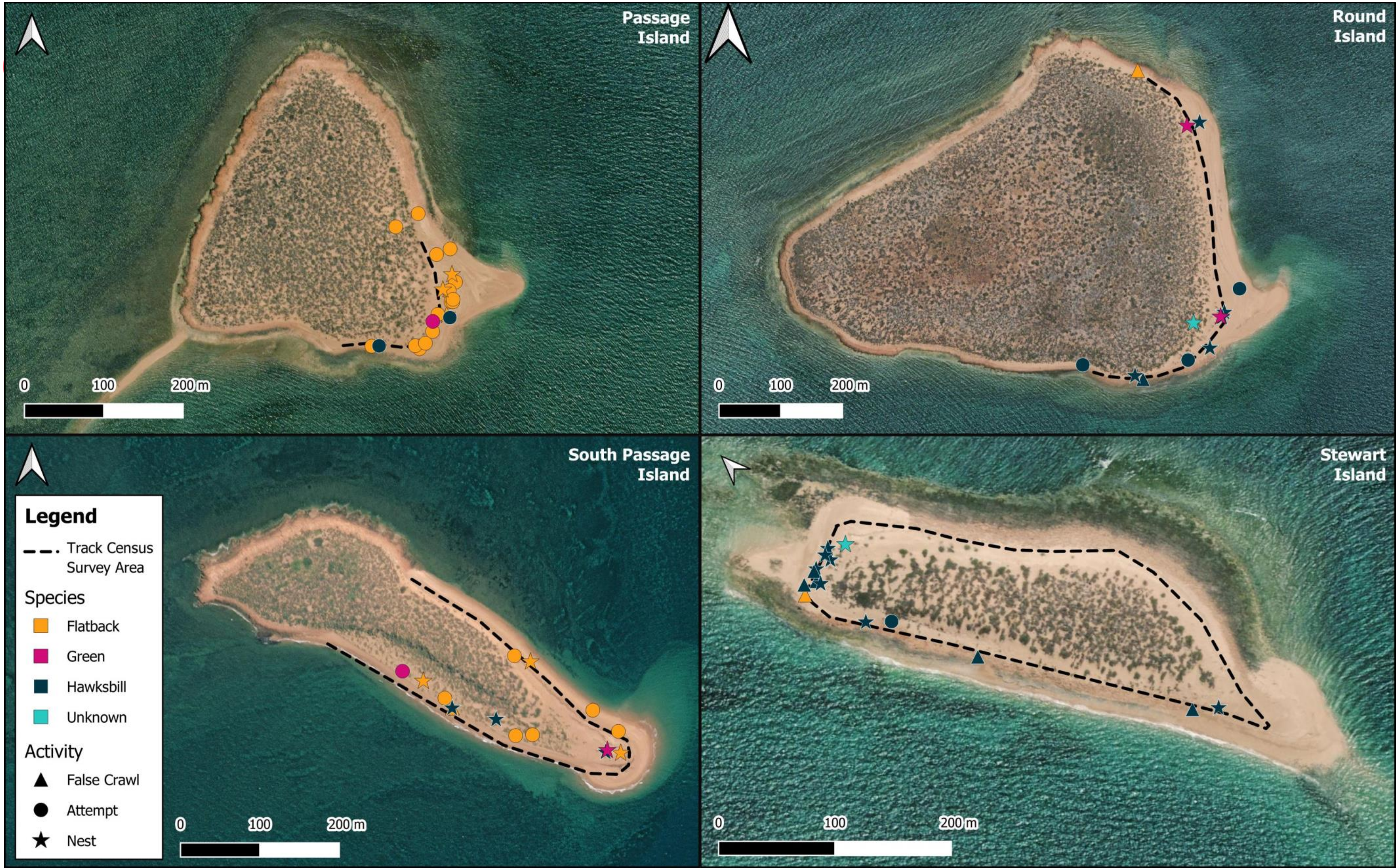


Figure 5-5 Marine turtle nesting activity at sites monitored daily during Field Survey 1 (top), Field Survey 2 (middle) and Field Survey 3 (bottom) of the 2024/25 season. Note y-axis scales are different

Mardie Project: Marine Turtle and Artificial Light Monitoring 2024/25

Figure 5-6 Track census records opportunistically captured during the 2024/25 marine turtle monitoring season at Angle (top left), Fortescue (top right), Mardie (bottom left) and Middle Passage (bottom right) islands



Mardie Project: Marine Turtle and Artificial Light Monitoring 2024/25

Figure 5-7 Track census records opportunistically captured during the 2024/25 marine turtle monitoring season at Passage (top left), Round (top right), South Passage (bottom left) and Stewart (bottom right) islands. Note: one flatback attempt at Passage Island has not been mapped position data was not available

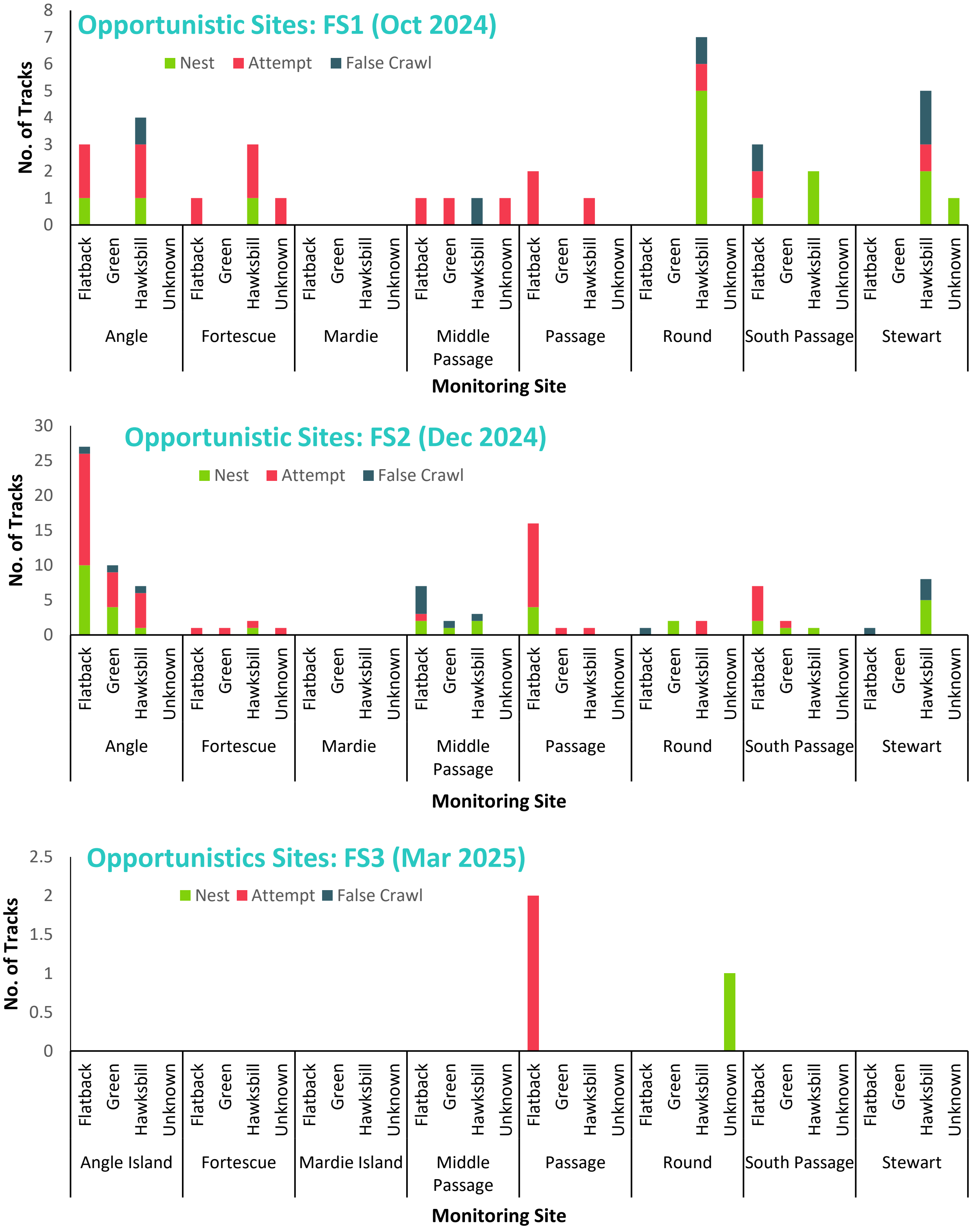


Figure 5-8 Marine turtle nesting activity at opportunistically monitored sites during Field Survey 1 (top), Field Survey 2 (middle) and Field Survey 3 (bottom) of the 2024/25 season. Note y-axis scales are different

The track census surveys at the opportunistic islands recorded 103 marine turtle tracks (line-in data excluded; Figure 5-6; Figure 5-7). Of these, 60 were flatback tracks (58%), 24 were hawksbill tracks, (23%), and 18 were green turtle tracks (17%). Only one track could not be identified to species level (1%; Figure 5-8). A total of 36 nests (35% of all tracks) were recorded across opportunistically monitored sites, with half of these being laid by flatbacks (*n* = 18; 50%), and the remainder being laid by hawksbill (*n* = 10; 28%) and green (*n* = 8; 22%) turtles.

3. Field Survey 3

At the completion track census surveys for FS3, four nesting activity records for adult turtles had been recorded across the ten monitored islands and the mainland (excluding line-in data; Figure 5-5; Figure 5-8; Appendix C). These were comprised of: one nest laid by an unknown species at Round Island, two nesting attempts by flatback turtle/s at Passage Island (Figure 5-7), and one nesting attempt by a flatback turtle at Long Island, which was located outside of the monitoring area at the northern tip of the island (see Figure 5-3). No activity was recorded on the mainland.

5.3.2 Nightly Nesting Activity

Overnight nesting activity records were calculated for flatback and hawksbill turtles at sites monitored daily (i.e. both mainland sites, and Long and Sholl islands) in October 2024 and December 2024. The average number new emergences (i.e. false crawls, attempts, and nests) and nests laid occurring over track census days (i.e. excluding line in data) are presented in Table 5-6, and detailed summary statistics (including those for green turtles) are presented in Table C-4 (Appendix C).

Nightly nesting activity at opportunistically surveyed islands was not assessed given the opportunistic nature of the survey effort and unevenness in survey days between islands, field surveys, and seasons. Additionally, nesting activity in March 2025 (i.e. FS3) was not measured given this period falls outside of the peak nesting season for all three marine turtle species present in the Mardie region.

5.3.2.1 Mainland

Nesting attempts were limited along the mainland throughout the 2024/25 season (Table 5-6; Figure 5-4). No nesting attempts of any kind were recorded at Mardie Creek (West), and this was consistent with records from baseline. Only a single hawksbill attempt was recorded at Mardie Creek (East) in December 2024 (0.1 tracks/night, 0.0 nests/day). This was lower than measured during the 2022/23 season (0.6 tracks/night, 0.2 nests/day), however, was consistent with the low hawksbill nester abundance reported across the monitored offshore islands (Table 5-6).

Table 5-6 Survey duration, number of tracks, nesting success, and overnight nesting activity for hawksbill and flatback turtles at Long and Sholl islands and the mainland monitoring sites in 2024/25 as compared to baseline. Blue shading = 2024/25 data; green shading = flatback; n = number; Tracks.d = mean nesting attempts per day; nests.d = mean nests laid per day. Line-in data excluded

Location	Season	Survey days (n)	Month	Species	Tracks (nesting success)	Tracks.d (nests.d)
Long	2018/19	13	Dec	Flatback	135 (30%)	10.4 (3.2)
	2021/22	13	Oct	Hawksbill	4 (0%)	0.3 (0.0)
		12	Dec	Flatback	64 (36%)	5.3 (1.9)
				Hawksbill	28 (50%)	2.3 (1.2)
	2024/25	14	Oct	Flatback	39 (36%)	2.8 (1.0)
				Hawksbill	44 (32%)	3.1 (1.0)
		13	Dec	Flatback	164 (32%)	12.5 (4.0)
				Hawksbill	78 (32%)	6.0 (1.9)
Sholl	2018/19	13	Dec	Flatback	89 (44%)	6.8 (3.0)
	2021/22	14	Oct	Hawksbill	18 (44%)	1.3 (0.6)
		12	Dec	Hawksbill	9 (44%)	0.8 (0.3)
				Flatback	83 (41%)	6.9 (2.8)
	2024/25	14	Oct	Flatback	20 (35%)	1.4 (0.5)
				Hawksbill	20 (25%)	1.4 (0.4)
		13	Dec	Flatback	102 (30%)	7.8 (2.4)
				Hawksbill	35 (23%)	2.7 (0.6)
Mardie Creek East	2018/19	13	Dec	Flatback	2 (0%)	0.2 (0.0)
	2022/23	14	Oct	Hawksbill	8 (38%)	0.6 (0.2)
		14	Dec	Flatback	8 (38%)	0.6 (0.2)
	2024/25	14	Oct	Flatback	0 (0%)	0.0 (0.0)
				Hawksbill	0 (0%)	0.0 (0.0)
		13	Dec	Flatback	0 (0%)	0.0 (0.0)
				Hawksbill	1 (0%)	0.1 (0.0)
Mardie Creek West	2018/19	13	Dec	Flatback	2 (0%)	0.2 (0.0)
	2022/23	14	Oct	Hawksbill	0 (0%)	0.0 (0.0)
		14	Dec	Flatback	0 (0%)	0.0 (0.0)
	2024/25	14	Oct	Flatback	0 (0%)	0.0 (0.0)
				Hawksbill	0 (0%)	0.0 (0.0)
		13	Dec	Flatback	0 (0%)	0.0 (0.0)
				Hawksbill	0 (0%)	0.0 (0.0)

5.3.2.2 Offshore Islands

Nester abundance on Long Island was greater in December 2024 (22.4 ± 14.0 tracks/night; 6.9 ± 5.2 nests/day) than October 2024 (5.9 ± 5.6 tracks/night; 2.0 ± 2.1 nests/day; Appendix C). Flatback turtles were more abundant than hawksbill turtles across both field surveys, however, nesting success rates were similar between species (range 32 – 36%; Table 5-6).

Nester abundance on Sholl Island was lower across the 2024/25 season than at Long Island in both October 2024 (2.9 ± 2.9 tracks/night; 0.9 ± 1.0 nests/day) and December 2024 (12.9 ± 8.5 tracks/night; 3.5 ± 3.0 nests/day), however, at both monitoring sites, was greater than recorded during baseline in December (Table 5-6).

5.3.3 Nesting Distribution

Significant clustering of nesting activity was observed at Long and Sholl Islands (both east and west), with the highest density of tracks identified at the southern end of Long Island (12.0 tracks within a 20 m radius), followed by Sholl (East; 5.9 tracks within a 20 m radius) and Sholl (West; 3.5 tracks within a 20 m radius; Figure 5-9; Table 5-7). Nearest neighbour analyses confirmed that nesting activity was non-random at all three monitoring areas (Table 5-7).

The overall clustering of tracks was greatest at Sholl (West; *Z* score = -12.5), followed by Sholl (East; *Z* score = -10.9) and Long Island (*Z* score = -8.0). While no distribution metrics were available for the baseline monitoring or 2023/24 datasets, nesting activity distribution for baseline was described in the MTMP as "dispersed across surveyed habitat at Sholl (West), whereas the pattern of nesting activity at Sholl (East) and Long Island was significantly clustered towards the southern end of each beach at both locations" (PENV 2023b). The increase in clustering at Sholl (West) in 2024/25 was driven by the concentrated abundance of nesting attempts in the centre region of this monitoring area, as well as the two clusters of activity located towards the southern spit. At Sholl (East) and Long Island, nesting attempts continued to occur more frequently at the southern end of the beach in 2024/25.

Table 5-7 Distribution analyses for marine turtle nesting activity within monitoring areas at Long and Sholl islands in 2024/25. m = metres

Analysis	Metric	Island		
		Long	Sholl (West)	Sholl (East)
Heatmap	Peak activity density (20 m radius)	12.0	3.5	5.9
Nearest Neighbour (NN)	Observed Mean Distance (m)	6.7	12.1	7.9
	Expected Mean Distance (m)	11.4	47.5	19.2
	NN Index	0.6	0.3	0.4
	Activity Count	102.0	77.0	94.0
	Z Score	-8.0	-12.5	-10.9

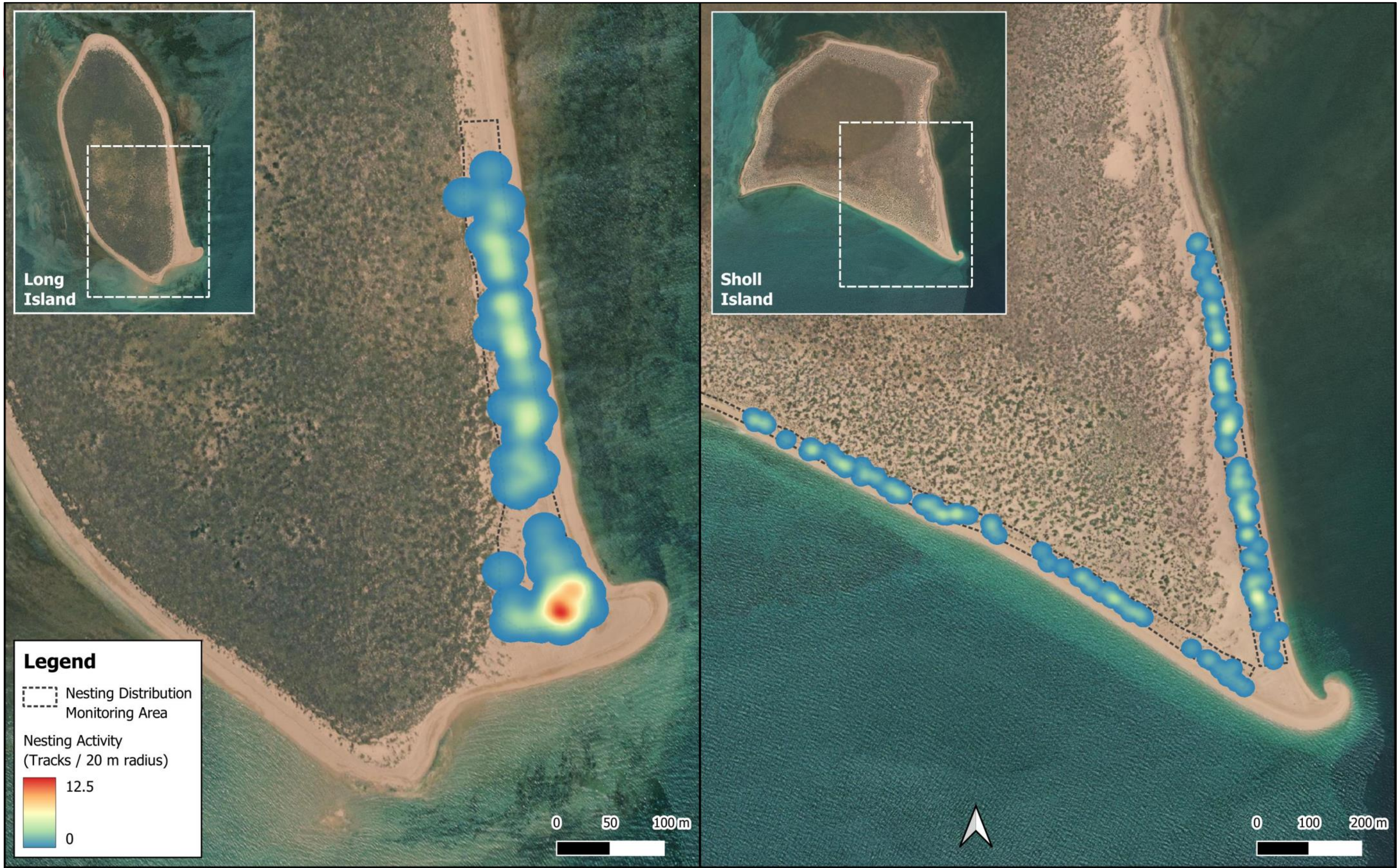


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Figure 5-9 Track density (tracks within a 20 m radius) for all marine turtle species within the monitoring areas (black dashed polygons) on Long and Sholl Islands in 2024/25

5.3.4 Nesting Success

Nesting success (i.e. the percentage of tracks that resulted in a nest) was calculated separately for flatback, hawksbill and green turtles from track census data (i.e. excluding line-in data), as well as collectively (Table 5-8). Records of nesting success at all monitoring locations and per species are tabulated in Appendix C.

