Quantifying Nesting Success and Hatchling Survival of Flatback Turtles Through Continuous Monitoring

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Abstract

Chevron Australia Pty Ltd on behalf of itself, Mobil Australia Resources Company Pty Limited, Shell Australia Pty Ltd, Osaka Gas Gorgon Pty Ltd, MidOcean Gorgon Pty Ltd and JERA Gorgon Pty Ltd (hereafter collectively referred to as "Chevron Australia"), operates Gorgon Project. The Gorgon Project is located on Barrow Island, a regionally significant nesting site for flatback turtles. Although Chevron Australia conducts annual in-person turtle monitoring, camera-based methods of monitoring could provide a more continuous, less intrusive, and less labour-intensive method of observation. This would allow turtle behaviour and survival to be studied over longer periods, improving our understanding of the species' population dynamics. This project aimed to quantify nesting success and hatchling survival rates on two Barrow Island beaches using 16 solar-powered cameras for continuous observation, and determine whether the environmental conditions can predict these rates. So far, nesting emergences have occurred at an average tide height of 344mm, and 28% of nesting emergences have been successful (i.e. eggs laid). Meanwhile, 65% of hatchlings have avoided predation on-shore to reach the water's edge safely. Further analyses are required to determine whether the temperature, humidity, wind, luminosity, and moon phase can predict successful nesting or hatchling survival.

1. Introduction

Sea turtle populations are monitored globally in conservation programs, but collecting quantitative and continuous data over long periods of time presents many challenges. Flatback turtles (*Natator depressus*) are listed by the International Union for Conservation of Nature (IUCN) as data deficient, and confidence in their population trends are lacking. Unlike the six other species of sea turtles, flatback turtles only lay their eggs on Australia's northern coasts and islands (DCCEEW, 2021). Barrow Island, a Class A Nature Reserve, is one of these islands, located off the Pilbara coast in Western Australia (WA). It is recognized as one of the largest flatback rookeries, with over 5000 nests being laid on its eastern beaches between the November and February nesting season every year (DBCA, 2017). Barrow Island is also home to Chevron Australia's Gorgon Project, the largest single resource project in Australia (Chevron Australia, 2022). Chevron Australia has an obligation to maintain and protect the biodiversity of Barrow Island, and has supported the annual assessment and monitoring of flatback turtles since 2005/2006 (Pendoley Environmental, 2023).

The summer and often-nocturnal preferences for nesting flatbacks to emerge onto shore, however, make in-person monitoring a labour-intensive task, involving long hours of physical work in hot, humid, and dark conditions (Pendoley Environmental, 2023). As a result, there are limitations in the types of observations that can be collected, and missing data either needs to be extrapolated or left unknown. A camera-based method which allows for the continuous observation of turtles can collect data which could contribute to a more comprehensive understanding of the species' behaviour and threats. Additionally, if used over months or years, longer-term patterns or trends may be identified, which can inform future management and conservation strategies.

Currently, the longest flatback monitoring program in WA is managed by Chevron Australia and takes place on Barrow Island. It involves nightly beach patrols between November and January every year to collect nesting data, such as the number of turtles that emerge to nest (Pendoley Environmental, 2023), which remain limited in flatback literature to this day. Meanwhile, to our knowledge, only two studies have previously attempted to quantify on-shore predation of flatback hatchlings. The first used local anecdotes, tracks of hatchlings and predators, and visual observations of predators with hatchlings to estimate predation rates of flatback hatchlings on Crab Island, Queensland (Limpus et al., 1983). Birds were responsible for majority of the predation observed, peaking at 38% of hatchlings predated in May 1978. Crabs were the only other predator noted in the study, predating only 0.2% of hatchlings during the same time. More recently, Avenant et al., 2023 used infrared cameras to record the on-shore fates of flatback hatchlings at Thevenard Island, WA. Of the 314 hatchlings recorded in the study, the fate of 47% could be determined. Of these, 70% made it safely to the water, while 30% were predated on-shore, by either ghost crabs, silver gulls or Caspian terns. Hatchlings that emerged alone had the highest rate of predation, with an exponential decline in mortality as the number of hatchlings emerging at the same time increased.

