भारतीय वन्यजीव संस्थान
Wildlife Institute of India

POPULATION STATUS OF DUGONGS IN TAMIL NADU

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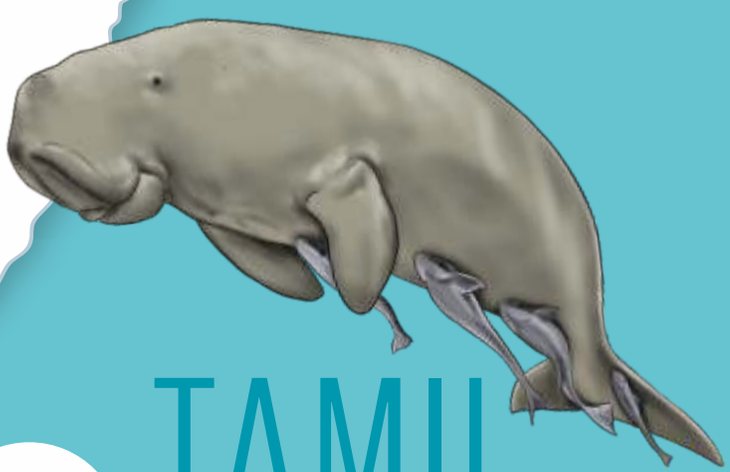

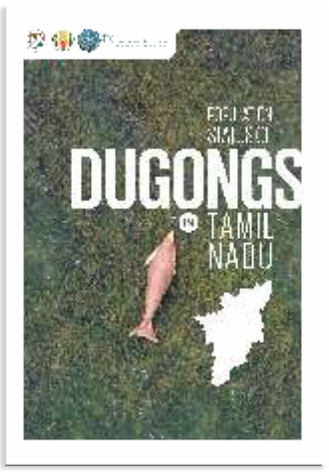

Population Assessment report submitted to Tamil Nadu Forest Department

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FOREWORD

Along the quiet, shallow waters of Tamil Nadu's coast lives one of India's most elusive marine mammals-the dugong. Sightings are rare, populations are small, and every individual matters. Understanding how many remain, where they occur, and how they use coastal habitats is therefore not just a scientific exercise, but a responsibility toward a species that has shared these waters with coastal communities for generations.

This technical report regarding Population Status of Dugongs in Tamil Nadu, represents an important step in that direction. Conducted by the Wildlife Institute of India (WII), the study presents a carefully designed population estimation of dugongs in Tamil Nadu using non-invasive, state-of-the-art tools, like drones. These methods allowed researchers to observe dugongs in their natural habitats with minimal disturbance, overcoming long-standing challenges associated with turbid waters, limited visibility, and the species' cryptic behaviour.

The Government of Tamil Nadu has demonstrated proactive leadership in dugong conservation through landmark initiatives such as the notification of India's first Dugong Conservation Reserve and the formal recognition and felicitation of dugong rescuers, reinforcing the vital role of coastal communities in species recovery and stewardship.

What makes this work especially valuable is not only the population estimates it provides, but the confidence and clarity it brings to future conservation planning. Dugongs are closely tied to seagrass ecosystems-habitats that support fisheries, coastal livelihoods, and blue carbon storage. By strengthening our understanding of dugong presence and distribution, this study also reinforces the need to protect and restore these fragile seascapes.

The dedication and technical rigor demonstrated by the WII research team are evident throughout this report. Their work lays a strong scientific foundation for long-term monitoring, informed decision-making, and adaptive management of dugong habitats in Tamil Nadu. It is my hope that the findings and recommendations presented here will be widely used-by policymakers, managers, researchers, and communities alike-to ensure that dugongs continue to remain a living part of Tamil Nadu's coastal heritage.

Supriya Sahu, IAS
Additional Chief Secretary to Government,
Environment, Climate Change & Forests Department
Secretariat,Tamil Nadu

FOREWORD

The conservation of dugongs along the Tamil Nadu coast represents one of the most challenging and meaningful commitments undertaken by the Forest Department-protecting a rare marine mammal while balancing ecological integrity, livelihoods, and coastal use. Dugongs are indicators of healthy seagrass ecosystems, and their continued presence reflects the effectiveness of science-based management and sustained field-level conservation action. Protecting this species is not only about safeguarding a marine mammal, but about caring for an entire coastal ecosystem and the communities that depend on it. For the Forest Department, this responsibility carries both urgency and humility.

