IAIA Paper Outline:

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Paper Topic – Adaptive Coastal Development Management: Red Sea Turtle Nesting

Preferred Session – Marine Impact Assessment for Ecosystem Based Marine Spatial Planning

Summary Statement: The challenges and prospects of ensuring protection for the turtle habitat in the pre-concept design phase of development in the Al Wajh Lagoon, Red Sea Saudi Arabia

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Abstract: The recent development along the Al Wajh Lagoon of the Red Sea has generated prospects and challenges for development and conservation in the coastal marine environment. The challenge is to strike a balance in reconciling coastal development with conservation, using an adaptive management approach to achieve developmental and conservation goals. The lagoon, comprising 92 islands, is believed to support the largest aggregation of nesting Hawksbill turtles (*Eretmochelys imbricata*) and the second-largest aggregation of nesting Green turtles (*Chelonia mydas*) in the Red Sea. RSG has introduced an adaptive management approach aimed at achieving developmental goals and objectives while accounting for sustainable use and conservation of resources. Based on the outputs from the Marine Spatial Planning (MSP) and project masterplanning processes, conservation and development islands were identified. As the project has progressed and understanding of the system has improved, challenges related to reconciling the needs of the development with conservation objectives have been identified. This paper highlights the efforts taken to improve understanding of turtle populations in the RSG area and discusses environmental design approaches that have been taken to embed conservation measures into the planning process with a view to safeguarding turtle nesting habitat through robust interventions in the pre-concept design phase. It supports the need to ensure that conservation efforts can be optimized through adaptive management approaches that are science-based and reconsidered as the project progresses.

Introduction

In 2016, the Kingdom of Saudi Arabia (KSA) commenced implementation of ambitious and far-reaching plans to diversify the national economy in line with the national strategy, Vision 2030. A key tenet of the national strategy is to substantially increase the volume of non-pilgrimage tourists travelling to KSA. The development of key destinations along KSA's Red Sea coastline was identified as an important driver that would allow for this objective to be realized. To facilitate this vision, The Red Sea Development Company (TRSDC), now Red Sea Global (RSG), was established in 2018 by KSA's Public Investment Fund (PIF) with a remit to develop The Red Sea (TRS). TRS aims to develop luxury tourism and residential facilities based predominantly around the archipelago of islands within a natural lagoon referred to as the Al Wajh Bank.

The Al Wajh Bank and the surrounding lagoon ecosystem is a particularly sensitive natural location with a high-quality marine environment. The lagoon, comprising 92 islands, supports regionally significant aggregations of nesting Hawksbill (*Eretmochelys imbricata*) and Green turtles (*Chelonia mydas*). In 2018, RSG undertook a Marine Spatial Planning process (Chalastani, et al., 2020). Taking into account the outcomes of the MSP process, the RSP Concept Masterplan (CMP) has targeted development of seven of the largest islands in the lagoon and 24 of the smaller islands for development through a phased development approach. Phase 1 of the development is nearing completion, with two hotels open as of the time of writing and the rest planned to open by the end of 2025.