The objective of this project was to collect continuous observations of flatback turtles throughout one nesting and hatchling season to identify aspects of activity that are difficult to study through on-site monitoring. Specifically, this project aimed to quantify the rates of successful nesting and on-shore hatchling predation at Barrow Island using 16 solar-powered cameras running continuously for five months (December 2023 to April 2024). It also aimed to identify whether longer-term trends in these rates are related to environmental factors, such as tide height, temperature, wind, or luminosity, and what level of these environmental conditions are most closely associated with high rates of successful nesting and hatchling survival.

2. Methodology

2.1 Site Description

This study was conducted on two beaches on the Eastern side of Barrow Island: Terminal Beach, and Yacht Club South (YCS) Beach. These sites were selected as they had a pathway for the camera trailers to reach the beach without disrupting native vegetation during equipment setup and takedown. Terminal Beach is located immediately north of the Gorgon marine infrastructure, with sand concentrated in the highest densities at the southern end (Chevron, 2021). Historically, Terminal has generally had a higher density of nesting turtles than YCS, which is located further south of the marine infrastructure and is bounded by rock headlands on the southern end. Both beaches have a reef habitat in the area between low and high tide, known as the intertidal area. Within each beach, two study sites which had ample sand and minimal spinifex (i.e. maximum nesting habitat) were selected.

2.2. Field Equipment and Setup

Four camera towers were set up across Terminal and YCS beach. Each camera tower consisted of a solar-powered trailer, sourced from EcoQuip Australia Pty Ltd (Mobile Solar Surveillance Tower – MSST4), and four infrared CCTV cameras attached atop a mast which extended vertically up to 8m (see Figure 1). The four cameras faced approximately 90° from each other and slanted down to capture an almost 360° view of the surrounding beach area. Each tower was secured in its position using the trailer's four stabiliser legs and anchored by large limestone blocks on all four sides. Inside each tower was a digital video recorder (DVR) and a monitor which stored and live-displayed the footage respectively. Two towers were placed on each beach, approximately 100m apart.