The Population Status of Dugongs in Tamil Nadu report presents the results of a population estimation study conducted entirely by the Wildlife Institute of India (WII), with support from the Tamil Nadu Forest Department. The Forest Department's role has been to facilitate and enable this work-through field coordination, logistical assistance, and alignment with ongoing conservation initiatives-so that robust scientific assessments could be carried out effectively along Tamil Nadu's extensive coastline.

The study's use of drones and underwater camera systems reflects a progressive and responsible approach to monitoring an elusive marine mammal. These non-invasive methods allowed the WII research team to observe dugongs in their natural environment with minimal disturbance, while overcoming long-standing challenges posed by poor visibility and the species' cryptic behaviour.

The Forest Department remains committed to creating an enabling environment for such science-led conservation efforts. Initiatives such as the establishment of the Dugong Conservation Reserve, habitat-focused management interventions, and collaborative field actions reflect a growing shift toward inclusive, ecosystem-based conservation. These efforts underscore the belief that marine conservation is most effective when science, management, and local knowledge come together.

The collaboration with WII has been particularly valuable in ensuring that scientific findings are directly relevant to management and policy. The insights and recommendations presented in this report will support habitat protection, guide future monitoring, and strengthen long-term conservation planning for dugongs in Tamil Nadu.

I commend the Wildlife Institute of India team for their dedication and technical rigour, and I acknowledge the support provided by Forest Department officers and frontline staff. It is my hope that this report will serve as a strong foundation for continued collaboration and sustained action to ensure that dugongs remain a living part of Tamil Nadu's coastal heritage.

Thiru. Rakesh Kumar Dogra, IFS
Principal Chief Conservator of Forests &
Chief Wildlife Warden, Tamil Nadu

FOREWORD

Effective conservation of dugongs depends on one essential requirement: sound, long-term scientific evidence. For a species that is naturally rare, slow to reproduce, and difficult to detect, population assessment is not a one-time exercise but a continuing process that must be sustained over years. This technical report contributes meaningfully to that process by strengthening our understanding of dugong presence and distribution along the Tamil Nadu coast.

Population Status of Dugongs in Tamil Nadu report has been carried out by the Wildlife Institute of India, using carefully designed survey protocols and modern, non-invasive tools. These methods allowed our research team to overcome long-standing limitations associated with conventional surveys in shallow and turbid coastal waters, while ensuring that observations were made with minimal disturbance to dugongs and their habitats.

For WII, this effort is part of a long-standing and deeply held commitment to dugong conservation. Over the years, the Institute has steadily invested in building scientific knowledge, refining monitoring techniques, and strengthening national capacity for marine mammal research. This report provides a strong scientific baseline-one that will allow future assessments to track change, measure the effectiveness of conservation actions, and guide adaptive management.

The study was made possible through the support of the Tamil Nadu Forest Department, whose cooperation and facilitation enabled fieldwork across a wide and logistically complex coastline. Such collaboration between research institutions and management authorities remains central to ensuring that scientific outputs are relevant, usable, and responsive to conservation needs.

Looking ahead, the findings presented in this report reinforce the need for continued and systematic monitoring of dugongs. The Wildlife Institute of India remains committed to carrying this work forward-strengthening long-term monitoring frameworks, supporting state-led conservation efforts, and ensuring that dugong management in India continues to be guided by robust scientific evidence.

I acknowledge the dedication and perseverance of our research team in undertaking this demanding fieldwork, and I trust that this report will serve as a valuable reference for managers, researchers, and policymakers working toward the long-term conservation of dugongs.