5.3.4.1 Mainland

Nesting success for all green and hawksbill turtles was 0% for all surveys combined at both mainland monitoring sites during the 2024/25 season (Table 5-8). No flatback nesting activity was reported on the mainland during 2024/25.

Table 5-8 Marine turtle nesting success (%) by monitoring frequency and site, species, and season. Dash indicates no nesting attempts recorded

Survey Frequency	Location	Species	Nesting Success (%)		
			21/22	23/24	24/25
Daily	Islands	Flatback	41	18	32
		Hawksbill	44	33	29
		Green	15	43	25
		All	**41**	**19**	**30**
	Mainland	Flatback	45	8	-
		Hawksbill	-	-	0
		Green	-	0	0
		All	**45**	**7**	**0**
Opportunistic	Islands	Flatback	50	22	28
		Hawksbill	47	22	46
		Green	33	33	42
		All	**47**	**22**	**36**

5.3.4.2 Daily Islands

Nesting success at islands monitored daily (i.e. Long and Sholl) was higher in 2024/25 (30%) than in 2023/24 (19%), however, was lower than baseline (2021/22; 41%; Table 5-8).

Nesting success was higher for flatback turtles at the routine islands for the 2024/25 season (32%) in comparison to the 2023/24 season (19%), but lower compared to baseline 2021/22 (41%; Table 5-8). Nesting success remained stable at the routine islands for flatback turtles in FS1 and FS2, ranging from 31% to 35%. By FS3, the abundance of nesting flatbacks had significantly reduced, with the nesting success rate dropping to 0% after one unsuccessful nesting attempt was made at Long Island (Appendix C).

Nesting success for hawkbill turtles at Long and Sholl islands was lower during the 2024/25 season (29%) than during 2023/24 and 2021/22 (33 and 44%, respectively; Table 5-8). Nesting success remained at 32% for hawksbill turtles during FS1 and FS2 at Long Island, and no new hawkbill tracks were recorded during FS3. Sholl Island displayed similar, although lower, nesting success trends across surveys, with nesting success for hawksbills being recorded at 25% and 23% for FS1 and FS2, respectively (Appendix C). It should be noted that during the 2024/25 season, the abundance of hawksbills was much greater than in previous seasons ($n_{hawksbill\ tracks}$ = 177, 40, and 59 at Long and Sholl Islands in 2024/25, 2024/23 and 2021/22, respectively; Appendix C).

Green turtle activity was only recorded at the islands monitored daily during the FS2 survey. During this time, nesting success for green turtles averaged 25%; a decrease from 2023/24 (43%) but an increase when compared to baseline (2021/22; 15%; Table 5-8). Nesting success for green turtles was slightly greater at Long Island (26%) than at Sholl Island (23%) during the 2024/25 season (Table 5-9).

Island-specific nesting success rates are presented per species in Table 5-9.

Table 5-9 Marine turtle nesting success (%) for all monitoring sites in 2024/25. Line-in data and 'Unknown' species records excluded. Asterisk indicates site monitored daily; dash indicates no nesting effort recorded

Location	Site	Nesting Success (%)		
		Flatback	Hawksbill	Green
Island	Long Island*	33	32	26
	Sholl Island*	31	24	23
	Angle Island	37	25	40
	Fortescue Island	0	40	0
	Mardie Island	-	-	-
	Middle Passage Island	25	50	33
	Passage Island	20	0	0
	Round Island	0	56	100
	South Passage Island	30	100	50
	Stewart Island	0	54	-
Mainland	Mardie Creek (East)*	-	0	0
	Mardie Creek (West)*	-	-	-

5.3.4.3 Opportunistic Islands

Nesting success at islands monitored opportunistically (i.e. Angle, Fortescue, Mardie, Middle Passage, Passage, Round, South Passage, and Stewart) was higher in 2024/25 (36%) than in 2023/24 (22%), however, was lower than baseline (2021/22; 47%; Table 5-8).

The overall nesting success for flatback turtles at opportunistically monitored islands in 2024/25 was 28% (Table 5-8). This was greater than in 2023/24 (22%), but less than that recorded at baseline (i.e. 2021/22; 50%). The highest nest success rate was recorded for flatbacks at Angle Island (37%), while zero flatback nests were recorded at Fortescue, Mardie, and Stewart islands (Table 5-9). The majority of nesting activity for flatbacks was recorded during FS1 (nesting success = 20%) and FS2 (nesting success = 30%), with only two attempts at Passage Island occurring in FS3 (nesting success = 0%).

All nesting attempts by hawksbills at opportunistically monitored islands were made in FS1 (nesting success = 50%) and FS2 (nesting success = 42%; Appendix C). No activity was recorded during FS3. Over the full season, nesting success for hawksbills at these sites was 46%, which was greater than in 2023/24 (22%) and equivalent with baseline (i.e. 2021/22; 47%; Table 5-8). The greatest nesting success for this species was reported at South Passage Island (100%), followed by Round and Middle Passage islands (56 and 50%, respectively; Table 5-9).

Green turtle nesting activity occurred in very low numbers across the opportunistically surveyed islands, with most activity occurring during FS2. There was one recorded nesting attempt in FS1 and no new tracks in FS3. The small number of tracks recorded in FS2 at Round Island resulted in a 100% nesting success, followed by 50% success at South Passage and 33% at Middle Passage (Table 5-9). When combined for these islands across all surveys, the overall nesting success for green turtles was 42%, which was greater than both last season (i.e. 2023/24) and baseline (i.e. 2021/22; both 33%; Table 5-8).

5.4 Nesting Habitat: Incubation Success

Excavations were conducted on systematically marked nests on Sholl and Long islands during FS2 and FS3 to determine incubation success metrics. Clutch size, hatch and emergence success were determined for all viable marked and opportunistic nests, whilst temperature data (used to determined clutch fate and the incubation environment) was only retrieved for marked nests. No clutches were marked on the mainland and no opportunistic nests were located for excavation.

5.4.1 Thermal Environment

5.4.1.1 Air Temperature and Rainfall

The mean daily maximum air temperature recorded at the Mardie weather station during the monitoring period (1 October 2024 – 31 March 2025) was 38.1 °C (range 28.4 – 45.8°C; *n* = 171), with the highest daily maximum temperature recorded on 19 December 2024 (Figure 5-10; BoM 2025a), with 330.6 mm of rain falling during this time. Total rainfall for the period was 330.6 mm, with the majority of rainfall being associated with the passing of Severe Tropical Cyclone Sean (114.6 mm on 20 January 2025; BoM 2025b).

Rainfall associated with Severe Tropical Cyclone Zelia was comparatively limited at the Mardie weather station (6.2 mm; 8 – 15 February 2025; BoM 2025c), however, was localized enough at the access track to Mardie Camp to render it unsafe to use. This resulted in a two-week delay to FS3.

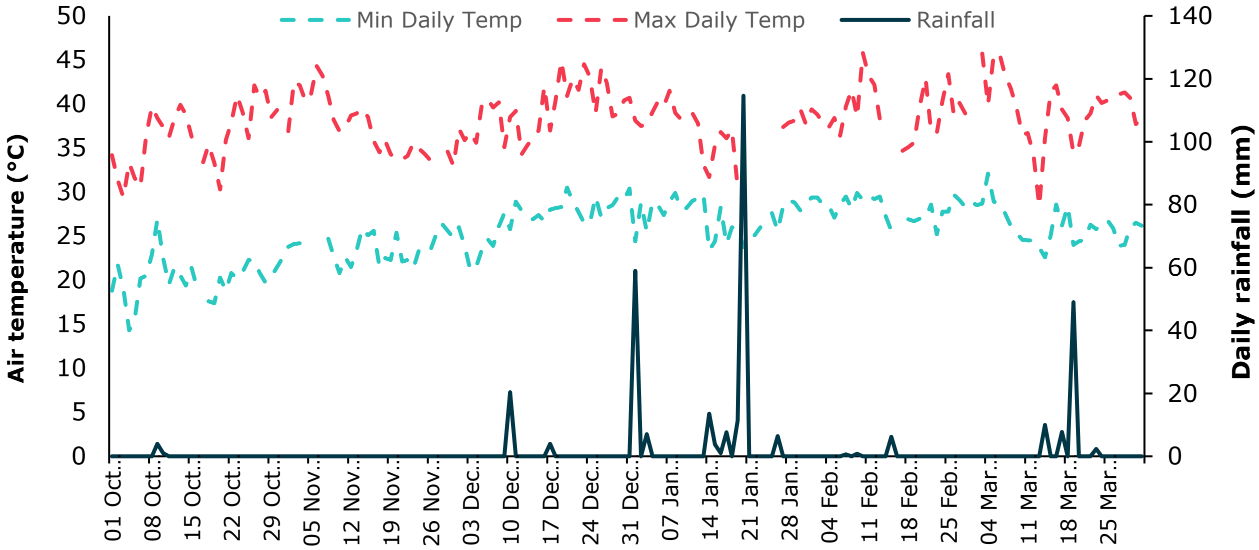

Figure 5-10 Daily air temperature and rainfall recorded at Mardie, Western Australia, between 1 October 2024 and 31 March 2025 (BoM 2025a)

5.4.1.2 Sand Temperature

Two control temperature loggers were deployed at monitoring sites that were surveyed on a daily basis (i.e. Long Island, Sholl Island, Mardie Creek West and Mardie Creek East) during FS1. Control loggers remained deployed in the sand for between 142 and 143 days between 19 October 2024 and 11 March 2025. The deployment duration included the entire incubation period of all marked clutches, and all control loggers – with the exception of one at Sholl Island – returned useable data.

Mean daily temperatures recorded by control loggers across the monitoring period were 33.9 ± 2.5 °C and 34.2 ± 2.4 °C for Long and Sholl Islands, respectively, and 34.9 ± 2.6 °C and 34.2 ± 2.1 °C for Mardie Creek West and East, respectively (Figure 5-11). As in previous seasons of monitoring (PENV 2019; 2023b; 2024), the sand temperature tended to be warmer along the mainland (34.6 ± 2.4 °C) than at the offshore islands (34.1 ± 2.5 °C).

Two significant temperature drops were recorded at all monitoring sites as a result of rainfall that fell in mid-January 2025 during the passing of Severe Tropical Cyclone Sean (14th – 20th; Figure 5-11). This rainfall impacted the development of marine turtle nests that were systematically marked during FS2 which were reaching a late phase of development (discussed in Section 5.4.2).

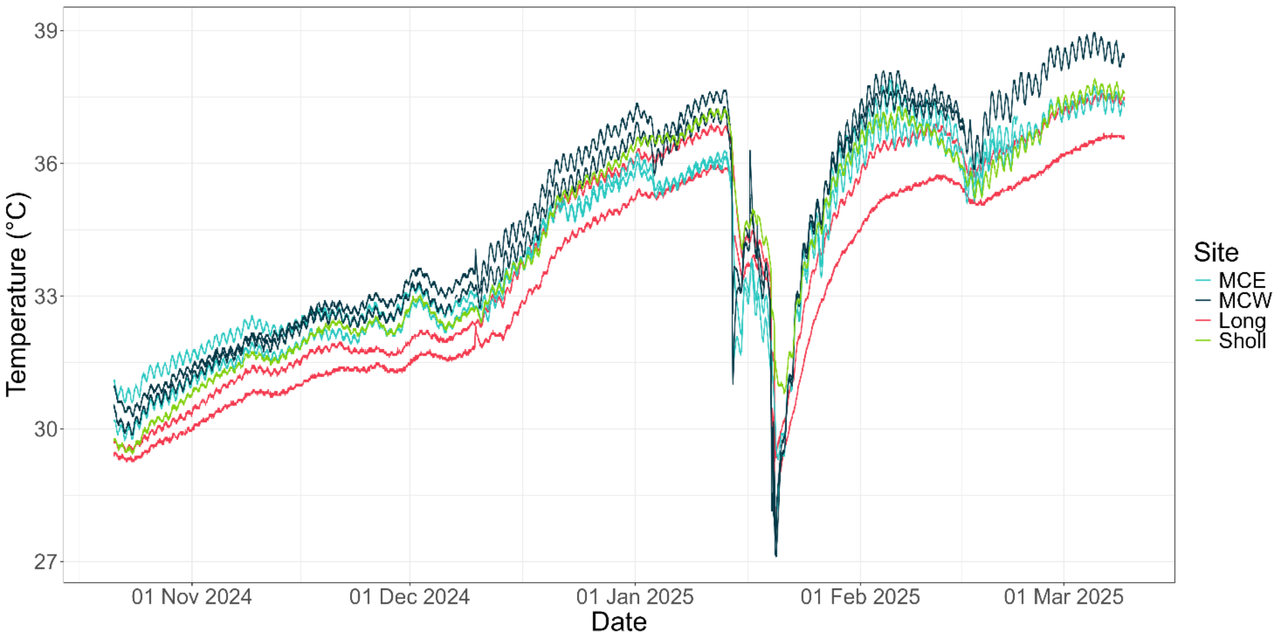

Figure 5-11 Control logger temperature profiles for the 2024/25 monitoring period. MCW = Mardie Creek West; MCE = Mardie Creek East

5.4.2 Clutch Fate

A total of 26 clutches were systematically marked during FS1 and FS2 on Sholl (*n* = 9) and Long (*n* = 17) islands (Figure 5-12; Table 5-10). Of these, 18 were flatback turtle nests, seven were hawksbill turtle nests, and one was a green turtle nest.

Twenty-two of the 26 nests were systematically marked during FS1. This included 16 flatback nests (73%) and six hawksbill nests (27%). The majority of nests (*n* = 14) were marked on Long Island (12 flatback nests (86%) and 2 hawksbill nests (14%)), with the remainder (*n* = 8) marked on Sholl Island evenly between flatback and hawksbill nests (*n* = 4 for both species). The remaining four marine turtle nests were marked during FS2, including two flatback, one hawksbill, and one green turtle nest. The majority of nests were marked at Long Island (*n* = 3; flatbacks and hawksbill), with the remaining green turtle nest marked at Sholl Island (Figure 5-12).

No clutches were marked on the mainland, as no nests were observed at either Mardie Creek West or Mardie Creek East. On average, nests were positioned 9.7 ± 6.1 m (range 1 – 22 m) above the spring tide line. Additionally, no opportunistic nests were excavated during the 2024/25 season.

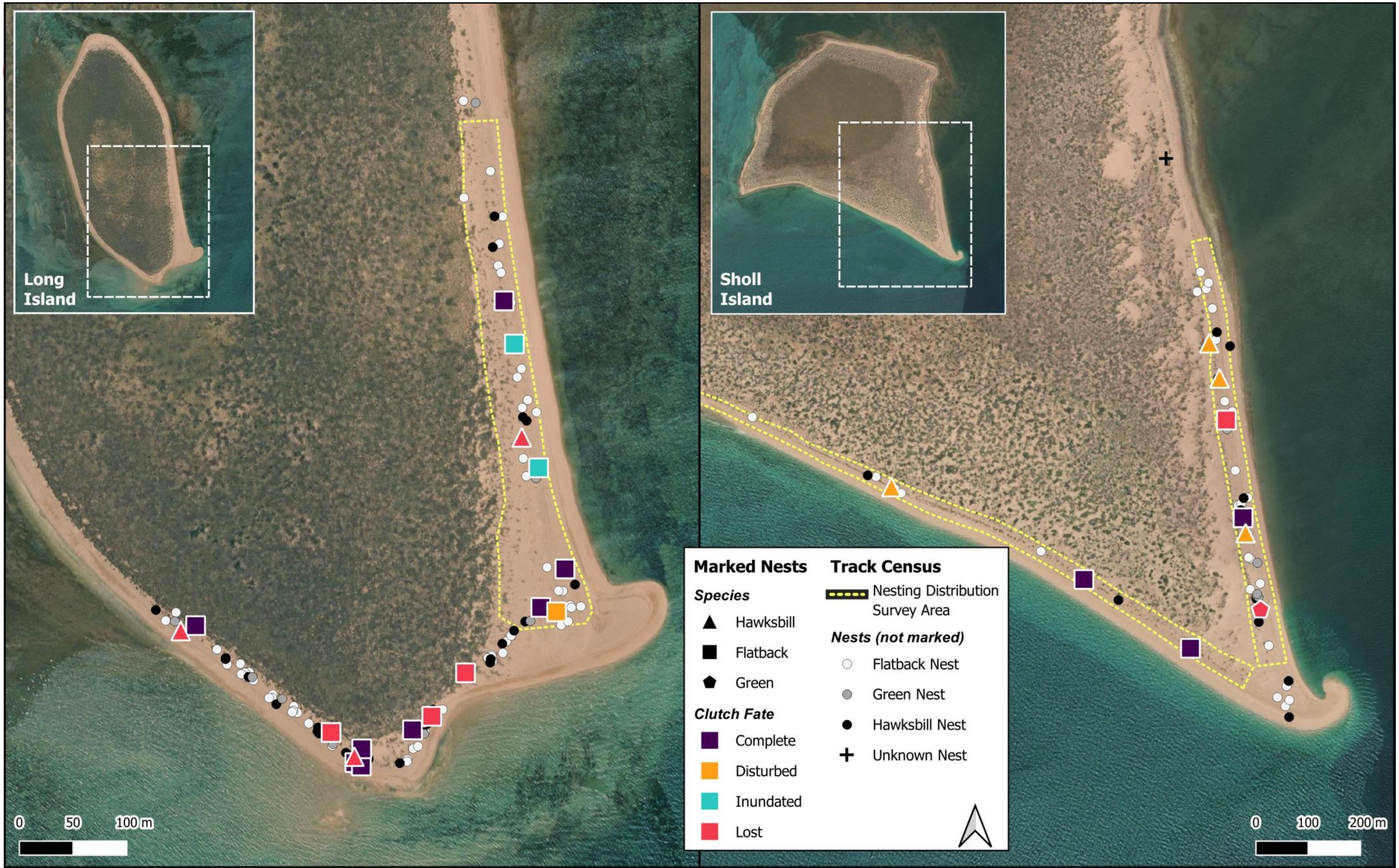

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Figure 5-12 Systematically marked nests relative to nesting distribution survey areas and all identified nests for flatback, hawksbill, and green turtles at Long and Sholl islands in 2024/25. Symbology defined in legend

Table 5-10 Clutch fate of all systematically marked nests on Sholl and Long islands in 2024/25. Note: no opportunistic nests were excavated in 2024/25.

Location	Species	Nest number	Distance to spring high tide line (m)	Clutch fate	Logger data recovered?	Temp. analysis?
Sholl Island	Flatback	1	2	Complete	Yes	Yes
	Flatback	2	1	Lost	No	No
	Flatback	3	12	Complete	Yes	Yes
	Flatback	4	12	Complete	Yes	Yes
	Flatback	5	10	Complete	Yes	Yes
	Flatback	6	2	Lost	No	No
	Flatback	7	7	Lost	Yes	No
	Flatback	8	3	Complete	Yes	Yes
	Flatback	9	17	Inundated (Rain)	Yes	No
	Flatback	10	22	Inundated (Rain)	Yes	No
	Flatback	11	9	Disturbed	Yes	No
	Flatback	12	10	Complete	Yes	Yes
	Flatback	13	7	Complete	Yes	Yes
	Flatback	14	16	Complete	Yes	Yes
	Hawksbill	1	18	Lost	Yes	No
	Hawksbill	2	1	Lost	No	No
	Hawksbill	3	3	Lost	Yes	No
Long Island	Flatback	1	7	Complete	Yes	Yes
	Flatback	2	11	Complete	Yes	Yes
	Flatback	3	6	Lost	No	No
	Flatback	4	13	Complete	Yes	Yes
	Green	1	17	Lost	Yes	No
	Hawksbill	1	3	Disturbed	Yes	No
	Hawksbill	2	12	Disturbed	Yes	No
	Hawksbill	3	11	Disturbed	Yes	No
	Hawksbill	4	19	Disturbed	Yes	No

Temp. = temperature.

Systematically marked clutches were excavated during FS3. Of these, eight (30.8 %) were unable to be relocated by the field team as they were lost to either beach erosion, the nest marking stake was lost to nearby turtle nesting activity, or disruption from sea eagles (the latter confirmed for a hawksbill nest on Sholl Island). All marked nests were located above the spring high tide line (6.9 ± 6.9 m; range 1 – 18 m). The temperature loggers in four of these nests were also unable to be recovered, however, data was downloaded via Bluetooth from the remaining four nests.