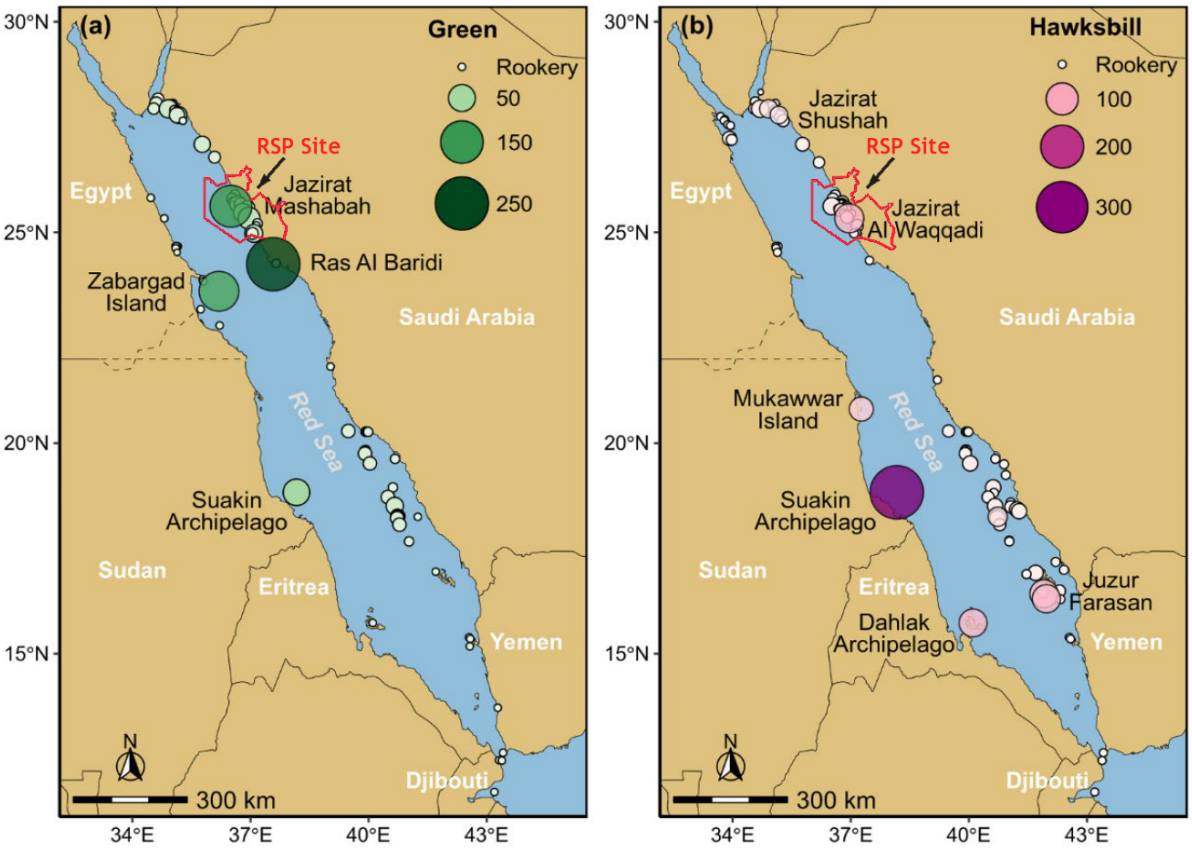
A Biodiversity Action Plan (BAP) developed for RSG has established a target of enhancing the population status to achieve net gain in absolute numbers ≥10% across past and present three-year averages, and to maintain the current genetic diversity of marine turtles in the project area. To help achieve this, RSG has initiated programs to enhance understanding of the marine turtle distribution and population dynamics with a view to developing and implementing informed management and conservation strategies.

The initial MSP and CMP exercise was conducted soon after the RSP was initiated and the understanding of the ecology of the Al Wajh lagoon was still developing. As the project has progressed and understanding of the system has improved, challenges with reconciling the needs of the development with conservation objectives have been identified. This paper aims to highlight the approaches that have been taken to embed conservation measures that safeguard turtle nesting habitat into the planning process and to mitigate these conflicts as they arise at the project level. There is a need to ensure that conservation and planning can be optimized through adaptive management approaches that are science-based and are reviewed and updated as the project progresses. This paper also identifies initiatives that RSG can apply at varying scales to further strengthen the planning efforts.

Turtle Breeding at TRS

Of the five species of turtle recorded in the Red Sea, two are commonly recorded at TRS. Hawksbill turtles are globally listed as Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, while the Green turtle is listed as Endangered globally (Meylan & Donnelly, 1999; Miller, 2018; Seminoff, 2004; Seminoff & Shanker, 2008). The Al Wajh Lagoon is recognized as one of the most important zones within the Red Sea in terms of Green turtle and Hawksbill turtle nesting distribution, abundance, and rookery size (Figure 1) (Al Ameri, et al., 2022; Shimada, et al., 2021).