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CONTENT

01

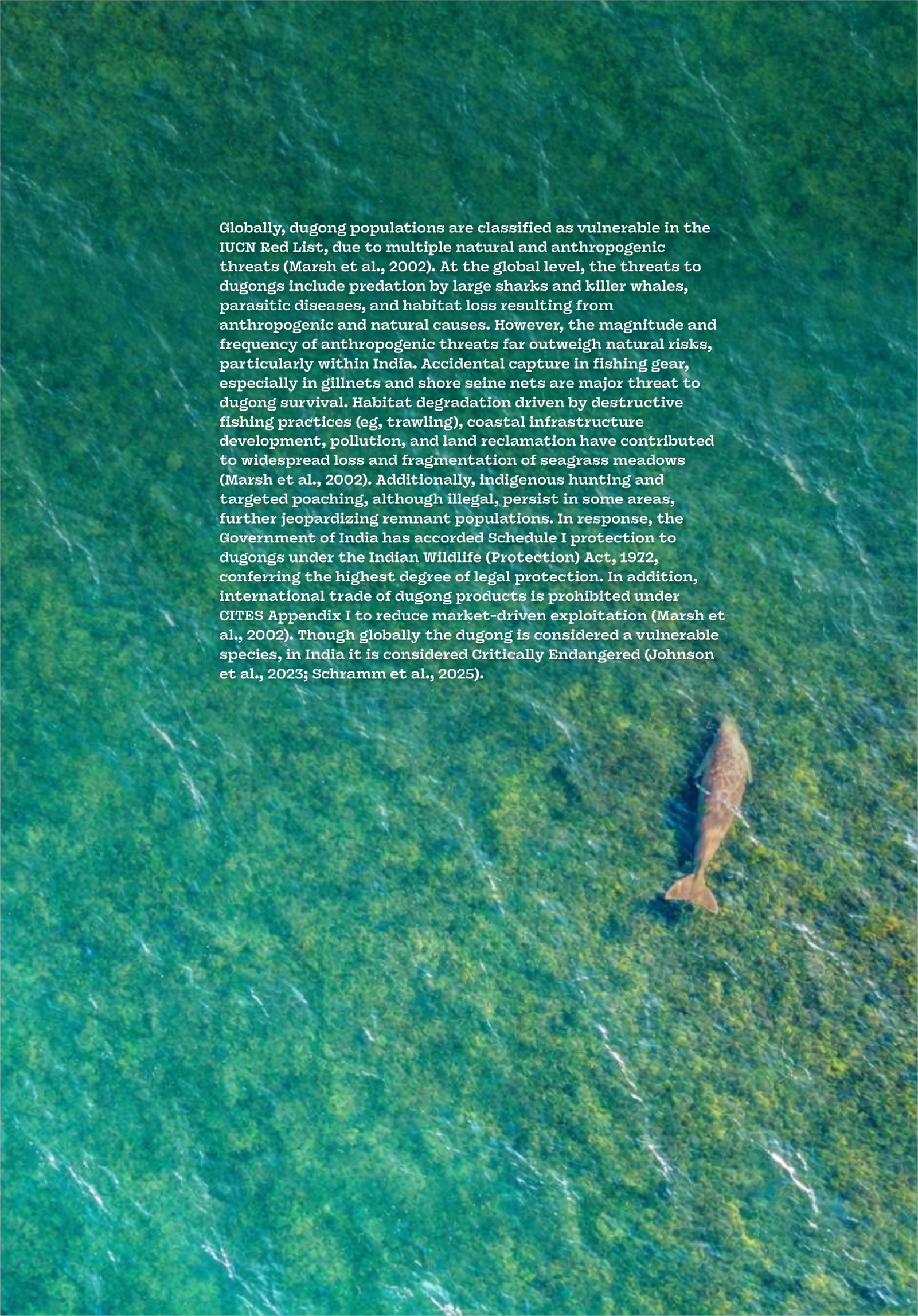
INTRODUCTION

The Dugong (*Dugong dugon* Müller, 1776), commonly known as the sea cow, is the only extant member of the family Dugongidae and one of the four living species within the order Sirenia. It is unique among Indian marine mammals as the only obligate herbivorous species adapted entirely to marine environments. Its closest living aquatic relatives are the three manatee species, which belong to the family Trichechidae, which inhabit the shallow, marshy coastal areas and freshwater rivers of the Caribbean Sea, the Gulf of Mexico, the Amazon basin, and West Africa (Heinsohn et al., 1977; Marsh et al., 2002; Sivakumar & Nair, 2010). Phylogenetic analyses have revealed that the Sirenia's nearest extant terrestrial relatives are proboscideans (elephants), which also explains several anatomical similarities and evolutionary adaptations observed between dugongs and elephants (Berta et al., 2006). Fossils of four more ancient species of Dugongidae were found in India, of which Ashokia antiqua were the oldest dugongs that occurred 42 million years ago, leading to a speculation that the dugongs might have originated from India.