None of the eighteen excavated nests were inundated by the spring high tide (average distance above spring tide line 10.9 ± 5.4 m; range 2 – 22 m). The two excavated nests that were marked in FS2, however, were impacted by the heavy rainfall associated with Severe Tropical Cyclone Sean in mid-January 2025 (see Section 5.4.4: BoM 2025b). Additionally, five of the marked clutches were disturbed during the incubation period, including one flatback nest on Long Island, and all four hawksbill nests marked on Sholl Island (Figure 5-12). These disturbances were most likely due to turtle nesting activity occurring in the same location following nest marking (Figure 5-9).

The remaining complete marked clutches (n = 11) were laid by flatback turtles on both Long (*n* = 8) and Sholl (*n* = 3) islands (Table 5-10). Following quality control of the data, all eight of these clutches were used to determine incubation success metrics (described below).

5.4.3 Clutch Size

Mean clutch size for excavated flatback turtle nests was 45.9 ± 4.1 eggs (40 – 53; n = 14) (Table 5-11). Hawksbill nests had a mean clutch size of 87.5 ± 22.8 eggs (64 – 118; n = 4).

5.4.4 Hatch and Emergence Success

Mean hatch and emergence successes for all flatback turtle nests monitored on Sholl and Long islands were 68.8 ± 33.0 % (0.0 – 95.5 %, *n* = 14; Table 5-11). Flatback nests located on Sholl Island had a greater mean hatch and emergence success on average than those at Long Island.

The mean hatch and emergence successes of hawksbill nests monitored on Sholl Island were 56.6 ± 22.6 % (37.3 – 86.1 %, *n* = 4).

The hatch and emergence successes of the two flatback nests on Long Island that were marked in FS2 and showed evidence of impact from the heavy rainfall in January 2025 was 15.9 ± 22.4 % (0.0 – 31.7 %). It is unlikely that inundation was caused by the spring tide, given the temporal consistency in temperature drops across all control loggers deployed during the 2024/25 monitoring season, including on the mainland (Figure 5-10). The contents of these inundated nests were predominantly fully developed embryos, indicating that the rainfall was a significant contributor to mortality of these nests during the final stages of the incubation period. Temperature data retrieved via BlueTooth from the remaining two nests marked in FS2 (one green nest at Sholl Island and one hawksbill at Long Island) also indicated impacts from rainfall, however, the nests were unable to be relocated for excavation.

Table 5-11 Hatch and emergence success of excavated flatback and hawksbill turtle clutches (marked and opportunistic). Inundated nests have not been included.

Location	*n*	Statistic	Clutch size	Hatch Success (%)	Emergence Success (%)
Flatback Turtles					
Sholl Island	3	Mean	47.0	89.5	89.5
		St. Dev	2.6	7.4	7.4
		Min.	44.0	81.3	81.3
		Max.	49.0	95.5	95.5
Long Island	11	Mean	45.5	63.2	63.2
		St. Dev	4.4	35.2	35.2
		Min.	40.0	0.0	0.0
		Max.	53.0	92.9	92.9
Total	14	Mean	45.9	68.8	68.8
		St. Dev	4.1	33.0	33.0
		Min.	40.0	0.0	0.0
		Max.	53.0	95.5	95.5
Hawksbill Turtles					
Sholl Island	4	Mean	87.5	56.6	56.6
		St. Dev	22.8	22.6	22.6
		Min.	64.0	37.3	37.3
		Max.	118.0	86.1	86.1
Long Island	0	Mean	-	-	-
		St. Dev	-	-	-
		Min.	-	-	-
		Max.	-	-	-
Total	4	Mean	87.5	56.6	56.6
		St. Dev	22.8	22.6	22.6
		Min.	64.0	37.3	37.3
		Max.	118.0	86.1	86.1

5.4.4.1 Incubation Environment

Eleven temperature profiles from marked, complete clutches were used to determine incubation statistics (Table 5-12). All eight were from flatback nests, with three marked on Sholl Island and the remaining eight on Long Island.

The mean incubation period for flatback clutches was 46.5 ± 1.6 days (range 44 – 49 days), and clutches had a mean daily temperature of 32.1°C (range 31.5 – 32.7°C) during this time. The thermosensitive period (middle trimester of incubation) lasted an average of 15.5 days (range 14 – 17) and had a mean daily temperature of 31.7°C (range 31.0 – 32.6°C). The proportion of the incubation period for flatbacks spent above the thermal tolerance range of 33°C was 34.2 % for flatback nests. This typically coincided with the third trimester of the incubation period for both turtle species.

No systematically marked hawksbill nests remained in a complete state by FS3. As a result, there are no incubation data for 2024/25 to present for hawksbill turtles.

Table 5-12 Incubation period statistics from marked flatback and hawksbill turtle clutches that were determined to be complete based on excavation and temperature data

Location	Flatback					Hawksbill				
	n	Mean IP (days)	Mean IP temp. (°C)	Mean TSP (days)	Mean TSP temp. (°C)	*n*	Mean IP (days)	Mean IP temp. (°C)	Mean TSP (days)	Mean TSP temp. (°C)
Sholl	3	46.3	31.9	15.7	31.5	0	-	-	-	-
Long	8	46.5	32.2	15.5	31.8	0	-	-	-	-
Total	11	46.5	32.1	15.5	31.7	0	-	-	-	-

IP = incubation period, TSP = thermosensitive period.

5.5 Hatchling Orientation

A total of seven individual hatchling fans were recorded during the 2024/25 monitoring season. All of these were observed in FS2 (i.e. December 2024) and comprised of at least five hatchling tracks. Summary statistics for hatchling orientation metrics, including nest fan spread and offset angles, are provided for the routinely monitored sites (Table 5-13) and opportunistically monitored sites (Table 5-14) below.

Table 5-13 Summary statistics for hatchling fans at routinely surveyed locations in 2024/25. Note: greed indicates no exceedance, orange indicates trigger level exceedance and red indicates threshold level exceedance.

Statistic		Location					
		Sholl Island (East)	Sholl Island (West)	Long Island	Mardie Creek East	Mardie Creek West	All
n		2	2	3	0	0	**7**
Spread Angle (°)	**Mean**	58.0	65.5	50.7	-	-	**57.0**
	StDev	14.1	2.1	13.8	-	-	**11.9**
	Min	48.0	64.0	35.0	-	-	**35.0**
	Max	68.0	67.0	61.0	-	-	**68.0**
Offset Angle (°)	**Mean**	4.5	9.8	2.7	-	-	**5.2**
	StDev	2.1	5.3	2.0	-	-	**4.1**
	Min	3.0	6.0	0.5	-	-	**0.5**
	Max	6.0	13.5	4.5	-	-	**13.5**

All seven of the hatchling fans recorded this season were recorded across sites that were monitored daily. Four of the seven hatchling fans were recorded on Sholl Island, including two on the western beach and two on the eastern beach (Figure 5-13), and all were for flatback turtles. The remaining three hatchling fans were recorded on Long Island. Two of these were associated with flatback nests, and one with a hawksbill nest. No hatchling fans were recorded at Mardie Creek West and Mardie Creek East across the entire monitoring period.

It should be noted that the three fans recorded on Long Island were located outside of the designated monitoring area (see Figure 5-13). However, these were included in the analyses for 2024/25 given the low number of fans encountered this season and because they were not located on the spit (i.e. a direct pathway to the ocean was clear at all three sites). There were no significant differences in the spread or offset angles between Long and Sholl islands (Kruskal-Wallis test, $p>0.05$).

Opportunistically monitored islands were also surveyed throughout the monitoring period for hatchling fans, however, none were observed (Table 5-14). This was likely the combined result of low nester abundance this season and the need to delay FS3 following the passing of Severe Tropical Cyclone Zelia (i.e. FS3 was completed later in hatching season than originally planned optimal timing).

As in 2023/24, when the hatchling orientation data from Sholl and Long islands for 2024/25 were compared to benchmark data from the MTMP (PENV 2023; exceedance criteria presented in Table 5-15), one trigger-level spread angle exceedance was reported for Sholl Island (West; Table 5-15). Reported spread and offset angles for all other locations, and when fans were considered collectively across all monitored sites, were well below exceedance criteria (Table 5-15).

Table 5-14 Summary statistics for hatchling fans at opportunistically surveyed locations in 2024/25

Statistic		Location							
		Round Island	Middle Passage Island	Angle Island	Mardie Island	South Passage Island	Stewart Island	Fortescue Island	All
n		0	0	0	0	0	0	0	0
Spread Angle (°)	**Mean**	-	-	-	-	-	-	-	-
	StDev	-	-	-	-	-	-	-	-
	Min	-	-	-	-	-	-	-	-
	Max	-	-	-	-	-	-	-	-
Offset Angle (°)	**Mean**	-	-	-	-	-	-	-	-
	StDev	-	-	-	-	-	-	-	-
	Min	-	-	-	-	-	-	-	-
	Max	-	-	-	-	-	-	-	-

Figure 5-13 Nest fans located for hatchling orientation assessments in 2024/25

*Table 5-15 Benchmark hatchling orientation spread and offset angle statistics, trigger and threshold criteria. Benchmark data are from the Mardie Salt Project: Marine Turtle Monitoring Program (PENV 2023b). Trigger and threshold criteria are based on baseline mean + 2*StDev and baseline mean + 3*StDev, respectively. Green shading indicates no exceedance; orange shading indicates trigger-level exceedance*

Location	Baseline			2024/25	Criteria	
	n	Mean	StDev	Mean ± StDev (*n*)	Trigger	Threshold
Spread Angle (°)						
Sholl Island (East)	22	60.7	18.0	58.0 ± 14.1 (2)	**96.6**	**102.0**
Sholl Island (West)	8	45.0	8.9	65.5 ± 2.1 (2)	**62.8**	**98.9**
Long Island	37	52.8	16.7	50.7 ± 13.8 (3)	**86.3**	**91.7**
All	67	54.4	17.0	57.0 ± 11.9 (7)	**88.5**	**92.0**
Offset Angle (°)						
Sholl Island (East)	22	8.8	6.2	4.5 ± 2.1 (2)	**21.3**	**27.5**
Sholl Island (West)	8	4.9	5.5	9.8 ± 5.3 (2)	**15.9**	**21.3**
Long Island	37	8.7	6.8	2.7 ± 2.0 (3)	**22.4**	**29.2**
All	67	8.3	6.5	5.2 ± 4.1 (7)	**21.3**	**27.9**

5.5.1.1 Predation Observations

Two of the seven (28.6 %) hatchling fans measured this season were associated with predator tracks and/or activity. Both were located on Sholl Island; one on the western beach and one on the eastern beach (Figure 5-13).

Predator tracks at the western nest fan were made by crab/s and reptiles (i.e. lizard/s), with the field team noting that a lizard may also have predated some hatchlings at this site based on the observed hatchling tracks.

At the eastern site, lizard tracks were also observed, and hatchling predation was deemed likely to have occurred. In this instance, the lizard dug near the nest cone to a depth of approximately 30 cm, and based on the available hatchling tracks, 26 of the 27 hatchlings made it to the water (i.e. one was predated).

5.6 Artificial Light Monitoring

Light monitoring cameras were successfully deployed at pre-determined locations close to the Projects development envelope at Mardie Creek (West), Mardie Creek (East), Sholl Island (West), Sholl Island (East), Long Island, Middle Passage Island, Round Island, as well as at bat habitat located near Mardie Pool (Figure 4-1) during FS2 and FS3.

5.6.1 Artificial Light Sources

Several sources of horizon light were visible within the captured light monitoring imagery at varying levels of brightness and located at different bearings from each monitoring location. Light sources identified by satellite imagery (see Figure 3-1 in Appendix D) visible from each monitoring location include:

- Mardie Creek (West): No sources of horizon light visible.
- Mardie Creek (East): No sources of horizon light visible.
- Long Island: Cape Preston, Sino Iron, and Mardie Onshore.
- Middle Passage Island: Cape Preston.
- Sholl Island (West): Sino Iron and Mardie Onshore.
- Sholl Island (East): Cape Preston, Sino Iron and Mardie Onshore.
- Round Island: Cape Preston, Sino Iron, and Mardie Onshore.
- Mardie Pool: Sino Iron and Mardie Village.

5.6.2 Night-time Light Emissions

Measured WOS sky brightness was darkest at Mardie Creek West (21.35 Vmag/arcsec^2) followed by Long Island (21.27 Vmag/arcsec^2; Table 5-16). The brightest WOS sky brightness value was captured at Mardie Pool (21.01 Vmag/arcsec^2). The dominant light source visible across monitoring sites was the Sino Iron development, which was visible in an easterly to south-easterly direction from most monitoring locations, including Long, Sholl and Round islands as well as Mardie Pool (see Appendix D). Substantial horizon shielding of all light sources along the horizon from dunes/vegetation was observed from both Mardie Creek (East) and Mardie Creek (West).

Project-associated light visible in processed imagery for 2024/25 included Mardie Village and Mardie Onshore Facilities. Mardie Village was observed as a distinct source of light from Mardie Pool, however, was shielded by vegetation and/or dunes from all other locations. The newly constructed Mardie Onshore Facilities were also observed as a distinct source of light from Long Island, Sholl Island (both sites), and Round Island, and was shielded by vegetation and/or dunes from all other locations.

Multiple unidentified sources of light were also visible in the Sky42 data captured in 2024/25. Two unidentified sources of light were visible from Long Island at a bearing of 130° and 137° on the 2nd of December 2024 (Figure 3-5 in Appendix D). An additional source of unidentified light was visible from Middle Passage Island at a bearing of 125° on the 8th of March 2025 (Figure 3-8 in Appendix D). Vessels were also visible from Sholl Island East and Round Island as faint sources of horizon light.

Measured zenith sky brightness was darkest at Round Island and Mardie Creek West (21.63 and 21.55 Vmag/arcsec^2 respectively, Table 5-16). The brightest zenith sky brightness was captured at Mardie Pool (21.06 Vmag/arcsec^2). All monitoring locations are classified as rural night skies, except for Long Island, which is classified as an ideal natural dark night sky (Table 5-16). See Table 4-3 for details relating to WOS descriptions.

Table 5-16: Median sky brightness for whole-of-sky, horizon and zenith captured at light monitoring locations during the 2024/25 turtle monitoring season. See Table 4-3 for details relating to WOS description classifications.

Monitoring location	Sky Brightness (Vmag/arcsec^2)			WOS Description
	WOS	Horizon	Zenith	
Mardie Creek (West)	21.35	21.39	21.55	Rural night sky
Mardie Creek (East)	21.24	21.27	21.47	Rural night sky
Sholl Island (West)	21.05	20.95	21.41	Rural night sky
Sholl Island (East)	21.09	20.97	21.33	Rural night sky
Long Island	21.27	21.19	21.52	Ideal natural dark night sky
Middle Passage Island	21.14	21.01	21.53	Rural night sky
Round Island	21.23	21.08	21.63	Rural night sky
Mardie Pool	21.01	20.78	21.06	Rural night sky

5.6.3 Changes in Sky Brightness

The MTMP requires that the light monitoring results from offshore islands (2021/22) and the mainland (2022/23) form a baseline dataset for yearly data to be compared to throughout the monitoring program. Table 5-17 shows the WOS sky brightness measured over the last four seasons of monitoring, where data is available, along with the reported change in brightness from baseline data for this season (i.e. 2024/25 relative to baseline). Where baseline data is not available, the change in brightness is calculated from the first year of available data.

It should be noted that the positioning of stars, atmospheric conditions, changes in dune profile, vegetation height and other natural phenomena may cause variance in sky brightness from year to year, and therefore small changes in sky brightness are expected.

Table 5-17 Change in WOS sky brightness observed from baseline to 2024/25 at the light monitoring locations for the MTMP. Note that Vmag/arcsec^2 is measured on a logarithmic scale.

Monitoring location	WOS Sky Brightness (Vmag/arcsec^2)				Change in brightness (%)
	2021/22	2022/23	2023/24	2024/25	
Mardie Creek (West)	-	21.34*	21.30	21.35	↓ 0.92
Mardie Creek (East)	-	21.24*	21.22	21.24	0.00
Sholl Island (West)	-	-	21.53	21.05	↑ 55.60
Sholl Island (East)	21.16*	-	21.08	21.09	↑ 6.66
Long Island	21.19*	-	21.36	21.27	↓ 7.10
Middle Passage Island	-	-	21.42	21.41	↑ 0.93
Round Island				21.06	-
Mardie Pool	-	-	-	21.06	-

Asterisk denotes baseline dataset, blue values indicate reduction in WOS brightness, red values indicate increase in WOS brightness. Note: change in brightness is presented as percentage change, calculated after the logarithmic sky brightness values (Vmag/arcsec^2) were converted to a linear scale.

Increases in WOS sky brightness were observed at Sholl Island East (6.66 %), Sholl Island West (55.60 %) and Middle Passage Island (0.93 %). The comparatively larger increase in WOS sky brightness detected from Sholl Island (West; 55.6 %) was attributed to the newly constructed Mardie Onshore Facilities, which were observed as a bright source of direct light along the horizon from this location. Decreases in WOS sky brightness were observed from Long Island (-7.10 %) and Mardie Creek West (-0.92 %), which may be attributed to increases in vegetation height and/or changes in dune profile. No change in WOS sky brightness was observed from Mardie Creek (East) and no baseline data was available for comparison at Round Island or Mardie Pool; the 2024/25 records will serve as baseline records for these sites in future seasons.

5.7 Light Sources

While it is difficult to quantify changes in specific point sources of light between monitoring seasons, a qualitative analysis of changes in visible light sources from monitored locations has been outlined in Table 5-18.

This is the first season that light from the Mardie Onshore Facilities has been visible due to its recent construction. Light from Rio Tinto Mesa A mine, Barrow Island and Varanus Island was not recorded by the light cameras from any of the monitoring locations in 2024/25. It should be noted that these light sources still exist, however changes in vegetation height and/or dune profiles may cause changes in visibility of light sources across monitoring seasons.

Table 5-18 Change in visible light sources observed from 2021/22 to 2024/25 at light monitoring locations for the MTMP

Visible Light Source	Visibility by Monitoring Season		
	2021/22	2023/24	2024/25
Cape Preston	SIE, LI,	SIE, SIW, LI, ME*	LI, SIE, RI*
Sino Iron mine	SIE, LI	SIE, SIW, LI, ME*, MW*	MP*, LI, SIE, SIW, MPI, RI*
Mardie Village	SIE, LI	SIE, SIW, LI	MP*
Mardie Onshore Facilities^	-	-	LI, SIE, SIW, RI*
Rio Tinto MESA A mine	SIE, LI	-	-
Barrow Island	SIE	ME*, MW*	-
Varanus Island	SIE	-	-

*MW-Mardie Creek West; ME-Mardie Creek East; SIW-Sholl Island West; SIE-Sholl Island East; LI- Long Island; MPI-Middle Passage Island; RI-Round Island; MP-Mardie Pool. * denotes the first season for this location to be monitored.*
^ denotes first time light source has been recognised

5.7.1 Night-Time Light Emissions & Hatchling Orientation Indices

The comparison of visible light sources recorded in the 2024/25 season to benchmark light monitoring data collected for the MTMP revealed new detectable light sources in the Project area, that included the Mardie Onshore Facilities, and three unidentified sources of light.

When compared with the benchmark data, the hatchling orientation data from Sholl and Long Islands in the 2024/25 season had offset angle (i.e. misorientation) metrics below exceedance criteria across all locations. As in 2023/24, however, a trigger level spread angle (i.e. disorientation) exceedance was identified for Sholl Island (West; Table 5-15).

6. Discussion

BCI was compliant with the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A) with respect to marine turtle and artificial light monitoring undertaken as per the Mardie Salt Project MTMP (PENV 2023b) in 2024/25.

6.1 Nesting Habitat: Track Census

6.1.1 Nesting Activity

Flatback, hawksbill and green turtles were all observed to be nesting within the Mardie region during the 2024/25 nesting season. As in 2023/24 (PENV 2024), marine turtle nesting activity in 2024/25 was greatest at Sholl and Long islands during the December 2024 survey (FS2). Overall, flatback turtles were the most abundant nesters, followed by hawksbill and green turtles. At the mainland beaches and smaller, opportunistically monitored islands, marine turtle nesting activity was significantly lower, supporting the baseline evidence that indicates these sites provide less regionally significant nesting habitat than is available at Sholl and Long islands (PENV 2023b).