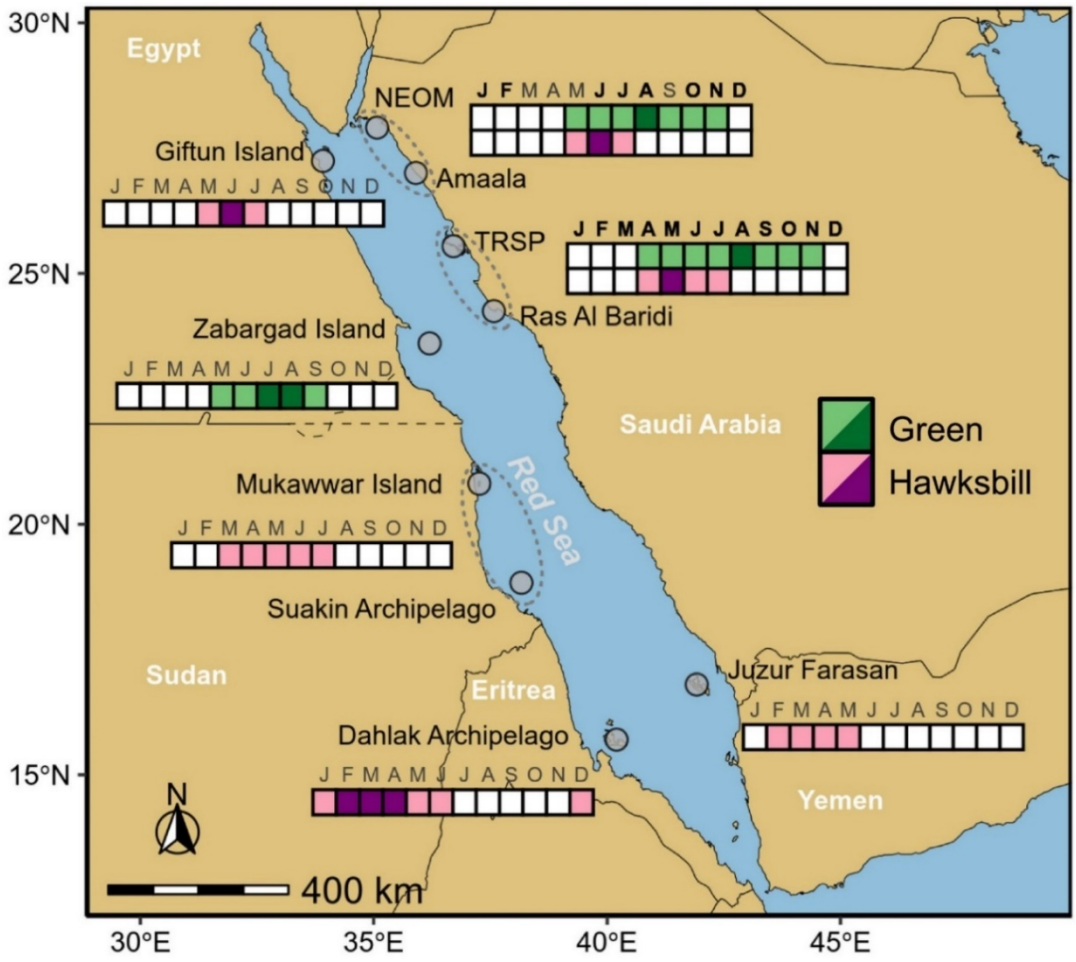
Figure 1 Distribution and Estimated Abundance of Nesting Green and Hawksbill Turtles in the Red Sea



Source: Adapted from Shimada et al. (2021)

The reproductive periods of both Green and Hawksbill turtles in the Red Sea are seasonal. In the northern Red Sea, at TRS, Hawksbill turtles have been traditionally understood to breed and nest between April and July, with a peak in May. Green turtles have been recorded nesting between April and November, with peak activity in August (Figure 2) (Shimada, et al., 2021).

Figure 2 Nesting Season of Green and Hawksbill Turtles in the Red Sea (Shimada, et al., 2021)



Lighter colors indicate nesting activities in each month (shown by a capital letter above each box) with darker colors denoting the peak periods.

Source: Shimada et al. (2021)

Understanding of nesting seasonality continues to develop. In February 2024, field survey personnel from RSG and King Abdullah University of Science and Technology identified female Hawksbill turtles exhibiting nesting approach behavior at two islands in TRS. This is the earliest month for recorded evidence of nesting behavior in the lagoon and suggests that there may be low levels of Hawksbill nesting activity in the Al Wajh lagoon throughout much more of the year than previously thought (Barrios-Garrido, H. *pers comm*).