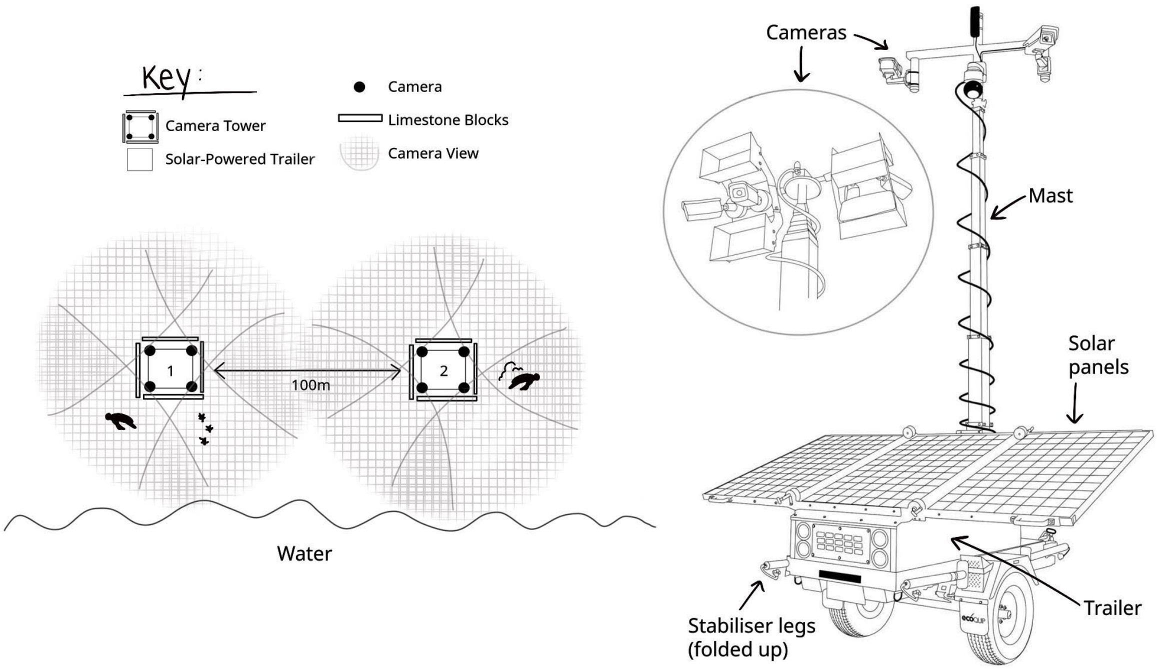

Figure 1 The study setup (left), and a camera tower (right) from EcoQuip (n.d.).

2.3. Data Collection and Footage Analysis

Each DVR could store approximately 1.5TB of footage and needed to be swapped every three weeks to maintain continuous recording. Each DVR had one identical replacement, and while one was in the tower, the footage on the other was being downloaded for temporary storage onto a hard drive (Seagate Expansion 5TB). This hard drive was then used to upload the footage onto the UWA Institutional Research Data Store for long-term storage.

All footage was viewed and analysed using VLC Media Player. For nesting turtles, the time that each individual turtle emerged from the water and their highest nesting success level was recorded, with the latter being the dependent variable. This variable was categorical with three levels: Success, Attempt, or False Crawl. A Success was recorded if the turtle laid eggs, an Attempt if the turtle dug in the sand but didn't lay eggs, and a False Crawl if the turtle emerged but did not even dig before returning to the water. If the turtle's nesting behaviour could not be determined, the success was recorded as Unknown and it was excluded from the final analyses.

Footage analysis for hatchlings involved recording the time that each individual hatchling emerged from the sand, and what their overall fate was on their crawl to the water. This fate was the dependent variable for nesting analyses, a categorical factor with three levels: Safe, Assumed Predated, and Observed Predated. Hatchlings were recorded as Safe if they were observed making it to the water at high tide when it was visible in the footage. At low tide when the water wasn't visible, the hatchling was recorded as safe if it made it to the edge of the camera's view towards the water's direction. If the hatchling was Observed Predated (i.e. predation visible through the footage) or Assumed Predated (e.g. hatchling followed by predator but visibility becomes obscured somehow), the predator species was also recorded. If the hatchling's fate was unable to be verified, it was recorded as "Unknown" and removed from the final analyses.

2.4. Statistical Analyses

For both nesting turtles and hatchlings, emergence time was used to calculate environmental factors like tide height, temperature, wind speed and direction, and humidity. Moon phase was also recorded based on the date of emergence, and luminosity will be calculated using R package Moonlit (Śmielak, 2023). These variables will be used in a Multiple Regression with Generalised Additive Mixed Model analysis to identify which factors are significantly related to nesting success and hatchling fate.

3. Results and Discussion

3.1. Nesting Results and Discussion

In the current dataset, females were seen emerging to nest 227 times on Terminal and 324 on YCS, for a total of 551 nesting emergences. Of these, 153 (28%) successful nests, 239 (43%) had at least one nest excavation attempt but was not observed to have successfully nested, 32 (6%) false crawled, and 127 (23%) were unknown. With the exception of one successful nesting attempt at 11:00, all other nesting emergences were between 13:00 and 04:00, with 19:00 being the most common time. January 22nd and January 23rd were the two most emergence-dense days, with 41 and 33 nesting emergences observed respectively (see Figure 2).