The abundance of flatback nesters varied greatly between October and December 2024 (2.3 and 12.5 tracks/night, respectively), however, the abundance of hawksbills at Long and Sholl Islands remained comparatively consistent over the same period (3.1 and 6.0 tracks/night). This aligns with the findings of the 2021/22 and 2023/24 marine turtle monitoring surveys (PENV 2022; 2024), where no clear October peak in hawksbill nester abundance was detected across monitoring sites. Furthermore, in comparison to baseline surveys at Long and Sholl islands, the nester abundance of flatbacks was similar, while the abundance of hawksbills, particularly in December 2024, was greater (see Table 5-6). While monthly census surveys undertaken at Rosemary Island between August and December 2020 suggested that October represents the peak nesting period for hawksbill turtles in the Dampier Archipelago (PENV 2024), the continued lack of a defined October peak in the 2024/25 again suggests that hawksbill nesting within the Mardie offshore island region either (i) has a different peak, or (ii) has a peak that extends over a greater period of time. The abundance of nesting marine turtles is known to vary temporally in response to the life history characteristics of the species (e.g. remigration intervals) as well as environmental conditions at their offshore foraging grounds (Pendoley et al. 2014). At present, it is difficult to quantify these patterns for the Mardie region as 2024/25 season represents only the second year of monitoring post-baseline for the Mardie MTMP. Following the third year of data capture (i.e. 2025/26), closer examination of the significance of these species-specific trends in abundance may be possible.

Green turtle nesting activity was minor when compared to the nesting contribution of flatback and hawksbill turtles during the 2024/25, which was also the case during the baseline and 2023/24 monitoring surveys for the Mardie islands region (PENV 2023b; 2024). Green turtles typically favour high energy oceanic beaches with a deep sandy seabed approach (e.g. as is found on the west coast Barrow Island, north coast Thevenard Island, and at Serrurier Island; Pendoley 2005) and not the beach types characterised by the mainland and coastal island beaches surveyed as part of the MTMP. Furthermore, green turtles are known to nest over a period of approximately four to six months in Western Australia (Limpus 2009), with a peak typically occurring between December and January. This timing is supported by results from systematic green turtle monitoring on North West Cape, where the 2021/22 green nesting season was characterised by high levels of nesting activity peaking in December 2021 (PENV 2024). The results for the current and baseline surveys of the Mardie offshore islands region are therefore likely to be representative of both the physical characteristics at monitoring sites for the MTMP, and the spatial and temporal levels of green nesting activity in the area, which are regulated by the El Nino Southern Oscillation (Sollow et al. 2002). As a result, and as reported in 2023/24 (PENV 2024), the Mardie region is not considered a regionally significant rookery for green turtles.

6.1.2 Nesting Distribution

While specific distribution metrics were not available for marine turtle nesting activities at Long and Sholl islands in 2023/24 (PENV 2024b), track census surveys undertaken in 2024/25 revealed little change in the distribution patterns compared to those reported during the baseline period for the MTMP (PENV 2023b).

Significant clustering of nesting activity was observed across Sholl Island (East and West) and Long Island, with the southern end of Long Island continuing to host the greatest density of nesting attempts. The clustering reported for Sholl (West) in 2024/25 was the only notable difference to observations from the baseline period, when the distribution of tracks at this site was described as 'dispersed'. Without specific clustering metrics for direct comparison, it is not possible to quantitatively describe this change. However, from the available distribution heatmaps and given the observation of tracks throughout entire Sholl (West) monitoring area (see Figure 5-9) it is likely that this to be due to physical characteristics of the sub-tidal benthos and their influence on marine turtle emergence point selection (Pendoley 2005), rather than any Project-attributable change in nesting habitat health. Continued monitoring of nesting distribution metrics in upcoming seasons will allow for the consistency of these clustering behaviours to be better understood.

6.1.3 Nesting Success

Nesting success varied by species and monitoring site during the 2024/25 season. The nesting success of flatback turtles on Sholl and Long Islands was greater in 2024/25 (32%) than during the previous season (i.e. 2023/24; 18%), but lower than reported for baseline (41%). The same pattern was observed for flatbacks across the opportunistically monitored islands (27, 22, and 50%, respectively). This can be explained by naturally occurring cycles in the abundance of flatbacks from season to season, whereby females remigrate to nesting beaches every second year on average and not consistently each year (Pendoley et al. 2014).

In contrast, nesting success for hawksbills was lower in 2024/25 (28%) than in 2023/24 (33%) and at baseline (44%). This decrease is likely the result of both the high density of hawksbills attempting to nest along the southernmost, soft dune system at Long Island, where structurally-sound egg chambers appear difficult to create (L. Peel, *pers. obs. 2025*), and the numerous false crawls reported at Sholl Island (West) for this species (see Figure 5-3). At opportunistically monitored islands, however, nesting success patterns for hawksbills demonstrated similar levels in 2024/25 (46%) when compared to baseline (47%), both of which were greater than that observed in 2023/24 (22%). These differences among sites highlight the extent of natural variation that can occur within a region and between seasons, and future monitoring will be critical to better understanding these trends at Mardie.

Nesting success remained low on the mainland following three unsuccessful nesting attempts across the 2024/25 season. This aligns with records captured during baseline and in 2023/24 (PENV 2023b; 2024) and is an artefact of the mainland nesting habitat in the vicinity of the Project being of relatively poor quality compared to the offshore islands and other mainland nesting sites in the Pilbara (e.g. Back Beach Onslow, Ashburton Delta, Mundabullangana and Cemetery Beach; Pendoley et al. 2016; Pendoley 2024).

6.2 Nesting Habitat: Incubation Success

6.2.1 Systematic

Twenty-six nests were systematically marked across Long and Sholl islands during the 2024/25 season, with 11 (42%) of these – all of which were flatback nests – having a fate considered to be 'Complete' (see Table 5-10). As in 2023/24, no nests were marked on the mainland in 2025/25 because no new nests were observed. Of the remaining nests, eight were lost to beach and/or dune erosion, which is likely to have been compounded by weather conditions during the passing of Severe Tropical Cyclones Sean and Zelia (BoM 2025b, c), and a further five were disturbed during the incubation period, most likely by other turtles attempting to nest in a similar area (see Figure 5-12). Such loss rates are typical for systematic nest marking programs, particularly on the highly dynamic beaches of offshore islands, and similar losses were experienced during baseline monitoring and in 2023/24 (PENV 2023b; 2024).

Excavated, complete flatback clutches had an average clutch size of 45.9 eggs, which was slightly lower than the average clutch sizes reported previously for Long and Sholl islands (range 48 – 52 eggs; PENV 2023b; 2024), but within the range of previous observations across the Pilbara (Pendoley et al. 2014; Avenant et al. 2024). Hatch and hatchling emergence successes for 2024/25 (both 68.8%) were similar lower than those reported last season (2023/24; 81 and 80%, respectively; PENV 2024), but similar to those observed during baseline (2021/22; 65% PENV 2023b). This reduction in success rates can be attributed to the severe weather systems that occurred across the Pilbara in 2024/25 (see Section 5.4.1), the associated rainfall from which impacted at least two of the systematically marked flatback nests this season (hatch and emergence successes of 0.0% and 31.7% for both metrics, respectively). Heavy rainfall, such as that which fell during mid-January 2025 (114.6 mm; see Figure 5-11), can cool, and limit oxygen availability to, incubating marine turtle nests, and this impact causes greater levels of mortality during the early- and late-stages of incubation (Limpus et al. 2021). Comparatively, a lack of rainfall during the 2023/24 season (total = 6.2 mm; PENV 2024), and outside of the critical incubation period for flatback nests laid during the peak in December, contributed to the higher hatch and emergence successes for flatbacks last season.

No systematically marked hawksbill nests remained in a complete state by FS3. As a result, there are no incubation data for 2024/25 to present for hawksbill turtles.

6.2.2 Opportunistic

Additionally, despite routine monitoring by an experienced field team during FS3, zero opportunistic nests were excavated during 2024/25. This is likely the combined result of (i) the two-week delay to the field survey following Severe Tropical Cyclone Zelia, (ii) the lower overnight nesting rate for hawksbills compared to baseline reducing the number of available nests to excavate, and (iii) the potential for significant inundation impacts from rainfall associated with Severe Tropical Cylone Zelia (as observed for the two relocated nests that were marked during FS2). In future monitoring seasons, while it is likely that opportunistic excavations will be possible, it is recommended that systematically marking a greater number of nests during FS1 and FS2 for excavation during FS3 remain a priority for the MTMP. Incubation data retrieved *via* opportunistic excavations is inherently biased towards more successful nests because hatchlings need to survive to emerge and create tracks to allow for location of the nest cone and associated egg chamber, rendering it less reliable than incubation data retrieved systematically.

6.3 Hatchling Orientation

As described in Section 6.2.2 above, biological and environmental factors resulted in no opportunistic excavations being completed in 2024/25, and these same factors contributed to the limited hatchling orientation data available for the present season. However, from the seven available fans measured across Long and Sholl islands, including those outside of the monitoring area at Long Island (see Figure 5-13), spread and offset angles did not significantly differ. Similarly to the incubation data, flatback hatching fans (n = six) outnumbered hawksbills (n = one) in 2024/25, with two nest cones (both flatbacks) being associated with evidence of predator activity, including reptile digging and crab tracks. When compared with the benchmark data, the hatchling orientation data from Sholl and Long Islands in the 2024/25 season had offset angle (i.e. misorientation) metrics below exceedance criteria across all locations. A trigger level spread angle (i.e. disorientation) exceedance, however, was identified for Sholl Island (West; Table 5-13); a result that aligned with findings reported in 2023/24 (PENV 2024) and that is discussed in Section 6.4.1 below.

6.4 Artificial Light Monitoring

Comparison of light monitoring data recorded at eight locations in 2024/25 with the past four seasons of light monitoring (where available), demonstrated an increase in whole-of-sky brightness at Sholl Island (East), Sholl Island (West) and from Middle Passage Island. The comparatively larger increase in WOS sky brightness detected from Sholl Island (West; 55.6 %) was attributed to the newly constructed Mardie Onshore Facilities, which were observed as a bright source of direct light along the horizon and were also visible from Long Island, Sholl Island (East), and Round Island. A decrease in WOS sky brightness was reported at Long Island and Mardie Creek (West), which may be attributed to increases in vegetation height and/or changes in dune profile shielding previously available light. No change in WOS sky brightness was observed from Mardie Creek (East). Light from Mardie Village was visible from Sholl Island (East and West) and Long Island in the 2023/24 season, however, was not visible from Sholl Island (East) in 2024/25. This is likely due to changes in vegetation height and/or dune shielding the previously visible lighting. Artificial light from Sino Iron and Mardie Village was visible from Mardie Pool, which represented a new monitoring site in 2024/25. The brightest visible light sources across the monitoring area continue to include the port at Cape Preston and Sino Iron mining facilities, with the addition of light from the newly constructed Mardie Onshore Facilities in the 2024/25 season.

The measured 55.6 % increase in artificial light from Sholl Island (West) that was associated with the newly constructed Mardie Onshore Facilities represented the greatest change to the artificial light-scape for the Project in 2024/25. Light modelling for the Project (PENV 2023c) predicted an increase in WOS brightness between 58 % (base) and 73 % (worst-case) from Sholl Island (southern-most tip) following the completion of construction activities, and the measured increase in WOS during 2024/25 falls below both of these predictions. Furthermore, the risk assessment provided in the Illumination Plan (BCI Minerals 2023) quantified the residual risk of Project-associated lighting to marine turtles as 'low' for all locations and life stages if all management actions outlined in Table 6-2 of the Plan are fully implemented (BCI Minerals 2023). To ensure compliance and maintain the effectiveness of these management measures, an annual external lighting audit should be conducted at least six weeks prior to every turtle nesting season. This audit is critical in verifying that lighting management measures are in place to ensure potential impacts to marine turtles have been minimised. The potential for this measured increase in artificial lighting to impact marine turtles, and in particular, turtle hatchlings in 2024/25, is described in Section 6.4.1 below.

Sky glow from Sino Iron was visible from both Mardie Creek (East) and Mardie Creek (West) in during the 2023/24 season but was shielded at these monitoring locations during the 2024/25 season by changes in dune morphology and/or vegetation growth. Similarly, offshore sky glow from the oil and gas facility on Barrow Island was visible from Mardie Creek (West) and Mardie Creek (East) during the 2023/24 season but was not visible during the 2024/25 season due to shielding provided by dunes and/or vegetation.

Alongside the above known sources of light, two unidentified sources of light were visible from Long Island at a bearing of 130° and 137° on the 2nd of December 2024. An additional source of unidentified light was visible from Middle Passage Island at a bearing of 125° on the 8th of March 2025. Examination of these bearings (see Figure 4-1 in Appendix D) suggested that these unknown lights sources may have been marine vessels positioned between the monitored islands and the mainland, given that marine vessels were visible from Sholl Island (East) and Round Island as faint sources of light on the horizon. Alternatively, they may have been Project-associated lighting on the mainland. If the same sources are identified during the 2025/26 monitoring season, it is recommended that an investigation be undertaken to determine their origin and whether they are associated with the Project.

Artificial light monitoring was completed for the first time in 2024/25 season on the mainland at Mardie Pool (see Appendix D), as per outcome-based provision Number 4 of the Illumination Plan (see page 52; BCI Minerals 2023) and opportunistically at Round Island. The results presented in this report will serve as baseline for these sites in future seasons.

6.4.1 Artificial Light & Hatchling Orientation

Increases in measured artificial light have the potential to impact marine turtles located on the mainland and coastal islands. Potential impacts to emerging hatchling turtles include disorientation and/or misorientation by artificial lighting, which may cause hatchling turtles to take longer, or fail, to reach the sea, resulting in increased mortality through dehydration, predation, or exhaustion (Salmon & Witherington 1995). As in 2023/24, a trigger level spread angle (i.e. disorientation) exceedance was identified in hatchling orientation data collected at for Sholl Island (West) in 2024/25. Reported spread and offset angles for all other locations, and when fans were considered collectively across all monitored sites, were well below exceedance criteria.

Although the Mardie Onshore Facilities represented a new source of artificial light in 2024/25 that was visible from Sholl Island (West), it is difficult to determine whether this contributed to the trigger-level spread angle reported from this site given: (i) the low sample size, (ii) the position of observed hatchling fans near to the spit on Sholl Island, and (iii) similarities in hatchling orientation patterns observed during the previous monitoring season (i.e. 2023/24), which occurred prior to the construction of the Mardie Onshore Facilities.

The low sample size available at Sholl Island (West) in 2024/25 (n = 2) and that both nest fans were positioned close to the spit at the southern end of the island where dune profiles are likely to be less distinct for orientation purposes (Hirama et al. 2023), are likely contributing factors to this exceedance. Additionally, the average spread angle for hatchling fans at Sholl Island (West; 65.5 ± 2.1°) in 2024/25 was similar to that reported in 2023/24 (63.9 ± 29.3°), when no new lighting was visible on the horizon. These findings support the hypothesis that the trigger limit for the spread metric at Sholl Island (West) is too low and that spread angle variance was not wholly captured by the baseline dataset (PENV 2024).

Given the above compounding factors, the spread angle exceedance at Sholl Island (West) cannot be attributed to Project-associated lighting. It is recommended that monitoring of hatchling orientation at, and artificial light visibility from, Sholl Island (West) be continued in future seasons – as per the MTMP – and that the trigger and threshold values at this monitoring site be further reviewed at the completion of the 2025/26 season, when a larger sample size is available for examination.

6.5 Conclusion

BCI was compliant with the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A) with respect to marine turtle (this report) and artificial light monitoring (Appendix D) undertaken as per the Mardie Salt Project MTMP (PENV 2023b) in 2024/25. No Project-associated impacts were reported across abundance, distribution, incubation success, and hatchling orientation components of the MTMP, and artificial light monitoring using suitable light monitoring equipment was successfully conducted in accordance with the requirements of the MTMP. The results of the 2024/25 artificial light monitoring surveys were suitably analysed and compared to the baseline data (2021/22: offshore island, and 2022/23: mainland) to quantify any changes in sky brightness and identify new light sources, as outlined in the MTMP. In addition, artificial light monitoring was completed for the first time in the 2024/25 season on the mainland at Mardie Pool (Appendix D), as per outcome-based provision Number 4 of the Illumination Plan (see page 52; BCI Minerals 2023); generating baseline data for monitoring at this site.

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Appendix A. Approval Conditions for Marine Turtles

Approval	Condition No.	Condition
EPBC2018/8236	19	To minimise the impacts to marine turtles, the approval holder must: a. comply with condition 10 of the WA Approval (MS 1175)[1]; *and* c. The approval holder must implement the approved Marine Turtle Monitoring Program for the life of the project or until the Minister has confirmed in writing that the Marine Turtle Monitoring Program is no longer required.
EPBC2022/9169	37 & 38	37. To avoid and mitigate harm to marine turtles, the approval holder must: a. comply with conditions B5-1, B5-3, and B5-9 of the WA Approval, to the extent that the WA Approval conditions relate to protected matters, and 38. Prior to commencing any marine construction within the marine turtle nesting beach, submit the findings of the Marine Turtle Monitoring Surveys specified in conditions, B5-3, and of the WA Approval electronically to the department.
Ministerial Statement No. 1211	B5-1 (2) & (3)	The proponent shall implement the proposal to achieve the following environmental outcomes: 2. No change in marine turtle orientation (i.e. misorientation or disorientation) nesting beach utilisation, nesting success or hatchling survivorship as a result of artificial light emissions at both sandy beach habitat adjacent to the development and Long Island, Sholl Island and the Passage Islands (Angle, Middle and Round); and, 3. Significant marine fauna are not prevented/deterred from undertaking critical behaviours in biologically important areas.
	B5-3 (2)	The proponent must in consultation with DWER: (2) implement the Marine Turtle Monitoring Program (rev 3, submitted, May 2023) environmental management plan that satisfy the requirements of condition C4 and demonstrates how achievement of the significant marine fauna outcomes in B5-1(2-3) will be monitored and substantiated, and submit it to the CEO.

[1] Now superseded by MS 1211

Approval	Condition No.	Condition
	C4-1	Environmental Management Plans: Conditions Relating to Monitoring and Adaptive Management for Outcomes Based Conditions *and conditions (1) – (8) therein;* (1) threshold criteria that provide a limit beyond which the environmental outcomes are not achieved; (2) trigger criteria that will provide an early warning that the environmental outcomes are not likely to be met; (3) monitoring parameters, sites, control/reference sites, methodology, timing and frequencies which will be used to measure threshold criteria and trigger criteria. Include methodology for determining alternative monitoring sites as a contingency if proposed sites are not suitable in the future; (4) baseline data; (5) data collection and analysis methodologies; (6) adaptive management methodology; (7) contingency measures which will be implemented if threshold criteria or trigger criteria are met; and (8) reporting requirements.
	C4 (2)	The environmental management plan required under condition B5-3 is also required to: (1) be updated to include management actions, management targets and contingency measures that will establish whether the proposal is having a detectable difference on marine turtle orientation (i.e. misorientation or disorientation), and nesting beach utilisation as described in condition B5-1(2). (2) include a commitment to annually compare cumulative results against the baseline assessment (Pendoley Environmental 2019, Mardie Salt Project Marine Turtle Monitoring Program 2018/2019. Rev 0, Report No. RP-59001); (3) Include a monitoring plan that is in accordance with the recommendations published in the National Light Pollution Guidelines (2020); (4) provide criteria for when the Mardie Illumination Plan required by condition B6-5 will be revised in response to outcomes of the monitoring required by condition B5-3; and (5) Continue to be implemented until the CEO has confirmed by notice in writing, on advice from DBCA and DWER, that the outcome of condition B5-1(1-3) has been, and will continue to be met.

Appendix B. Field Survey Schedule

Table B1: Field survey schedule for the 2024/25. Mainland includes both eastern and western sides of Mardie Creek; x = survey day; shaded cells = line-in day.