A high proportion of the nesting recorded within TRS area is focussed on specific islands. Shimada et al. (2021) found that approximately 61% of nesting events in 2018 and 2019 were on Breem Island, with nesting also reported on 16 other islands (Figure 3). Hawksbill turtle nesting was more dispersed, with records from 2018 on 37 islands and 43% of nests on Al Waqqadi island (Figure 4). Based on RSG survey data, there were an estimated 173 nesting female Green and 69 Hawksbill turtles in TRS in 2022 (RSG, 2023).

Figure 3 Main Green Turtle Nesting Sites in TRS

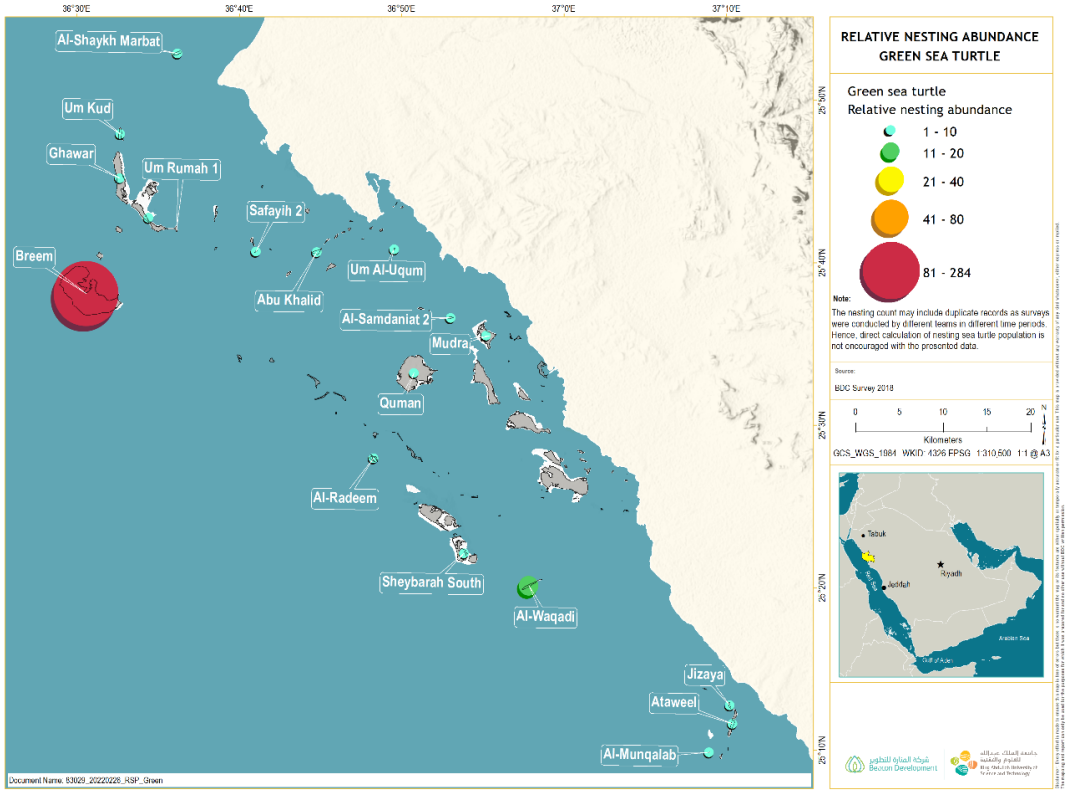
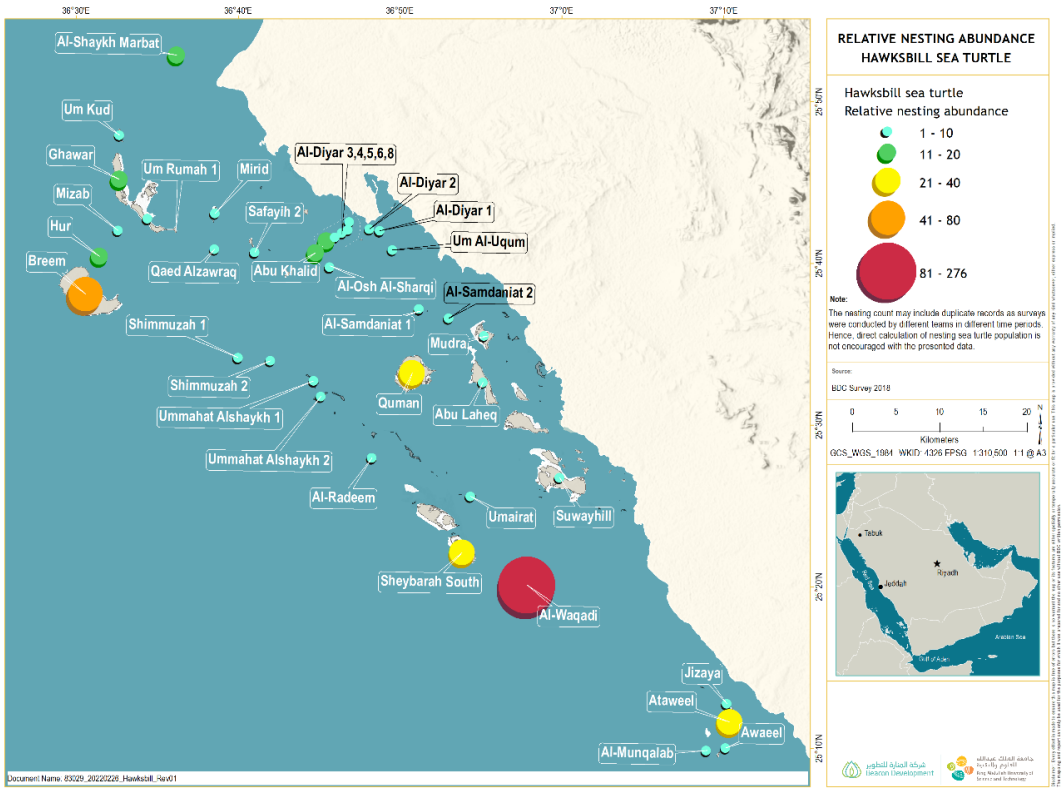