Members of the order Sirenia are recognized for their robust bodies, ventrally directed mouth gapes, and distinctively rounded, paddle-like forelimbs. They possess dorso-ventrally flattened tail flukes, which aid in aquatic locomotion. Unlike other marine mammals, sirenians are specialized primary consumers, relying almost exclusively on seagrasses and marine algae (Berta et al., 2015). Dugongs are further distinguished from manatees by their exclusively marine distribution, triangular dolphin-like tail fluke, and the presence of tusks, modified incisors that emerge in mature males and some older females. Their head is characterized by a pronounced, downward-facing snout, an adaptation for bottom-feeding on seagrass meadows (Berta et al., 2015). In contrast, manatees display a more rounded, paddle-shaped tail and have a broader tolerance for freshwater environments (Reynolds & Odell, 1991).

The dugong's habitat preferences are strongly associated with calm, sheltered, and nutrient-rich coastal waters, typically bays, shallow island areas, and reef systems shielded from heavy wave action. Such environments are ideal for the growth of extensive seagrass meadows - an ideal feeding ground for dugongs (Heinsohn et al., 1977; Marsh et al., 2002). Owing to their obligate dependence on seagrass meadows, dugongs act as ecological sentinels of coastal marine ecosystem health. Their grazing activity influences seagrass community structure, productivity, and nutrient cycling, making them a keystone species of seagrass habitats (Marsh et al., 2002). However, the degradation of seagrass meadows due to both natural and anthropogenic disturbances directly translate to reduced dugong populations, highlighting the interconnectedness of dugong survival and seagrass conservation.

The global distribution of dugongs encompasses warm coastal waters, including the northern and eastern coasts of Africa, the Red Sea, the Persian Gulf, the coasts of Australia, Sri Lanka, India, Indonesia, and various Pacific islands (Marsh et al., 2002). In India, distribution of dugongs is patchy, with major concentrations in wide, shallow, and sheltered waters, such as the Gulf of Mannar and Palk Bay regions in Tamil Nadu, the Gulf of Kutch region of Gujarat and the Andaman and Nicobar group of Islands. These areas coincide with the quality of seagrass meadows, which are essential for dugong foraging (Kannan et al., 1999; Marsh et al., 2002; Jones, 1967). Historically, dugongs were also recorded in the Lakshadweep islands; however, they are now locally extinct in the Lakshadweep islands (Husar, 1975).



Globally, dugong populations are classified as vulnerable in the IUCN Red List, due to multiple natural and anthropogenic threats (Marsh et al., 2002). At the global level, the threats to dugongs include predation by large sharks and killer whales, parasitic diseases, and habitat loss resulting from anthropogenic and natural causes. However, the magnitude and frequency of anthropogenic threats far outweigh natural risks, particularly within India. Accidental capture in fishing gear, especially in gillnets and shore seine nets are major threat to dugong survival. Habitat degradation driven by destructive fishing practices (eg, trawling), coastal infrastructure development, pollution, and land reclamation have contributed to widespread loss and fragmentation of seagrass meadows (Marsh et al., 2002). Additionally, indigenous hunting and targeted poaching, although illegal, persist in some areas, further jeopardizing remnant populations. In response, the Government of India has accorded Schedule I protection to dugongs under the Indian Wildlife (Protection) Act, 1972, conferring the highest degree of legal protection. In addition, international trade of dugong products is prohibited under CITES Appendix I to reduce market-driven exploitation (Marsh et al., 2002). Though globally the dugong is considered a vulnerable species, in India it is considered Critically Endangered (Johnson et al., 2023; Schramm et al., 2025).

02

DUGONG CONSERVATION INITIATIVES IN TAMIL NADU

2.1 Research on Dugongs and their habitats

Research on dugongs in Tamil Nadu has been extensive and the presence of dugongs in the Gulf of Mannar and Palk Bay region was systematically reported by James (1967) and Lal Mohan (1976). The earlier studies on dugongs also flagged emerging pressures such as illegal hunting, incidental catches in fishing operations, the spread of mechanized trawling, and the destruction of vital seagrass habitats that highlighted subsequent population collapses. Silas and Fernando (1985) were among the first to highlight that without immediate and coordinated conservation action, including community engagement and international cooperation, the dugong may face local extinction. Followed by Badrudeen et al. (2004), who documented various stranding and incidental catch records happened between 1994 and 2000 in the Tamil Nadu coasts.