Date	Survey Sites										
	Mainland	Mardie	Fortescue	Stewart	Sholl	Round	Long	Middle Passage	Angle	Passage	South Passage
Field Survey 1											
18-Oct-24	*Mobilisation and on-site inductions*										
19-Oct-24	x				x		x				
20-Oct-24	x				x	x	x	x	x		
21-Oct-24					x		x				
22-Oct-24	*No activity*	x	x	x	x		x	x			
23-Oct-24	x				x	x	x	x	x	x	x
24-Oct-24	x	x	x	x	x	x	x	x	x	x	x
25-Oct-24	x				x	x	x	x	x	x	x
26-Oct-24	x				x		x				
27-Oct-24	x				x	x	x				
28-Oct-24	x	x	x	x	x	x	x	x	x	x	
29-Oct-24	x	x	x	x	x	x	x	x	x	x	x
30-Oct-24	x				x		x				
31-Oct-24	x				x	x	x				
01-Nov-24	x	x	x	x	x	x	x	x	x	x	x
02-Nov-24	*Demobilisation*										
Field Survey 2											
29-Nov-24	*Mobilisation and on-site inductions*										
30-Nov-24	x				x		x				
01-Dec-24	x				x		x	x	x		
02-Dec-24	x				x	x	x			x	x
03-Dec-24	x	x	x	x	x		x				
04-Dec-24	x				x	x	x	x	x		

05-Dec-24	x				x		x			x	x
06-Dec-24	x	x	x	x	x		x				
07-Dec-24	x				x	x	x	x	x		
08-Dec-24	x				x		x			x	x
09-Dec-24	x	x	x	x	x		x				
10-Dec-24	x				x	x	x	x	x		
11-Dec-24	x				x		x			x	x
12-Dec-24	x	x	x	x	x		x				
13-Dec-24	x				x	x	x	x	x		
14-Dec-24	*Demobilisation*										
Field Survey 3											
03-Mar-25	*Mobilisation and on-site inductions*										
04-Mar-25	x				x		x				
05-Mar-25	x				x	x	x	x	x		
06-Mar-25	x				x	x	x			x	x
07-Mar-25	x	x	x	x	x		x				
08-Mar-25	x				x	x	x	x	x		
09-Mar-25	x				x		x			x	x
10-Mar-25	x	x	x	x	x		x				
11-Mar-25	x				x	x	x	x	x		
12-Mar-25	x				x		x			x	x
13-Mar-25	x	x	x	x	x		x				
14-Mar-25	x				x	x	x	x	x		
15-Mar-25	x				x	x	x	x		x	x
16-Mar-25	x	x	x	x	x		x				
17-Mar-25	x				x	x	x	x	x	x	x
	Demobilisation										

Appendix C. Track Census 2024/25

Table C-1 Track census results and nesting success for flatback turtles from all monitoring field surveys in 2021/22 (baseline), 2023/24 and 2024/25. NA = Not applicable. Line-in day and 'Unknown' turtle tracks are not included. MPI = Middle Passage Island; SPI = South Passage Island

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
FS1	Long Island	15	12	14	6	12	15	2	0	10	23	24	39	65	50	36
	Sholl Island	5	6	7	2	5	8	1	2	5	8	13	20	63	46	35
	Angle Island	0	1	1	0	6	2	0	2	0	0	9	3	NA	11	33
	Fortescue Island	NA	0	0	NA	1	1	NA	0	0	NA	1	1	NA	0	0
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	2	0	0	1	1	1	0	0	0	3	1	1	67	0	0
	Passage Island	0	NA	0	0	NA	2	0	NA	0	0	NA	2	NA	NA	0
	Round Island	0	1	0	1	3	0	0	2	0	1	6	0	0	17	-
	SPI	NA	1	1	NA	0	1	NA	0	1	NA	1	3	NA	100	33
	Stewart Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	Islands Total	**22**	**20**	**23**	**10**	**28**	**30**	**3**	**6**	**16**	**35**	**55**	**69**	**63**	**37**	**33**
	Mardie Creek East	1	0	0	0	1	0	0	0	0	1	1	0	100	0	-
	Mardie Creek West	1	0	0	0	2	0	0	0	0	1	2	0	100	0	-
	Mainland Total	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**0**	**100**	**0**	**-**
	FS1 Total	**24**	**20**	**23**	**10**	**28**	**30**	**3**	**6**	**16**	**37**	**58**	**69**	**65**	**34**	**33**
FS2	Long Island	23	59	52	37	288	101	4	49	11	64	396	164	36	15	32
	Sholl Island	34	41	31	36	154	56	13	30	15	83	225	102	41	18.2	30
	Angle Island	4	10	10	1	17	16	0	6	1	5	33	27	80	30	37
	Fortescue Island	NA	1	0	NA	1	1	NA	0	0	NA	2	1	NA	50	0
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	4	3	2	4	15	1	2	1	4	10	19	7	40	16	29
	Passage Island	5	1	4	3	9	12	0	0	0	8	10	16	63	10	25

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
	Round Island	2	3	0	4	8	0	1	1	1	7	12	1	29	25	0
	SPI	NA	2	2	NA	2	5	NA	1	0	NA	5	7	NA	40	29
	Stewart Island	NA	0	0	NA	3	0	NA	3	1	NA	6	1	NA	0	0
	Islands Total	72	120	101	85	497	192	20	91	33	177	708	326	41	17	31
	Mardie Creek East	1	0	0	0	2	0	0	0	0	1	2	0	100	0	-
	Mardie Creek West	0	1	0	1	5	0	0	1	0	1	7	0	0	14	-
	Mainland Total	**1**	**1**	**0**	**1**	**7**	**0**	**0**	**1**	**0**	**2**	**9**	**0**	**50**	**11**	**-**
	FS2 Total	**73**	**121**	**101**	**86**	**504**	**192**	**20**	**92**	**33**	**179**	**717**	**326**	**41**	**17**	**31**
FS3	Long Island	0	0	0	0	6	1	0	0	0	0	6	1	NA	0	0
	Sholl Island	1	3	0	9	19	0	1	4	0	11	26	0	9	12	-
	Angle Island	0	0	0	0	1	0	0	0	0	0	1	0	NA	0	-
	Fortescue Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	0	0	0	0	2	0	0	0	0	0	2	0	NA	0	-
	Passage Island	1	0	0	0	0	2	1	0	0	2	0	2	50	NA	0
	Round Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	SPI	NA	1	0	NA	0	0	NA	0	0	NA	1	0	NA	100	-
	Stewart Island	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
	Islands Total	**2**	**4**	**0**	**9**	**28**	**3**	**2**	**4**	**0**	**13**	**36**	**3**	**15**	**11**	**0**
	Mardie Creek East	2	0	0	5	0	0	0	1	0	7	1	0	29	0	-
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**2**	**0**	**0**	**5**	**0**	**0**	**0**	**1**	**0**	**7**	**1**	**0**	**29**	**0**	**-**
	FS3 Total	**4**	**4**	**0**	**14**	**28**	**3**	**2**	**5**	**0**	**20**	**37**	**3**	**20**	**11**	**0**
GRAND TOTAL		101	101	145	124	110	560	225	25	103	49	236	812	398	43	18

Table C-2 Track census results and nesting success for hawksbill turtles from all monitoring field surveys in 2021/22 (baseline), 2023/24 and 2024/25. NA = Not applicable. Line-in day and 'Unknown' turtle tracks are not included. MPI = Middle Passage Island; SPI = South Passage Island

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
FS1	Long Island	0	2	14	0	0	20	4	0	10	4	2	44	0	100	32
	Sholl Island	8	8	5	0	3	7	10	3	8	18	14	20	44	57	25
	Angle Island	1	0	2	2	0	2	2	0	1	5	0	5	20	NA	40
	Fortescue Island	NA	0	1	NA	0	2	NA	0	0	NA	0	3	NA	NA	33
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	#DIV/0!
	MPI	7	0	0	1	0	0	3	0	1	11	0	1	64	NA	0
	Passage Island	3	0	0	0	0	1	1	0	0	4	0	1	75	NA	0
	Round Island	10	1	5	0	0	1	8	0	1	18	1	7	56	100	71
	SPI	NA	0	2	NA	0	0	NA	0	0	NA	0	2	NA	NA	100
	Stewart Island	NA	0	2	NA	0	1	NA	0	2	NA	0	5	NA	NA	40
	Islands Total	**29**	**11**	**31**	**3**	**3**	**34**	**28**	**3**	**23**	**60**	**17**	**88**	**48**	**65**	**35**
	Mardie Creek East	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**-**
	FS1 Total	**29**	**11**	**31**	**3**	**3**	**34**	**28**	**3**	**23**	**60**	**17**	**88**	**48**	**65**	**35**
FS2	Long Island	14	3	25	0	2	39	14	7	14	28	12	78	50	25	32
	Sholl Island	4	0	8	0	2	12	5	9	15	9	11	35	44	0	23
	Angle Island	1	0	1	0	0	5	1	0	1	2	0	7	50	NA	14
	Fortescue Island	NA	0	1	NA	0	1	NA	1	0	NA	1	2	NA	0	50
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	#DIV/0!
	MPI	1	0	2	0	0	0	4	0	1	5	0	3	20	NA	67
	Passage Island	2	0	0	0	0	1	2	0	0	4	0	1	50	NA	0

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
	Round Island	6	1	0	4	1	2	6	3	0	16	5	2	38	20	0
	SPI	NA	0	1	NA	0	0	NA	0	0	NA	0	1	NA	NA	100
	Stewart Island	NA	0	5	NA	0	0	NA	0	3	NA	0	8	NA	NA	63
	Islands Total	**28**	**4**	**43**	**4**	**5**	**60**	**32**	**20**	**34**	**64**	**29**	**137**	**44**	**14**	**31**
	Mardie Creek East	0	0	0	0	0	0	0	0	1	0	0	1	NA	NA	0
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**NA**	**NA**	**0**
	FS2 Total	**28**	**4**	**43**	**4**	**5**	**60**	**32**	**20**	**35**	**64**	**29**	**138**	**44**	**14**	**31**
FS3	Sholl Island	0	0	0	0	0	0	0	1	0	0	1	0	NA	0	-
	Long Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Angle Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Fortescue Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	0	0	0	0	0	0	0	2	0	0	2	0	NA	0	-
	Passage Island	1	0	0	1	0	0	1	0	0	3	0	0	33	NA	-
	Round Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	SPI	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Stewart Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Islands Total	**3**	**0**	**0**	**1**	**0**	**0**	**13**	**3**	**0**	**17**	**3**	**0**	**18**	**0**	**-**
	Mardie Creek East	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**-**
	FS3 Total	**3**	**0**	**0**	**1**	**0**	**0**	**13**	**3**	**0**	**17**	**3**	**0**	**18**	**0**	**-**
GRAND TOTAL		**60**	**15**	**74**	**8**	**8**	**94**	**73**	**26**	**58**	**141**	**49**	**226**	**43**	**31**	**33**

Table C-3 Track census results and nesting success for green turtles from all monitoring field surveys in 2021/22 (baseline), 2023/24 and 2024/25. NA = Not applicable. Line-in day and 'Unknown' turtle tracks are not included. MPI = Middle Passage Island; SPI = South Passage Island

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
FS1	Long Island	0	1	0	0	1	0	0	0	0	0	2	0	NA	50	-
	Sholl Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Angle Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Fortescue Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	0	0	0	0	1	1	0	0	0	0	1	1	NA	0	0
	Passage Island	1	0	0	0	0	0	1	0	0	2	0	0	50	NA	-
	Round Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	SPI	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Stewart Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Islands Total	**1**	**1**	**0**	**0**	**2**	**1**	**1**	**0**	**0**	**2**	**3**	**0**	**50**	**33.3**	**0**
	Mardie Creek East	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**NA**	**NA**	**-**
	FS1 Total	**1**	**1**	**0**	**0**	**2**	**1**	**1**	**0**	**0**	**2**	**3**	**1**	**50**	**33**	**0**
FS2	Long Island	1	0	13	0	1	33	5	1	4	6	2	50	17	0	26
	Sholl Island	1	1	7	0	0	14	6	1	10	7	2	31	14	50	23
	Angle Island	0	0	4	0	0	5	0	0	1	0	0	10	NA	NA	40
	Fortescue Island	NA	0	0	NA	0	1	NA	0	0	NA	0	1	NA	NA	0
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	#DIV/0!
	MPI	0	0	1	0	0	0	0	0	1	0	0	2	NA	NA	50
	Passage Island	1	0	0	1	0	1	1	0	0	3	0	1	33	NA	0

Field Survey	Location	Nest			Attempt			False Crawl			Total			Nesting Success (%)		
		21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25	21/22	23/24	24/25
	Round Island	0	0	2	0	0	0	1	0	0	1	0	2	0	NA	100
	SPI	NA	0	1	NA	0	1	NA	0	0	NA	0	2	NA	NA	50
	Stewart Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	#DIV/0!
	Islands Total	**3**	**1**	**28**	**1**	**1**	**55**	**13**	**2**	**16**	**17**	**4**	**99**	**18**	**25**	**28**
	Mardie Creek East	0	0	0	0	0	1	0	0	0	0	0	1	NA	NA	0
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	#DIV/0!
	Mainland Total	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**NA**	**NA**	**0**
	FS2 Total	**3**	**1**	**28**	**1**	**1**	**56**	**13**	**2**	**16**	**17**	**4**	**100**	**18**	**25**	**28**
FS3	Long Island	0	1	0	0	0	0	0	0	0	0	1	0	NA	100	-
	Sholl Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Angle Island	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Fortescue Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Mardie Island	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	0	NA	NA	-
	MPI	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Passage Island	1	0	0	1	0	0	1	0	0	3	0	0	33	NA	-
	Round Island	0	1	0	0	0	0	0	1	0	0	2	0	NA	50	-
	SPI	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Stewart Island	NA	0	0	NA	0	0	NA	0	0	NA	0	0	NA	NA	-
	Islands Total	**3**	**2**	**0**	**1**	**0**	**0**	**13**	**1**	**0**	**17**	**3**	**0**	**18**	**67**	**-**
	Mardie Creek East	0	0	0	0	1	0	0	0	0	0	1	0	NA	0	-
	Mardie Creek West	0	0	0	0	0	0	0	0	0	0	0	0	NA	NA	-
	Mainland Total	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**NA**	**0**	**-**
	FS3 Total	**3**	**2**	**0**	**1**	**1**	**0**	**13**	**1**	**0**	**17**	**4**	**0**	**18**	**50**	**-**
GRAND TOTAL		**7**	**4**	**28**	**2**	**4**	**56**	**27**	**3**	**16**	**36**	**11**	**100**	**19**	**36**	**28**

Table C-4 Average number of new tracks and nests (mean ± stdev (min – max)) per night (n) for marine turtles at Long and Sholl islands, and Mardie Creek (East) during Field Survey (FS) 1 and 2 the 2024/25 monitoring season

Monitoring Site / Species	n	Tracks	Nests
FS1			
Long Island	**14**	**5.9 ± 5.6 (0 - 17)**	**2.0 ± 2.1 (0 - 7)**
Flatback	14	2.8 ± 2.9 (0 - 10)	1.0 ± 1.2 (0 - 3)
Green	14	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
Hawksbill	14	3.1 ± 4.0 (0 - 10)	1.0 ± 1.5 (0 - 4)
Sholl Island	14	2.9 ± 2.9 (0 - 11)	0.9 ± 1.0 (0 - 3)
Flatback	14	1.4 ± 1.7 (0 - 5)	0.5 ± 0.8 (0 - 2)
Green	14	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
Hawksbill	14	1.4 ± 2.1 (0 - 8)	0.4 ± 0.5 (0 - 1)
Mardie Creek East (Mainland)	14	0.1 ± 0.3 (0 - 1)	0.0 ± 0.0 (0 - 0)
Flatback	14	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
Green	14	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
Hawksbill	14	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
FS2			
Long Island	**13**	**22.4 ± 14 (4 - 61)**	**6.9 ± 5.2 (0 - 19)**
Flatback	13	12.5 ± 11.2 (2 - 43)	4 ± 4.3 (0 - 12)
Green	13	3.8 ± 3.6 (1 - 14)	1.0 ± 1.2 (0 - 3)
Hawksbill	13	6.0 ± 7.8 (0 - 26)	1.9 ± 2.7 (0 - 9)
Sholl Island	13	12.9 ± 8.5 (2 - 28)	3.5 ± 3.0 (0 - 8)
Flatback	13	7.8 ± 8.3 (0 - 27)	2.4 ± 3.0 (0 - 8)
Green	13	2.4 ± 3.7 (0 - 11)	0.5 ± 1.4 (0 - 5)
Hawksbill	13	2.7 ± 2.0 (0 - 6)	0.6 ± 0.7 (0 - 2)
Mardie Creek East (Mainland)	13	0.2 ± 0.6 (0 - 2)	0.0 ± 0.0 (0 - 0)
Flatback	13	0.0 ± 0.0 (0 - 0)	0.0 ± 0.0 (0 - 0)
Green	13	0.1 ± 0.3 (0 - 1)	0.0 ± 0.0 (0 - 0)
Hawksbill	13	0.1 ± 0.3 (0 - 1)	0.0 ± 0.0 (0 - 0)

Appendix D. Artificial Light Monitoring Report 2024/25

BCI MINERALS LIMITED

Mardie Salt Project

Artificial Light Monitoring Report 2024-25

Document no. Rev 0: 311012-02345-EN-REP-0002

20 June 2025

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PROJECT 311012-02345 - 311012-02345-EN-REP-0002: Mardie Salt Project - Artificial Light Monitoring Report 2024-25

Rev	Description	Originator	Reviewer	Worley Approver	Revision Date	Customer Approver	Approval Date
Rev A	Internal Review	D. Bhattarai, S. Bruzzese, L. Peel	G. Hickson		27 May 2025		
Rev B	Client Review	D. Bhattarai, S. Bruzzese, L. Peel	G. Hickson	A. Knipe	29 May 2025		
Rev 0	Submit as final	DocuSigned by: Annabel Knipe D81763FFEDB64B1... A. Knipe	DocuSigned by: G. Hickson	DocuSigned by: Annabel Knipe D81763FFEDB64B1... A. Knipe	20 June 2025		

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Executive Summary

Mardie Minerals Pty Ltd is a wholly owned subsidiary of BCI Minerals Limited, and is the proponent developing the Mardie Salt and Potash Project, a greenfield high-volume salt production venture in the Pilbara region of Western Australia.

This Artificial Light Monitoring Report appends to *Mardie Salt Project: Marine Turtle Monitoring Program 2024/25* (Worley 2025) and details the outcomes of artificial light monitoring undertaken in 2024/25 to meet the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A of Worley 2025).

Suitable light monitoring cameras were deployed at pre-determined locations on the mainland and island beaches in December 2024 (Field Survey 2) and March 2025 (Field Survey 3), as per the *Mardie Salt Marine Turtle Monitoring Plan* (Pendoley Environmental 2023). In addition, artificial light monitoring was completed for the first time in the 2024/25 season on the mainland at Mardie Pool, as per outcome-based provision Number 4 of the *Mardie Salt and Potash Project Illumination Plan* (BCI Minerals 2023). This monitoring event will serve as a baseline for future seasons of monitoring at this site.

A new source of artificial light on the mainland, termed 'Mardie Onshore', was identified in 2024/25 and was visible from Long Island, Sholl Island (East and West), and Round Island. Two unidentified sources of light were visible from Long Island at a bearing of 130° and 137° on 2nd December 2024. An additional source of unidentified light was visible from Middle Passage Island at a bearing of 125° on 8th March 2025.

Comparison of light monitoring data recorded at eight locations in 2024/25 with the past four seasons of light monitoring (where available), revealed an increase in whole-of-sky brightness at Sholl Island (East and West) and from Middle Passage Island. The comparatively larger increase in whole-of-sky brightness detected from Sholl Island (West) was attributed to the newly constructed Mardie Onshore Facilities, which were observed as a bright source of direct light along the horizon. Decreases in whole-of-sky brightness were reported at Long Island and Mardie Creek (West), which may be attributed to increases in vegetation height and/or changes in dune profile shielding previously available sources of light. No change in whole-of-sky brightness was observed from Mardie Creek (East). The brightest visible light sources continue to include the port at Cape Preston and Sino Iron mining facilities, with the addition of light from the newly constructed Mardie Onshore Facilities in the 2024/25 season.

Based on this report, BCI is compliant with the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A Worley 2025) regarding light monitoring undertaken as per the Mardie Salt Project MTMP (PENV 2023b) in 2024/25.

Acronyms and Abbreviations

Term	Definition
BCI	BCI Minerals Limited
FS2	Field Survey 2
FS3	Field Survey 3
Illumination Plan	Mardie Salt and Potash Project Illumination Plan
LI	Long Island
Mardie Minerals	Mardie Minerals Pty Ltd
ME	Mardie Creek East
MP	Mardie Pool
MPI	Middle Passage Island
MS	Ministerial Statement
MTMP	Mardie Salt Marine Turtle Monitoring Plan
MW	Mardie Creek West
Project	Mardie Salt and Potash Project
RI	Round Island
SIE	Sholl Island East
SIW	Sholl Island West
SoP	Sulphate of Potash
VIIRS	Visible Infrared Imaging Radiometer Suite
Vmag/arcsec^2	Visual magnitudes per square arcsecond
WOS	Whole-of-sky

1. Introduction

1.1 Project Background

Mardie Minerals Pty Ltd (Mardie Minerals) is developing the Mardie Salt and Potash Project (the Project), a greenfield high-volume salt production venture in the Pilbara region of Western Australia. The Project will produce salt via evaporation of seawater, with a proposed production of 5 million tonnes per annum of concentrated salt, and 140,000 tonnes per annum of Sulphate of Potash (SoP). Mardie Minerals is a wholly owned subsidiary of BCI Minerals Limited (BCI).