Figure 4 Main Hawksbill Nesting Sites in TRS



Studies Initiated by RSG

Effective management requires high-quality data. At the initiation of the RSP in 2017, the understanding of turtle populations was limited, with no studies having been undertaken. Between 2018 and 2020, Shimada et al (2021) undertook field studies across numerous islands and coastal areas in the northern Red Sea. RSG subsequently initiated a series of studies aimed at improving understanding of turtle populations within their areas of management to guide conservation and development planning. These studies, listed in Table 1, were undertaken by King Abdullah University of Science and Technology (KAUST) Beacon Development (KBD) on behalf of RSG, working in partnership with Five Oceans Environmental Services LLC and Pendoley Environmental.

Table 1 List of Studies Commissioned by RSG to Inform Conservation and Planning Initiatives

Study Type	Project Type	Description
Survey	Turtle Nesting Beach Surveys	Site walkover surveys on potential nesting beaches were carried out over 54 nights from 2019 to 2022. The RSG's regulatory entity, the Red Sea Zone Authority (RSZA), also conducted surveys of turtle nesting beaches between 2021 and 2023
	Satellite Tracking of Nesting Females	Satellite tracking of 50 Green turtles and 10 Hawksbill turtles between 2019 and 2022 using Platform Terminal Transmitter (PTT) tracking equipment. The data collected from the satellite tracking has helped reveal valuable information on distribution of key foraging and inter-nesting habitat, nesting success rates, and migration routes and behaviour during migration, both within TRS and regionally within the wider Red Sea.
	Impact of Climate Change on Hatchling Survival	Eleven nests were assessed to estimate their hatching success values with data loggers installed at nests to track temperature during egg incubation. Data from the studies helps inform research of the relationship between temperature and hatchling success.
	Hatchling Arena Trials (Lighting Response and Survey)	Two hatchling arena trials were undertaken to help understand the sensitivity of hatchlings to artificial light at key locations in TRS area. The specific objectives were to collect hatchlings emerging from nests and subject them to *in situ* experimentation to help determine the effects of artificial lighting on orientation post-emergence.
Development of Design Guidelines	Development of Design Guidance for Mitigating Lighting Impacts on Turtle Nesting Beaches	Design guidance aimed specifically at mitigating impacts associated with artificial lighting during masterplan design.
	Development of Design Guidance for Suitable Planting Palette on Turtle Nesting Beaches	Guidance document aimed at providing advice on the plants that can be used to enhance turtle nesting beaches and to shield beaches from the potential effect of artificial lighting associated with development.