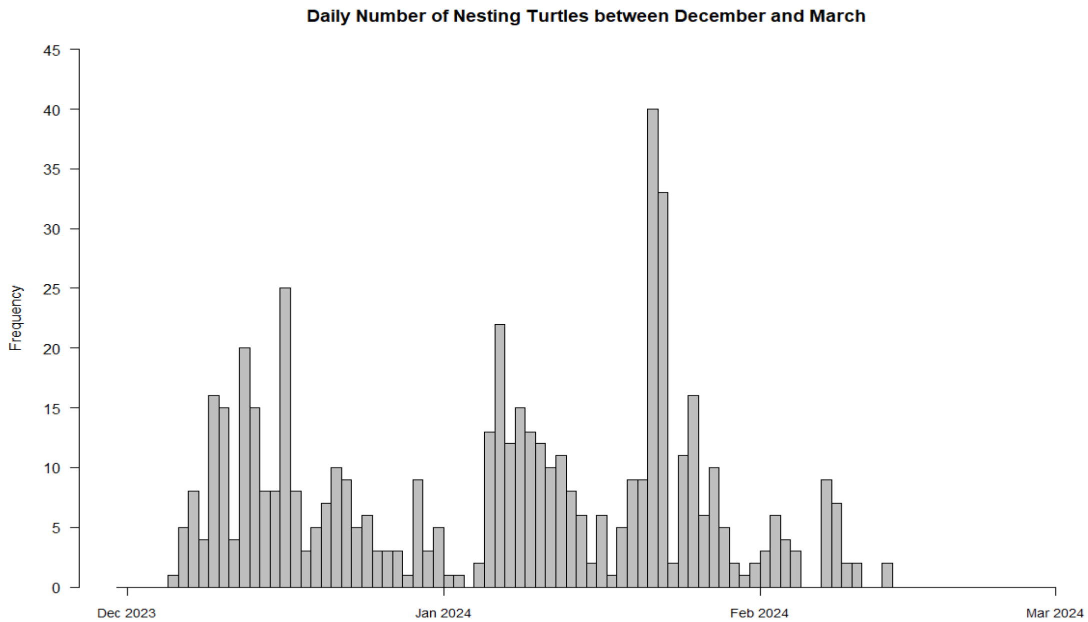

Figure 2 The daily frequency of nesting turtles that emerged on Terminal and YCS Beach between December 2023 and March 2024.

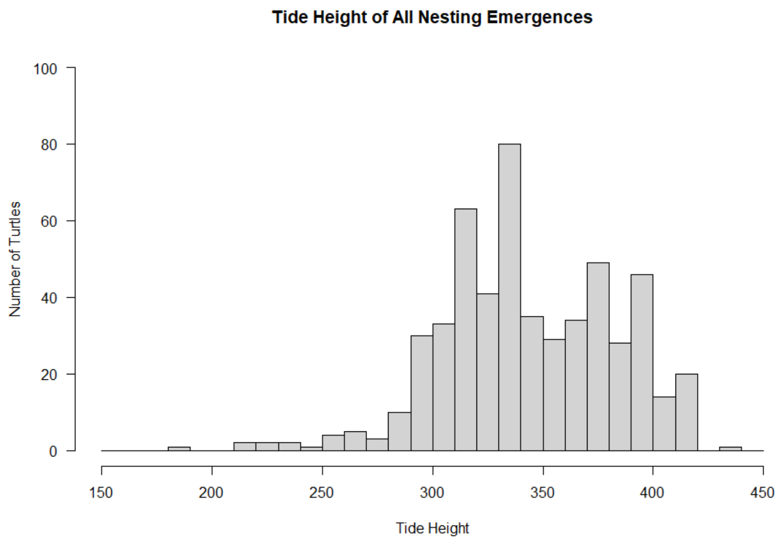

Figure 3 The tide height (mm) of all nesting emergences currently recorded between December 2023 and March 2024.

The tide height at the time of all nesting emergences ranged from 190mm to 431mm, with an average of 345mm (Figure 3). This average was consistent with expectations, with flatback turtles known to prefer soft-bottomed habitats (DCCEEW, 2021). Because the intertidal area on both Terminal and YCS Beach are reef, it follows that nesting females would prefer to emerge at a tide height that enables them to swim over the reefs, rather than use extra energy crawling over them at low tide.