The Project will comprise a series of evaporation and crystalliser ponds extending over an area approximately 30 km long, built predominately over existing mud and salt flat habitat. It will also feature a processing plant, a bitterns disposal pipeline and outfall, a trestle jetty and supporting infrastructure to produce and export salt and SoP.

1.2 Scope of Work and Objectives

This Artificial Light Monitoring Report appends to *Mardie Salt Project: Marine Turtle Monitoring Program 2024/25* (Worley 2025) and details the outcomes of artificial light monitoring undertaken in 2024/25 to meet the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A of Worley 2025).

As per the *Mardie Salt Marine Turtle Monitoring Plan* (hereafter 'MTMP'; Pendoley Environmental 2023), the 2024/25 Marine Turtle Monitoring Program was designed to collect monitoring data over the entire breeding and hatching season of hawksbill, flatback, and green turtles utilising mainland and island beaches in the vicinity of the Project. Data was collected to meet the following objectives:

- Identify the species of turtles nesting on the beaches,
- Identify the abundance and distribution of adult tracks on the nesting beaches,
- Collect baseline data on the health of the nesting habitat,
- Collect baseline data on hatchling orientation, and
- Measure the intensity and extent of light sources visible from nesting beaches.

This report outlines the findings of the artificial light monitoring survey conducted as part of the Marine Turtle Monitoring Program 2024/25. The objectives of the monitoring program are to measure the intensity and extent of light sources visible from nesting beaches, and to allow comparison with baseline data provided by Pendoley Environmental (2019; 2024).

In addition, artificial light monitoring was completed for the first time in the 2024/25 season on the mainland at Mardie Pool, as per outcome-based provision Number 4 of the *Mardie Salt and Potash Project Illumination Plan* (hereafter 'Illumination Plan'; see page 52; BCI Minerals 2023). This monitoring event will serve as a baseline for future seasons of monitoring at this site.

2. Methods

2.1 Survey Locations and Schedule

Suitable (Sky42) light monitoring cameras were deployed at pre-determined locations on the mainland at Mardie Creek (West) and Mardie Creek (East) as well as at the following offshore locations: Sholl Island (West), Sholl Island (East), Long Island, Middle Passage Island, and Round Island. Additional deployments were also completed on the mainland at a bat habitat located near Mardie Pool as per outcome-based provision Number 4 of the *Illumination Plan* (see page 52; BCI Minerals 2023).

All deployments were completed during Filed Survey 2 (FS2) and Field Survey 3 (FS3) over the new moon period and, where required due to logistical constraints (i.e. in FS3), the five following days (Table 2-1). Images of night-time light emissions on a 360° horizon were captured automatically by the cameras at 10-minute intervals between sunset and sunrise. All cameras were placed level on the ground, above the spring high tide line towards the base of the dune system. Deployment locations are presented in Figure 2-1.

Table 2-1: Light monitoring schedule for the 2024/25 monitoring season.

FS	Date	Survey Day #	Mardie Creek (West)	Mardie Creek (East)	Sholl (West)	Sholl (East)	Long (East)	Middle Passage	Round Island	Mardie Pool
FS2	30 Nov 2024	1								
	1 Dec 2024	2								
	2 Dec 2024	3								
	3 Dec 2024	4								
	4 Dec 2024	5								
	5 Dec 2024	6								
	6 Dec 2024	7								
	7 Dec 2024	8								
	8 Dec 2024	9								
FS3	3 Mar 2025	1								
	4 Mar 2025	2								
	5 Mar 2025	3								
	6 Mar 2025	4								
	7 Mar 2025	5								
	8 Mar 2025	6								
	9 Mar 2025	7								

Note: Shaded cells = survey nights. FS = Field Survey

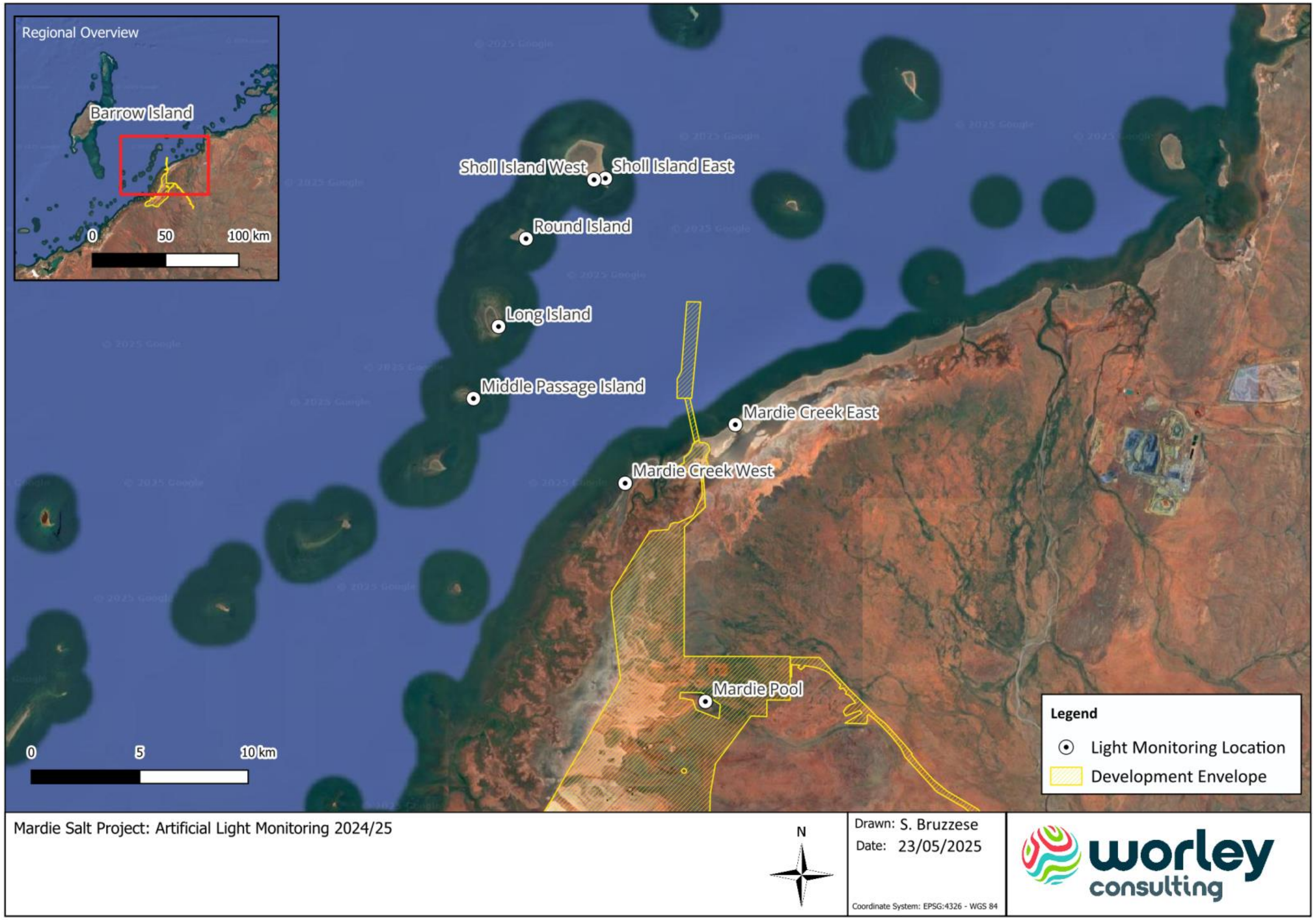

Figure 2-1: Light monitoring locations for the 2024/25 season

2.2 Identification of Potential Light Sources

Potential sources of artificial light captured by the Sky42 cameras were identified using Google Earth™ and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite imagery (Elvidge et. al, 2021; available at: https://eogdata.mines.edu/products/vnl/).

2.3 Data Processing

The quality of an image captured by a Sky42 light monitoring camera can be influenced by atmospheric factors such as the presence of the moon, twilight, cloud, rain, dust, humidity, or physical factors such as accumulation of sand or dust on the lens. Any images that are affected by physical factors were removed from the analysis, as well as any images that were affected by the moon or twilight.

Following quality checks, all suitable images were processed using specialised software to determine "whole-of-sky", "horizon" and "zenith" sky brightness levels. Whole-of-sky (WOS) is the mean value of sky glow in the entire image, zenith is the mean values of sky glow within the 0° – 30° directly overhead, and horizon is the mean value of sky glow within the 60° – 90° across the horizon. Nights with the clearest imagery and least amount of cloud cover were then selected for presentation within this report. It should be noted that the colour-coding used in these images represents sky brightness (described below) and is not indicative of how the visible light would be perceived by humans or wildlife.

Sky brightness is measured in units of visual magnitudes per square arcsecond (Vmag/arcsec^2); a standard unit that is used in astronomical measurements and is emerging as a standard for sky glow monitoring globally. The Vmag/arcsec^2 unit quantifies light intensity on an inverse logarithmic scale, where higher values represent lower intensity light, and lower values represent higher intensity light. Qualitative descriptions of the WOS values used to classify the night sky at each monitoring location are presented in Table 2-2.

2.4 Measuring Changes in Sky Brightness

The MTMP requires that the light monitoring results from offshore islands (2021/22) and the mainland (2022/23) form a baseline dataset for yearly data to be compared to throughout the monitoring program. This comparison is conducted by calculating the change in brightness of the WOS sky brightness metric from the baseline data to this season (i.e. 2024/25 relative to baseline). The change in brightness is presented as a percentage change, calculated by converting the sky brightness values measured in units of Vmag/arcsec^2 (a logarithmic scale) to a linear scale. Where baseline data is not available, the change in brightness is calculated from the first year of available data.

Table 2-2: Qualitative description of whole-of-sky (0° - 90°) brightness (Vmag/arcsec^2)

Whole-of-sky brightness (Vmag/arcsec^2)	Description
21.5 – 22.0	Ideal natural dark night sky
21.0 – 21.5	Rural night sky
20.0 – 21.0	Semi-rural night sky
19.0 – 20.0	Suburban night sky
18.0 – 19.0	Urban night sky
< 18.0	Urban/Industrial night sky

Note: To be used as a guide only.

3. Results

3.1 Artificial Light Sources

Several sources of horizon light were visible within the captured light monitoring imagery at varying levels of brightness and located at different bearings from each monitoring location. Light sources identified by satellite imagery (see Figure 3-1) visible from each monitoring location are shown in Table 3-1.

Table 3-1: Light sources identified by satellite imagery visible from each monitoring location

Monitoring Location	Light Source
Mardie Creek (West)	No sources of horizon light visible
Mardie Creek (East)	No sources of horizon light visible
Long Island	Cape Preston, Sino Iron, and Mardie Onshore
Middle Passage Island	Cape Preston
Sholl Island (West)	Sino Iron and Mardie Onshore
Sholl Island (East)	Cape Preston, Sino Iron and Mardie Onshore
Round Island	Cape Preston, Sino Iron, and Mardie Onshore
Mardie Pool	Sino Iron and Mardie Village

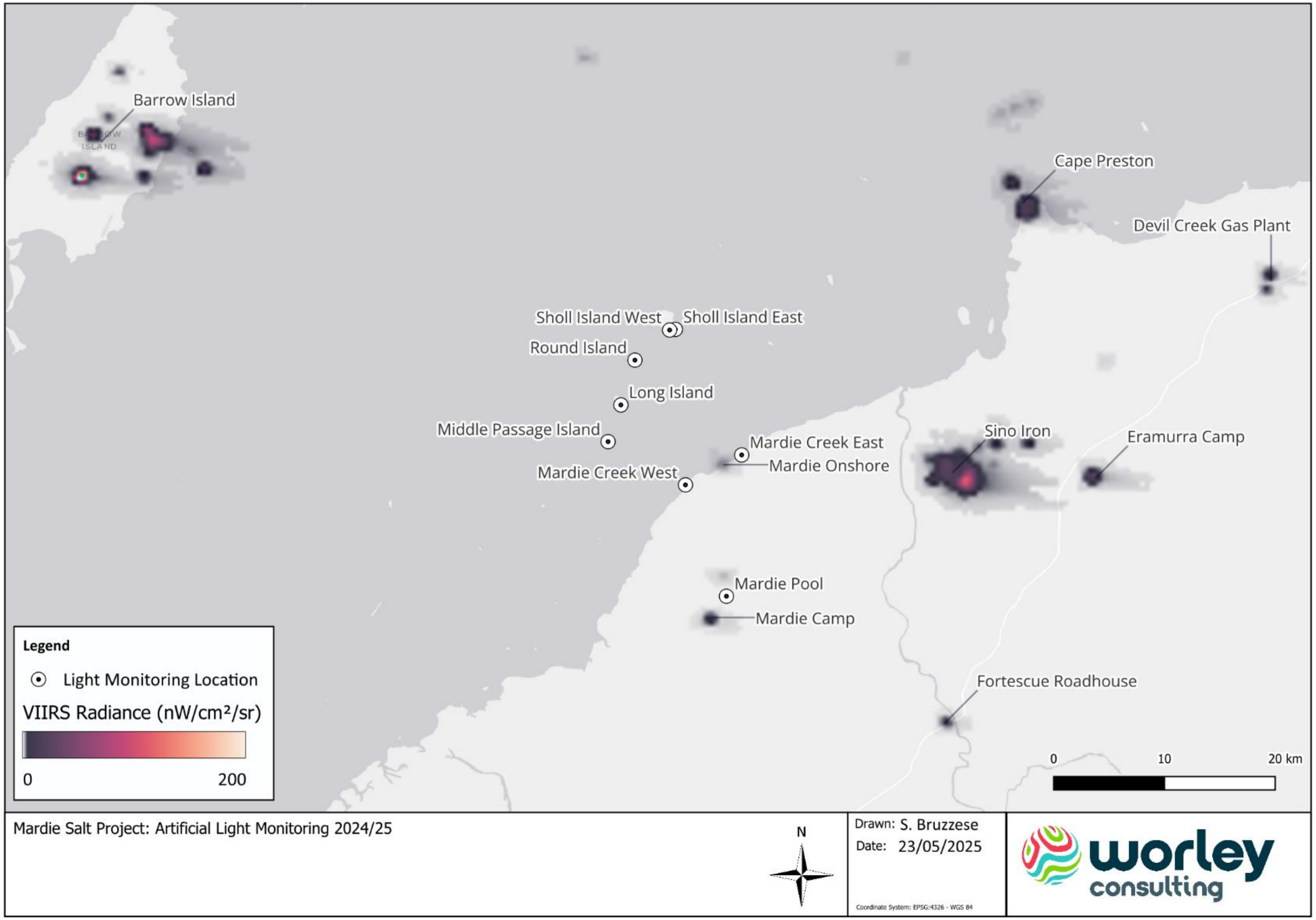

Figure 3-1: Artificial light sources within the Project Area and surrounding region, as detected by the VIIRS satellite

3.2 Night-time Light Emissions

Measured WOS sky brightness was darkest at Mardie Creek West (21.35 Vmag/arcsec^2) followed by Long Island (21.27 Vmag/arcsec^2; Table 3-2). The brightest WOS sky brightness value was captured at the Mardie Pool (21.01 Vmag/arcsec^2) monitoring location. The dominant light source visible across monitoring sites was the Sino Iron development, which was visible in an easterly to south-easterly direction from most monitoring locations, including Long, Sholl and Round islands as well as Mardie Pool (Figure 3-2 to Figure 3-8). Substantial shielding of all light sources along the horizon from dunes/vegetation was observed from both Mardie Creek (East) and Mardie Creek (West).

Project-associated light visible in processed imagery for 2024/25 included Mardie Village and Mardie Onshore Facilities. Mardie Village was observed as a distinct source of light from Mardie Pool; however, was shielded by vegetation and/or dunes from all other locations. The newly constructed Mardie Onshore Facilities were also observed for the first time in the 2024/25 season as a distinct source of light from Long Island, Sholl Island (both sites), and Round Island, but were shielded by vegetation and/or dunes from all other locations.

Multiple unidentified sources of light were also visible in the Sky42 data captured in 2024/25. Two unidentified sources of light were visible from Long Island at a bearing of 130° and 137° on the 2nd of December 2024 (Figure 3-5). An additional source of unidentified light was visible from Middle Passage Island at a bearing of 125° on the 8th of March 2025 (Figure 3-8). Vessels were also visible from Sholl Island East and Round Island as faint sources of horizon light.

Measured zenith sky brightness was darkest at Round Island and Mardie Creek West (21.63 and 21.55 Vmag/arcsec^2 respectively, Table 3-2). The brightest zenith sky brightness was captured at Mardie Pool (21.06 Vmag/arcsec^2). All monitoring locations are classified as rural night skies, except for Long Island, which is classified as an ideal natural dark night sky (Table 3-2). See Table 2-2 for details relating to WOS descriptions.

Table 3-2: Median sky brightness for whole-of-sky, horizon, and zenith captured at light monitoring locations during the 2024/25 turtle monitoring season

Monitoring location	Sky Brightness (Vmag/arcsec^2)			Description (See Table 2-2)
	WOS	Horizon	Zenith	
Mardie Creek (East)	21.24	21.27	21.47	Rural night sky
Mardie Creek (West)	21.35	21.39	21.55	Rural night sky
Mardie Pool	21.01	20.78	21.06	Rural night sky
Long Island	21.27	21.19	21.52	Ideal natural dark night sky
Sholl Island (West)	21.05	20.95	21.41	Rural night sky
Sholl Island (East)	21.09	20.97	21.33	Rural night sky
Middle Passage Island	21.14	21.01	21.53	Rural night sky
Round Island	21.23	21.08	21.63	Rural night sky

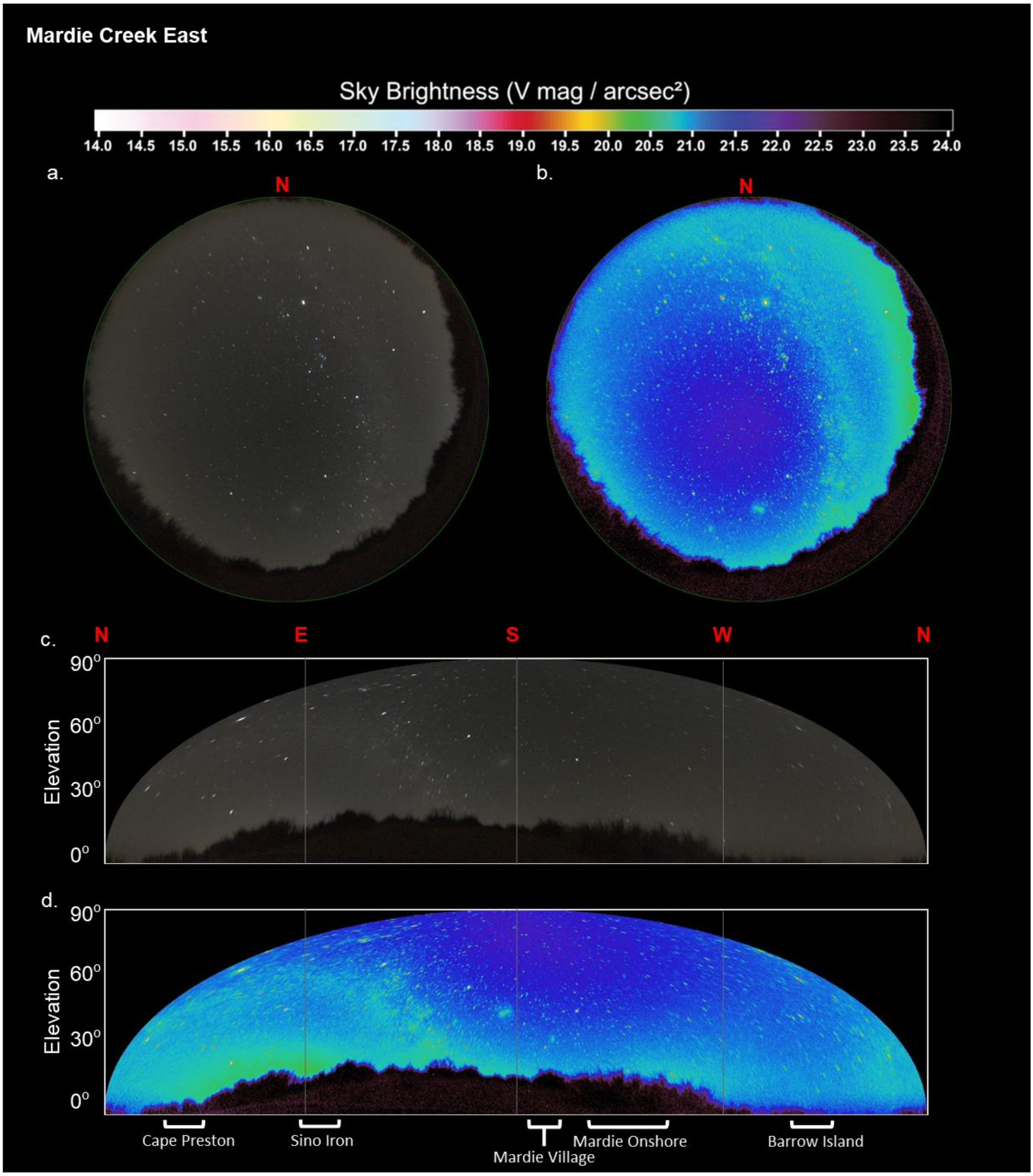

Figure 3-2: Artificial light monitoring results at Mardie Creek East on 1st December 2024. a. clearest raw circular image; b. processed circular image; c. Raw hammer-aitoff image; d. processed hammer-aitoff image.