Conflicts Between Coastal Development and Turtle Conservation

TRS CMP established a development framework that designated development areas and established both the land use and the intensity of use within each of the areas. On this basis, the islands that are scheduled for development are largely fixed. While an environmental planning approach was applied in the development of the RSP CMP, turtle nesting activity, or important turtle feeding habitat, is present in the majority of development zones, and conflicts between development and conservation objectives at the project level have nonetheless been encountered.

The risks to turtle populations associated with coastal development have been well-documented. Marine turtle nesting beaches constitute a conservation controlling factor, as they are the one habitat that cannot be replaced. Marine turtles need clear, unobstructed, and suitable beaches within which to lay their eggs. Long term beach loss can lead to declines – sometimes catastrophic – in marine turtle populations as they are not evolutionarily adapted to settling alternate nesting sites over short-term (decadal) periods. The beach zone typically provides the central zone of conflict between the needs of breeding turtle populations and development planning. Turtles typically favor beaches that are also preferentially targeted by masterplanning teams. This may be in the form of coastal real estate development of both hotels and private residences, with associated infrastructure and hard and soft landscaping. In some instances, shoreline modifications may also be proposed to extend or realign shorelines to increase capacity or meet aesthetic objectives.

Artificial lighting on or near beaches has been shown to deter females from nesting and to disrupt nesting behaviour. On beaches exposed to light, females will nest in higher numbers in areas that are shadowed. Moving sources of artificial light may also deter nesting or cause disturbance to nesting females. Offshore lighting sources have been shown to act as an attractant to hatchlings, causing aggregation and increased risk of predation. Similarly, offshore infrastructure such as jetties act as fish aggregation devices, attracting predatory species and increasing risk of hatchling predation. Changes to local hydrodynamics can also significantly impact upon the survival rates of hatchlings.

Specific risks to turtle nesting habitat and feeding grounds in TRS that have been identified during masterplan review include: proposed dredging and land reclamation, island raising to safeguard against future sea-level rise, the installation of utilities and transport infrastructure (with associated increases in maritime traffic), and construction of assets on, or in close proximity to, turtle nesting beaches. Typically, the conflicts are a consequence of the architectural firms developing the project designs not being appropriately sensitized to the ecological sensitivities of a given project site.

Design Interventions and Guidance

Capturing potential risks to turtle populations as early as possible in the design process is important because changes can be most easily effected, and negative impacts designed-out, during the early pre-concept and concept design phases. To facilitate this, RSG has developed a structured approach to environmental planning that allows for robust interventions in the pre-concept design phase. The environmental design approach seeks to identify key environmental constraints and opportunities at project inception and, working regularly with design teams to review design iterations, embed inherent protection measures into the design. The approach relies on site-specific data and adopts the typical mitigation hierarchy, deployed from the project visioning and continued throughout the design process.

Data and guidance derived from the studies listed in Table 1 are utilized to inform and guide the masterplan design. At the pre-CMP development phase, RSG design teams and architects are informed of sensitivities associated with turtles through stage-gate workshops and iterative environmental design feedback. Because the project development site is fixed, guidance aims to avoid impacts to the nesting beaches through modification of design, focusing on impacts associated with habitat loss and light spill.