Subsetting the data to contain only successful or unsuccessful nests (i.e. attempts and false crawls combined) produced similar results, with an average tide height of 340mm and 347mm respectively. However, visual inspection of the tide heights showed possible differences between successful and unsuccessful nests despite similar averages. While the successful nests exhibited a fairly standard "bell curve" distribution, there was a large drop off visible in the unsuccessful nests when tide height changed from 330-340mm to 340-350mm (Figure 4). While analyses have not yet been conducted to test whether this is statistically significant, it is an encouraging visual finding that the average tide height with a relatively high frequency of successful nests appears to correspond with a relatively low frequency of unsuccessful nests.

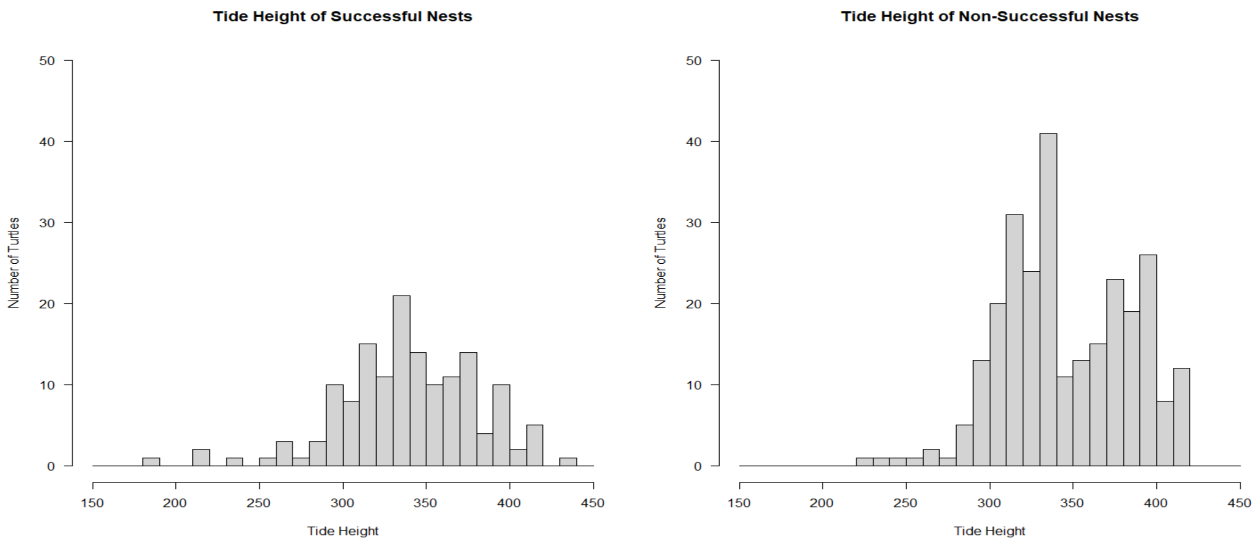

Figure 4 The tide height at the time of emergence for flatback turtles that successfully nested (left), and turtles that did not successfully nest (right).

3.2. Hatchlings Results and Discussion

Eight hundred and seventy-six hatchlings were observed in the current dataset. Of these, 567 (65%) were recorded as safe (i.e. not predated), 68 (8%) were assumed predated, 114 (13%) were observed predated, and the fate of the remaining 127 (14%) were unknown. Of the 182 observed or assumed predated, 52 (29%) were predated by silver gulls, 121 (66%) by bandicoots, 3 (2%) by water rats, 2 (1%) by bettongs, and 4 (2%) predators were unknown.

4. Conclusions and Future Work

So far, the continuous observation of flatback turtles has allowed for rates of nesting success and hatchling survival to be quantified in a way that was previously difficult to do through in-person monitoring. Future work will involve the inclusion of temperature, wind speed and direction, humidity, luminosity, and moon phase at the time of emergence to determine whether these environmental factors are associated with nesting success or hatchling survival.

5. Acknowledgements

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