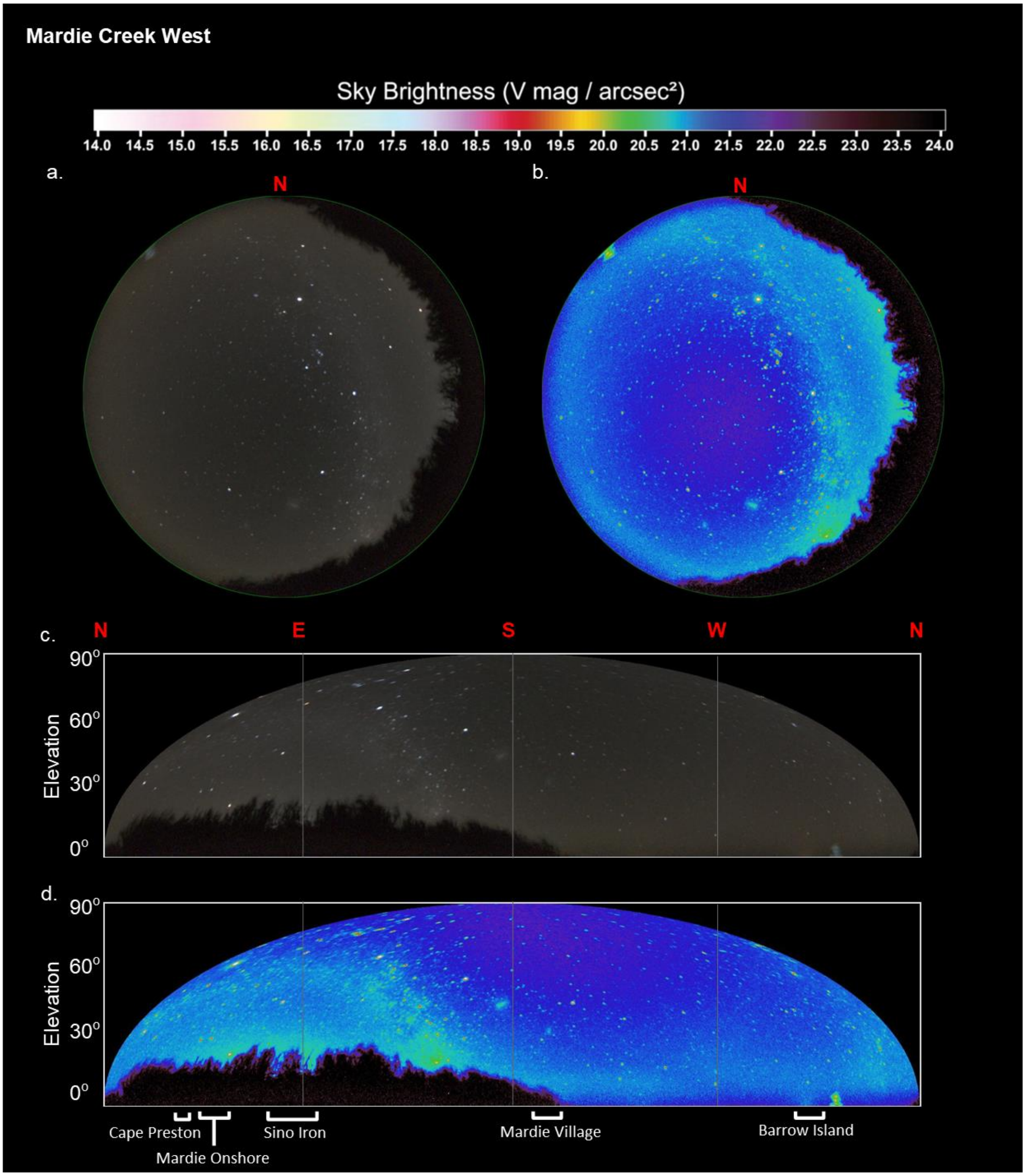

Figure 3-3: Artificial light monitoring results at Mardie Creek West on 1st December 2024. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

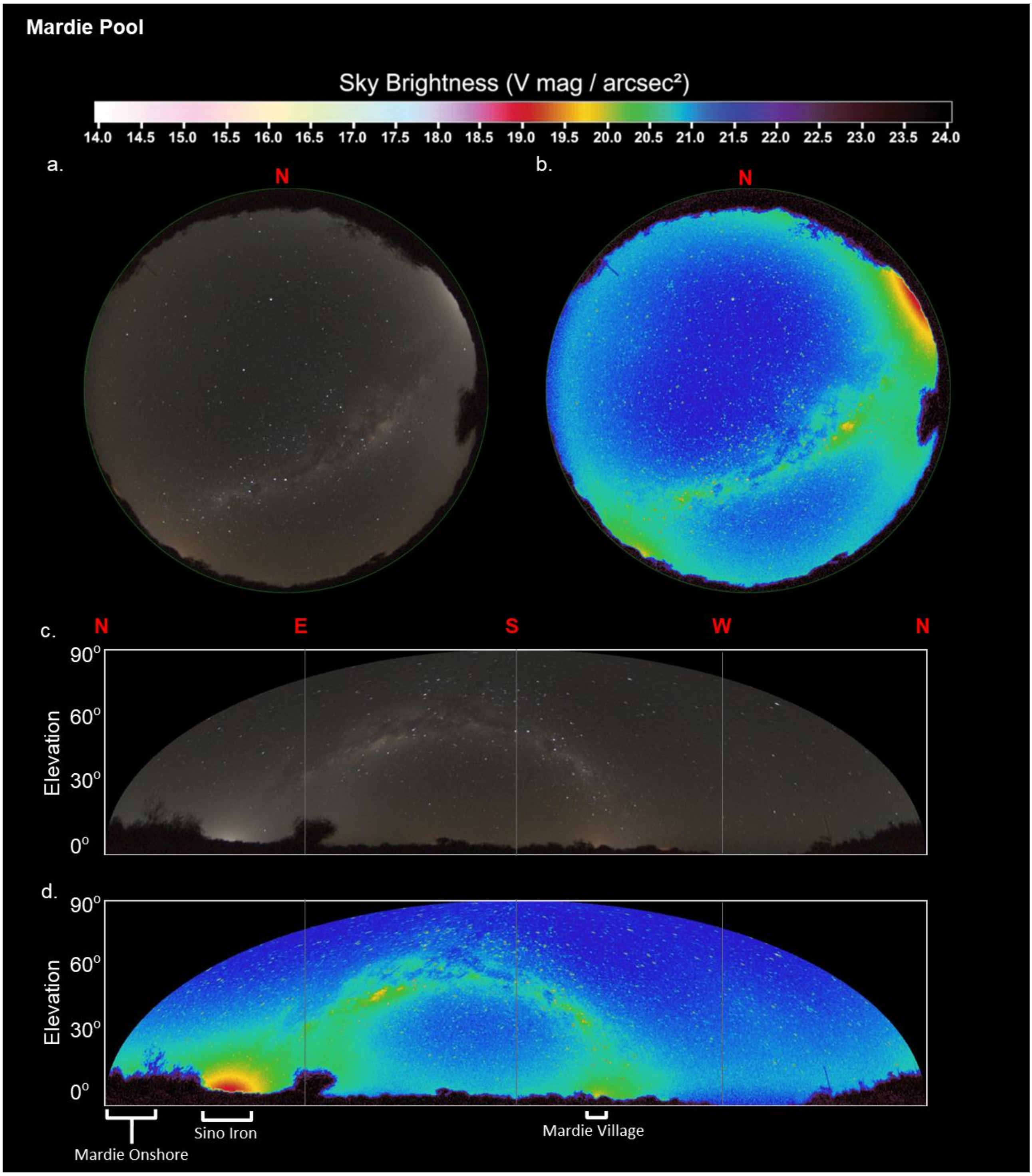

Figure 3-4: Artificial light monitoring results at Mardie Pool on 8th March 2025. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

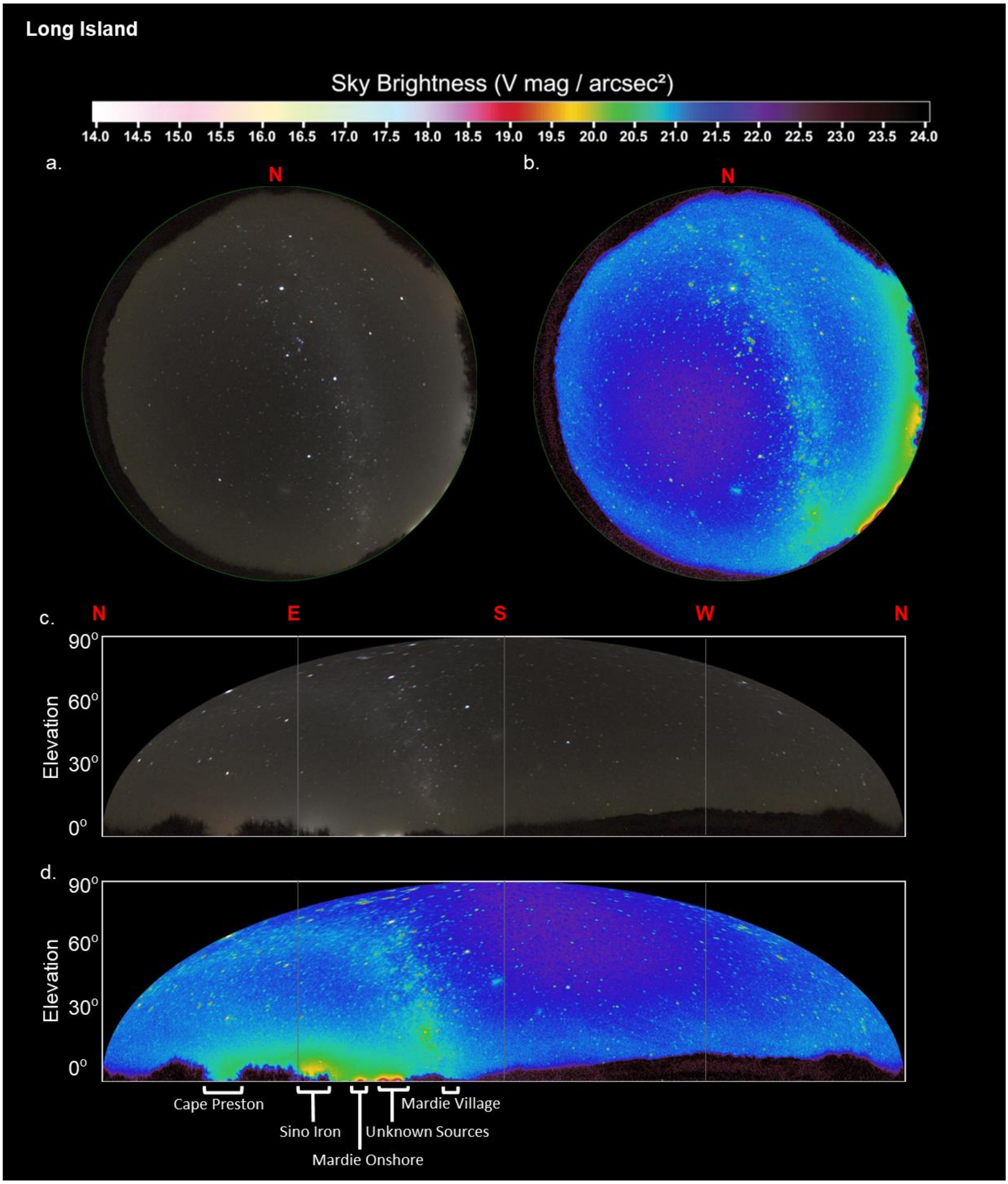

Figure 3-5: Artificial light monitoring results at Long Island on 2nd December 2024. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

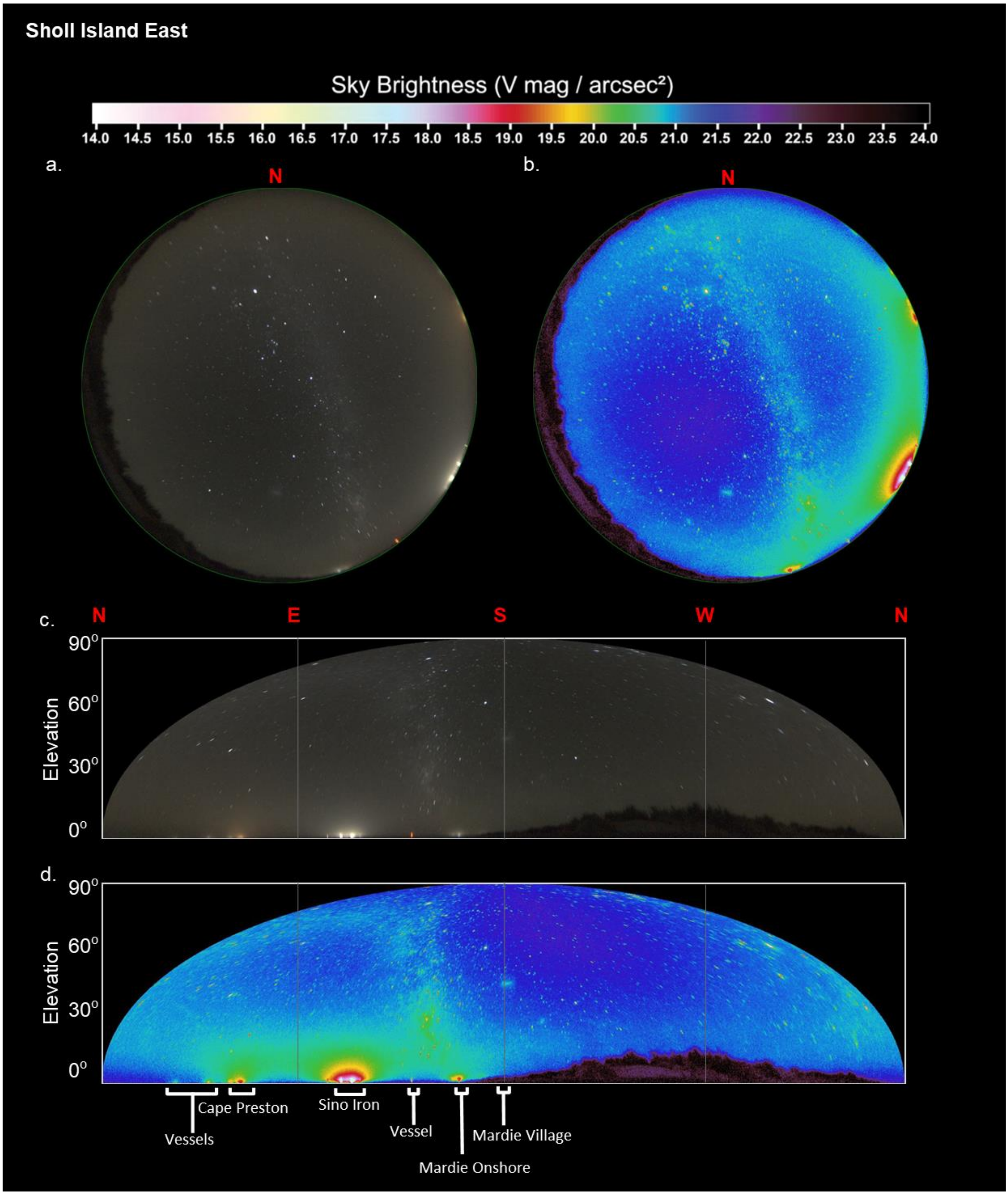

Figure 3-6: Artificial light monitoring results at Sholl Island East on 3rd December 2024. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

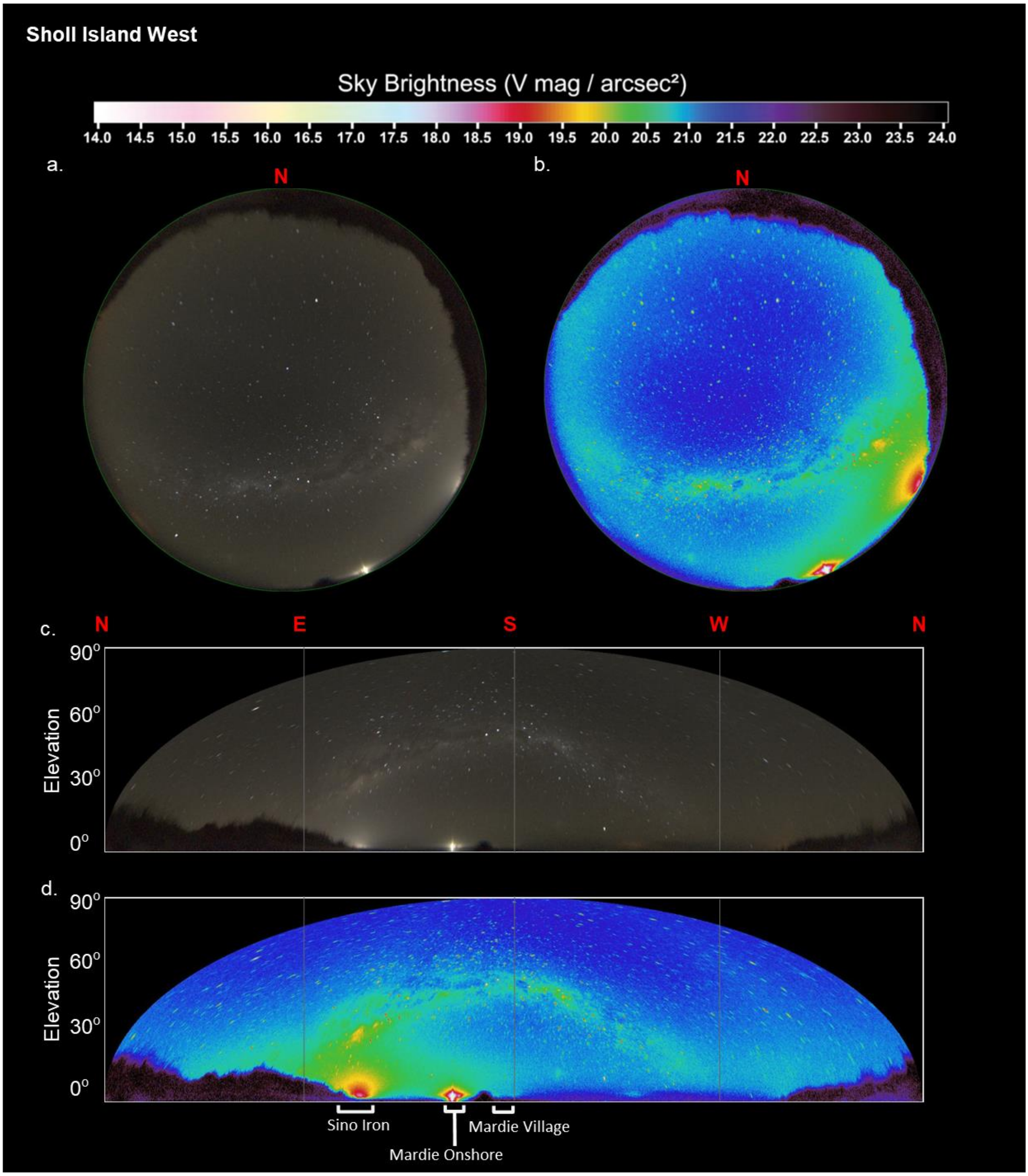

Figure 3-7: Artificial light monitoring results at Sholl Island West on 5th March 2025. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