Guidance to designers includes but is not limited to the following:

1. Maximize the setback distance from the back of the sandy beach, with buffers to be site-specific based on local topography and landform. On even the smallest islands, a minimum setback of 50 meters from confirmed nest sites is required;

2. Maintain the beach and associated dunes in their natural condition so that they are not encroached upon or modified in any way. Natural vegetation is to be retained;

3. Locate proposed development behind topographic features that provide natural shielding so that direct visibility of lights will be obscured from view from the sea and nesting beach;

4. Install artificial shielding (such as dunes, berms, banks, vegetation, walls) or mass buildings to screen development lighting impacts at the beach; and

5. Avoid locating offshore infrastructure or lighting sources (e.g. jetties, artificial islands, marinas) either on or offshore from turtle nesting beaches.

Adherence to the above covers two of the most important and effective approaches to manage light near turtle nesting beaches:

1. To ensure there is a tall, dark horizon behind the beach, and

2. To ensure there are no point sources of light visible from the beach or on the water through which hatchlings disperse.

In addition to the above setback considerations, specific turtle-aware lighting is incorporated into design. This follows International Best Practice and is based on the National Light Pollution Guidelines for Wildlife Including Marine Turtles, Seabirds, and Migratory Shorebirds (Commonwealth of Australia, 2020) as adopted by the Convention on the Conservation of Migratory Species of Wild Animals (CMS), of which KSA is a signatory.

Working in this manner, design modifications have been implemented that have included:

- Providing setbacks and screening to ensure protection of turtle nesting sites;

- Designating protection zones on development islands, where no development is permitted, specifically to ensure protection of turtle nesting beaches;

- Implementing protection zones to restrict development offshore from turtle nesting beaches;

- Reorienting proposed dredged channels to minimize impacts on reefs and avoid turtle nesting habitat; and

- Eliminating design components that present a significant risk to the integrity of beaches and of coral reef and seagrass habitats around development islands.

Recommendations for Future Management

RSG has employed a systematic planning approach that ensures key ecological data is provided to designers at the start of the project design process. This aims to ensure that mitigation is embedded in the masterplan design and that avoidance of impacts can most easily be accommodated through design modifications. As the design progresses, designs are updated and subjected to ongoing review and feedback to strengthen protections of habitats that are critically important to turtle populations.

In an area such as TRS, which has until recently been data-deficient, management efforts and planning guidance should employ the precautionary principle and target protection of all turtle nesting habitat and associated feeding grounds. As detailed in previous sections, significant protections can be implemented on a project-by-project basis by engaging with designers and sensitizing them to specific risks.

RSG has made efforts to enhance understanding of turtle ecology in the lagoon since the project's inception. For species such as turtles, where it can take many years of monitoring to understand inter-annual variation in population dynamics, long-term monitoring is required to improve understanding. RSG must continue to employ a proactive approach to developing this understanding by continuing to build on the work already conducted and implementing sitewide monitoring and post-construction surveys at completed project sites. Maintaining the collaborative approach with open data sharing between stakeholders will also be critical to ensuring the achievement of conservation objectives. With this in mind, several recommendations for future management are detailed in Table 2.

Table 2 Recommendations for Future Management

#	Description
1	Continue monitoring of nesting beaches throughout the calendar year. Nesting trends will only be determined after five to six years of continued monitoring. To improve coverage and efficiency of beach monitoring efforts across the lagoon's 92 islands, the use of Unmanned Aerial Vehicles (UAVs) to capture data and Artificial Intelligence (AI) to process imagery should be trialed in monitoring activities.
2	Ensure ongoing monitoring of Phase 1 assets that are coming online through 2025. Data collected on turtle behavior and nesting activity and success/failure should be collated and distributed to key stakeholders to inform development of later phases of the development.
3	Develop plans to inventory and protect nesting beaches, foraging areas, and inter-nesting/migratory habitat. The well-reasoned Australian Marine Turtle Recovery Plan 2017-2027 suggests that protecting a minimum of 70% of habitat is essential for marine turtle survival, but it cautions that this might not lead to population recovery. Analysis should be conducted to determine percentage loss at the end of Phase 1 and identify sites that warrant protection throughout the lagoon to meet this objective.
4	Ensure lighting design strategies are developed from the start of the project design process.
5	Where artificial beaches are created, these should be designed to mimic the physical characteristics and vegetation community structure on islands in the lagoon that support successful turtle nesting.

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