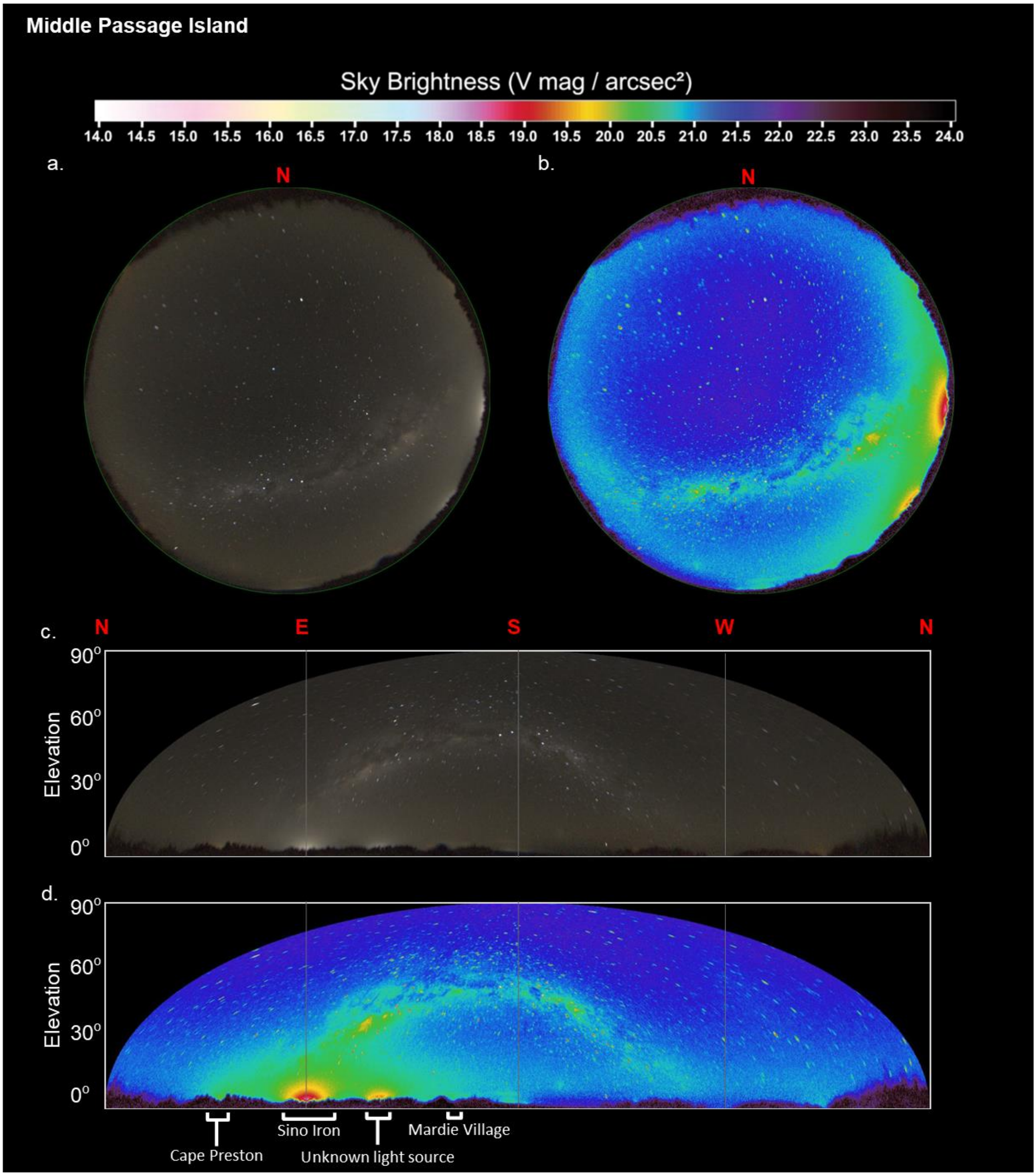

Figure 3-8: Artificial light monitoring results at Middle Passage Island on 8th March 2024. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

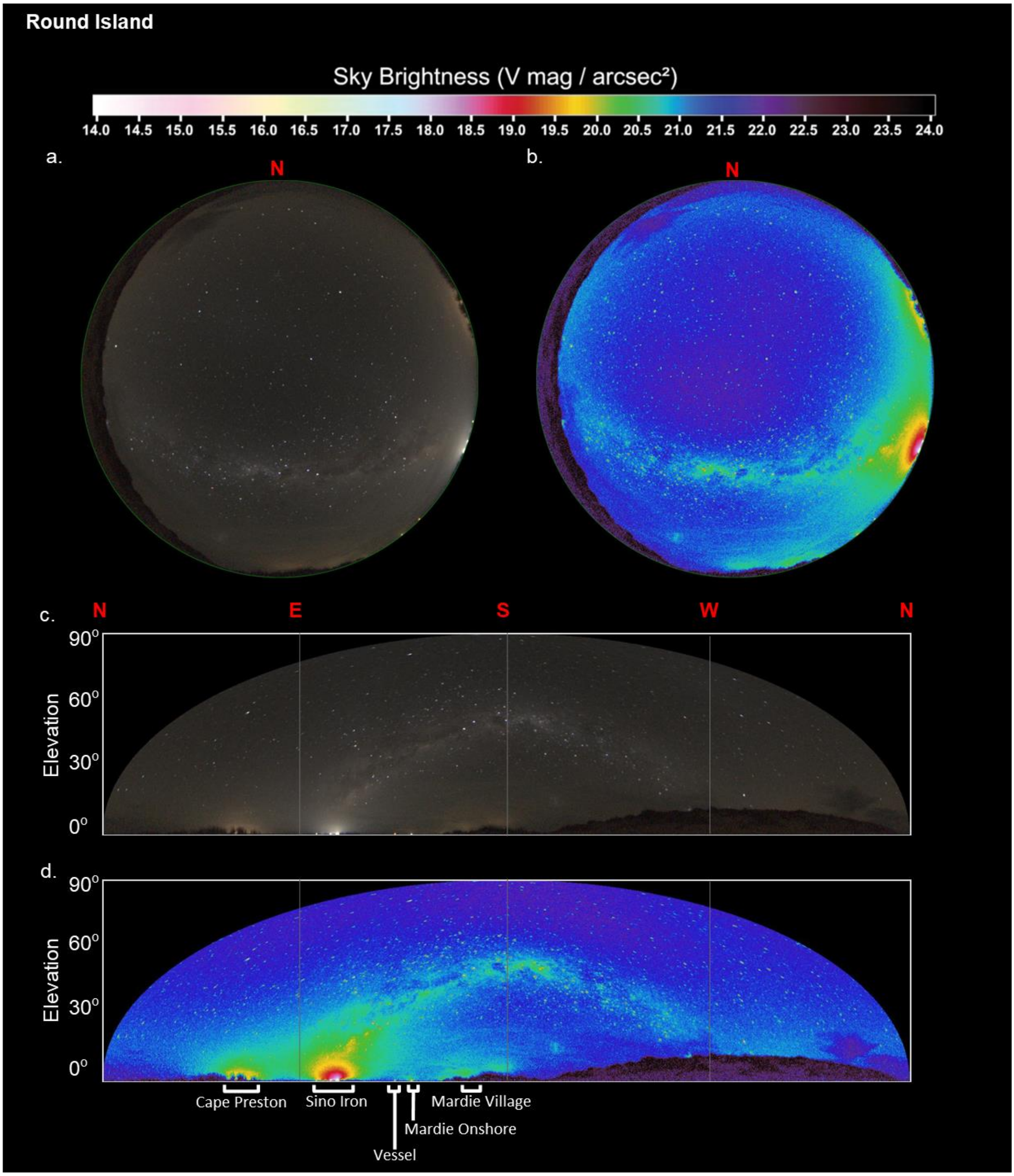

Figure 3-9: Artificial light monitoring results at Round Island on 4th March 2025. a. Clearest raw circular image; b. Processed circular image; c. Raw hammer-aitoff image; d. Processed hammer-aitoff image.

3.3 Historical Sky Brightness

The MTMP requires that the light monitoring results from offshore islands (2021/22) and the mainland (2022/23) form a baseline dataset for yearly data to be compared to throughout the monitoring program. Table 3-3 shows the WOS sky brightness measured over the last four seasons of monitoring, where data is available, along with the reported change in brightness from baseline data for this season (i.e. 2024/25 relative to baseline). Where baseline data is not available, the change in brightness is calculated from the first year of available data.

It should be noted that the positioning of stars, atmospheric conditions, changes in dune profile, vegetation height and other natural phenomena may cause variance in sky brightness from year to year, and therefore small changes in sky brightness are expected.

Table 3-3: Change in WOS sky brightness observed from baseline to 2024/25 at the light monitoring locations

Monitoring location	WOS Sky Brightness (Vmag/arcsec^2)				Change in brightness (%)
	2021/22	2022/23	2023/24	2024/25	
Mardie Creek (East)	-	21.24*	21.22	21.24	0.00
Mardie Creek (West)	-	21.34*	21.30	21.35	↓ 0.92
Mardie Pool	-	-	-	21.06	-
Long Island	21.19*	-	21.36	21.27	↓ 7.10
Sholl Island (West)	-	-	21.53	21.05	↑ 55.60
Sholl Island (East)	21.16*	-	21.08	21.09	↑ 6.66
Middle Passage Island	-	-	21.42	21.41	↑ 0.93
Round Island				21.06	-

Notes: Asterisk denotes baseline dataset, blue values indicate reduction in WOS brightness, red values indicate increase in WOS brightness. Change in brightness is presented as a percentage change, calculated by converting the sky brightness values measured in units of Vmag/arcsec^2 (a logarithmic scale) to a linear scale.

Increases in WOS sky brightness were observed at Sholl Island East (6.66 %), Sholl Island West (55.60 %) and Middle Passage Island (0.93 %). The comparatively larger increase in WOS sky brightness detected from Sholl Island (West; (55.60 %) was attributed to the newly constructed Mardie Onshore Facilities, which were observed as a bright source of direct light along the horizon from this location. Decreases in WOS sky brightness were observed from Long Island (-7.10 %) and Mardie Creek West (-0.92 %), which may be attributed to increases in vegetation height and/or changes in dune profile. No change in WOS sky brightness was observed from Mardie Creek (East) and no baseline data was available for comparison at Round Island or Mardie Pool. The 2024/25 records will serve as baseline records for these sites in future seasons.

3.3.1 Light Sources 2024/25

While it is difficult to quantify changes in specific point sources of light between monitoring seasons, a qualitative analysis of changes in visible light sources from monitored locations has been outlined in Table 3-4.

This is the first season that light from the Mardie Onshore Facilities has been visible due to its recent construction. Light from Rio Tinto Mesa A mine, Barrow Island and Varanus Island, which were observed in previous monitoring seasons (Pendoley Environmental 2019; 2023; 2024), were not recorded by the light cameras from any of the monitoring locations in 2024/25. It should be noted that these light sources still exist, however changes in vegetation height and/or dune profiles may cause changes in visibility of light sources across monitoring seasons.

Table 3-4: Change in visible light sources observed from 2021/22 to 2024/25 at light monitoring locations

Visible Light Source	Visibility		
	2021/22 and 2022/23	2023/24	2024/25
Cape Preston	SIE, LI	SIE, LI, SIW, ME*	SIE, LI, RI*
Sino Iron mine	SIE, LI	SIE, LI, SIW, ME*, MW*	SIE, LI, SIW, MP*, MPI, RI*
Mardie Village	SIE, LI	SIE, LI, SIW	MP*
Mardie Onshore Facilities^	-	-	SIE, LI, SIW, RI*
Rio Tinto MESA A mine	SIE, LI	-	-
Barrow Island	SIE	ME*, MW*	-
Varanus Island	SIE	-	-

Notes:

MW – Mardie Creek West;

ME – Mardie Creek East;

SIW – Sholl Island West;

SIE – Sholl Island East;

LI – Long Island;

MPI – Middle Passage Island;

RI – Round Island;

MP – Mardie Pool.

* denotes the first season for this location to be monitored.

^ denotes first time light source has been recognised.

4. Discussion

Comparison of light monitoring data recorded at eight locations in 2024/25 with the past four seasons of light monitoring (where available), revealed an increase in whole-of-sky brightness at Sholl Island (East and West) and from Middle Passage Island. The comparatively larger increase in WOS brightness detected from Sholl Island (West) was attributed to the newly constructed Mardie Onshore Facilities, which were observed as a bright source of direct light along the horizon. Decreases in WOS brightness were reported at Long Island and Mardie Creek (West), which may be attributed to increases in vegetation height and/or changes in dune profile shielding previously available sources of light. No change in WOS brightness was observed from Mardie Creek (East). The brightest visible light sources continue to include the port at Cape Preston and Sino Iron mining facilities, with the addition of light from the newly constructed Mardie Onshore Facilities in the 2024/25 season.

The comparison of visible light sources recorded in the 2024/25 season with baseline data from the MTMP found a new source of artificial light, which can be attributed to the newly constructed Mardie Onshore Facilities. The Mardie Onshore Facility was visible from Long Island, Sholl Island (East and West), Round Island, and from the inland monitoring site at Mardie Pool. Light from Mardie Village was visible from Sholl Island (East and West) and Long Island in the 2023/24 season; however, was not visible from Sholl Island (East) in 2024/25. This is likely due to changes in vegetation height and/or dune profile shielding the previously visible lighting.

Alongside these known sources of light, two unidentified sources of light were visible from Long Island at a bearing of 130° and 137° on 2nd December 2024. An additional source of unidentified light was visible from Middle Passage Island at a bearing of 125° on 8th March 2025. Examination of these bearings (see Figure 4-1) suggested that these unknown lights sources may have been marine vessels positioned between the monitored islands and the mainland, given that marine vessels were visible from Sholl Island (East) and Round Island as faint sources of light on the horizon. Alternatively, they may have been Project-associated lighting on the mainland. If the same sources are identified during the 2025/26 monitoring season, it is recommended that an investigation be undertaken to determine their origin and whether they are associated with the Project.

Sky glow from Sino Iron was visible from both Mardie Creek (East and West) during the 2023/24 season but was shielded at these monitoring locations during the 2024/25 season by changes in dune profile and/or vegetation growth. Similarly, offshore sky glow from the oil and gas facility on Barrow Island was visible from Mardie Creek (West) and Mardie Creek (East) during the 2023/24 season but was not visible during the 2024/25 season due to shielding provided by dunes and/or vegetation.

Artificial light monitoring was completed for the first time in the 2024/25 season (this report) on the mainland at Mardie Pool, as per outcome-based provision Number 4 of the *Illumination Plan* (see page 52; BCI Minerals 2023) and opportunistically at Round Island. The results presented in this report will serve as a baseline for these sites in future seasons.

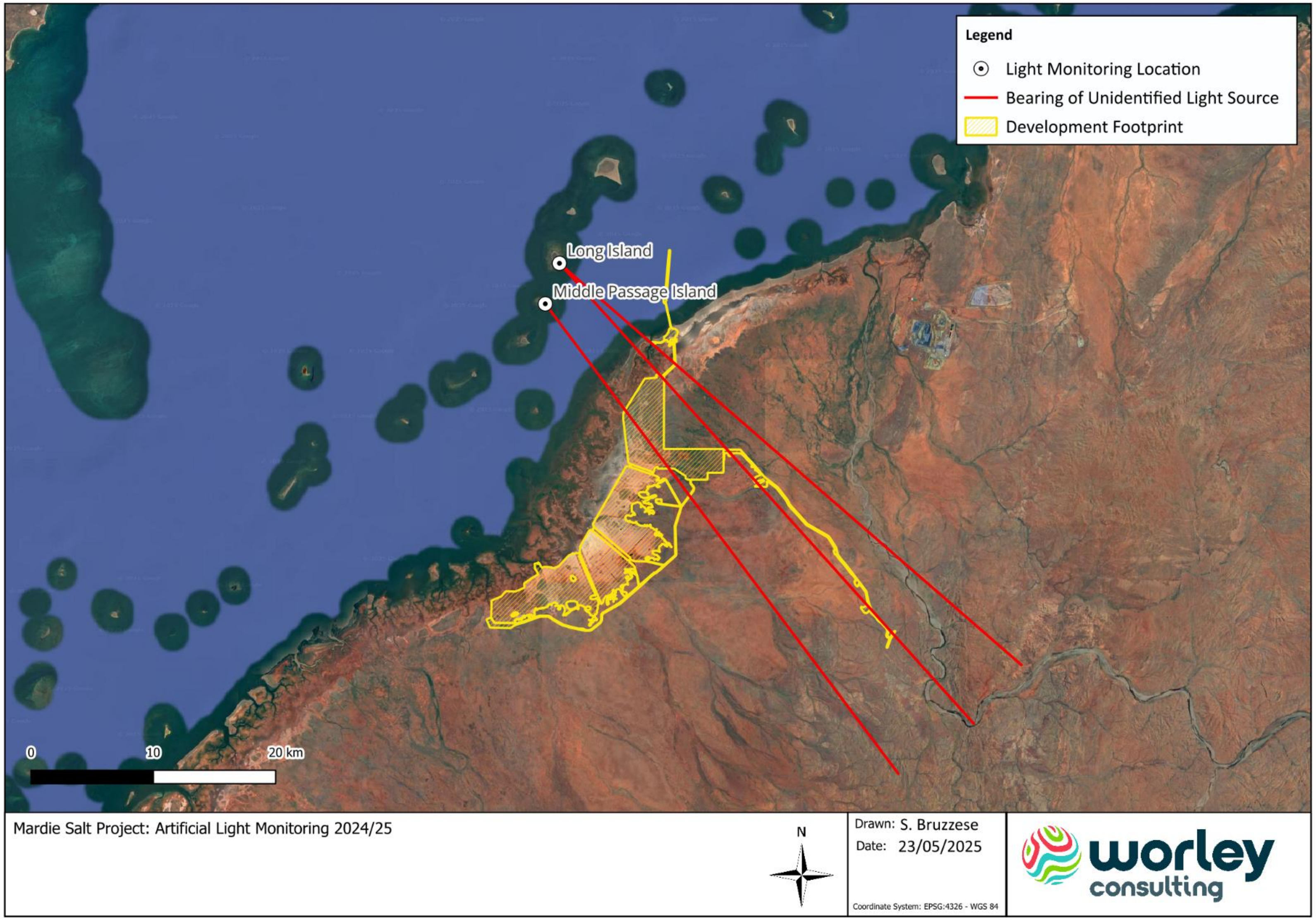

Figure 4-1: Bearings of unidentified light sources visible from Long and Middle Passage islands

5. Conclusion

Artificial light monitoring using suitable light monitoring equipment was successfully conducted in accordance with the requirements of the MTMP. The results of the 2024/25 artificial light monitoring surveys were suitably analysed and compared to the baseline data (2021/22: offshore islands, and 2022/23: mainland) to quantify any changes in sky brightness and identify new light sources, as outlined in the MTMP.

Monitored sky brightness data indicated the night skies at the monitoring locations were representative of a rural night sky. The brightest artificial light sources visible from most monitoring locations were the Sino Iron mine and the port at Cape Preston. Mardie Village represented a new source of artificial light in 2021/22 and was visible from Middle Passage Island in 2024/25. A new source of artificial light on the mainland, termed 'Mardie Onshore', was also identified in 2024/25 and was visible from Long Island, Sholl Island (East and West), and Round Island.

In addition, artificial light monitoring was completed for the first time in the 2024/25 season on the mainland at Mardie Pool, as per outcome-based provision Number 4 of the *Illumination Plan* (see page 52; BCI Minerals 2023), and which will serve as a baseline for future seasons of monitoring at this site.

Based on this report, BCI is compliant with the relevant approval conditions of MS 1211; EPBC2018/8236 and EPBC2022/9169 (Appendix A Worley 2025) regarding light monitoring undertaken as per the Mardie Salt Project MTMP (PENV 2023b) in 2024/25.

6. References

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