Building on this historical foundation, community-based research became an increasingly important part of dugong conservation in Tamil Nadu. Ilangakoon et al. (2008) pioneered structured interviews with fishers along the Tamil Nadu coast and in the Gulf of Mannar region. These interviews revealed a long-standing culture of hunting, high mortality rates due to gillnets and destructive fishing practices, and the persistence of threats even after legal protections were implemented. The study also identified ongoing habitat loss, not only from direct human exploitation but also from infrastructure projects such as the establishment of fishing ports, extension of shipping ports and more intensified fishing methods, which fragmented seagrass meadows and increased vessel traffic in dugong habitats. Recent studies focussed on dugong distribution and threat factors in the Gulf of Mannar and Palk Bay region have also reflected similar trends (Sivakumar & Nair, 2013; Anand et al., 2015). Despite being protected under the Indian Wildlife (Protection) Act 1972, dugongs remained at risk due to poor enforcement and ongoing human pressures in dugong habitats (Silas & Fernando, 1985; Ilangakoon et al., 2008; Anand et al., 2015).

2.2 Implementation of CAMPA-Dugong Recovery Programme

In this background, the Dugong Recovery Programme with the financial support of the MoEFCC CAMPA funding, was launched in 2016. One of the deliverables of the project is to identify and protect the critical dugong habitats in the Palk Bay and the Gulf of Mannar region. As part of the research programme, recent advances in research have included the spatial analyses and habitat modelling for predicting critical dugong habitats. The intensive work of the Wildlife Institute of India in collaboration with the Tamil Nadu Forest Department between 2017 and 2019 resulted in the spatial prioritization of dugong critical habitats, which was developed for Indian waters with special focus on Tamil Nadu coasts (Johnson et al., 2013; Seal et al., 2023). This finding emphasized that less than 15% of high-risk dugong habitats currently fall within protected areas, revealing a major gap in effective conservation coverage. This work has played a crucial role in informing recent policy actions, such as the declaration of the Dugong

Conservation Reserve in Palk Bay, which covers 448 km² of core dugong habitat and represents a significant step towards protecting the remaining populations. In addition, a number of community outreach activities and capacity building programmes for different stakeholders were conducted in Palk Bay and the Gulf of Mannar region under the Dugong Recovery Programme.

Despite these advances, dugongs in Tamil Nadu continue to face significant threats largely due to the fisheries interface. Incidental net entanglement of dugongs remains a primary cause of mortality. The ongoing loss and fragmentation of seagrass meadows further jeopardize both dugongs and the broader marine ecosystem. While policy responses such as protected area expansion, stricter law enforcement, and habitat restoration are positive steps, continued scientific research, regular monitoring, and community-based management remain critical for dugong survival in the region. In response, the Tamil Nadu Government proactively implemented several conservation initiatives, including seagrass restoration, training for frontline staff and community outreach activities in collaboration with the Wildlife Institute of India and other local stakeholders.

The *Global Assessment of Dugong Status and Conservation Needs* (Marsh & Schramm, 2024) had identified the Palk Bay-Gulf of Mannar region of Tamil Nadu as the most important habitat for seagrasses and dugongs in South Asia, emphasizing its designation as an Important *Marine Mammal Area* (IMMA). Over the last decade, Tamil Nadu has become a focal point for dugong research and recovery actions in India. The Government of Tamil Nadu has established the country's First Dugong Conservation Reserve in Palk Bay and proposed an International Dugong Conservation Centre at Manora, Thanjavur, with a scientifically prepared Management Plan. The report highlights the urgent need for targeted research to develop reliable population estimates and address major threats such as entanglement in fishing nets, habitat degradation, pollution, and climate-related seagrass loss (Marsh et al., 2025).

03

STATUS OF DUGONG POPULATION IN TAMIL NADU

3.1 Dugong Population Assessment based on Fisherfolk interview

Understanding the population size in a particular area is a primary step towards strategizing an effective management plan. In the past, dugong populations were assessed based on a combination of boat-based surveys, a citizen science approach and fisherfolk interviews. Since dugongs are a very elusive animal with very short surfacing time, the traditional boat survey method has limited success in dugong population estimation. Conservationists often use citizen science data and fisherfolk information to estimate the dugong population size (Sivakumar & Nair, 2013).

Contemporary research in Tamil Nadu's Palk Bay and Gulf of Mannar has shifted toward systematic, community-inclusive methodologies to generate more robust and current population estimates. Between the years 2007 and 2009, an extensive interview-based survey across 90 coastal villages in Tamil Nadu was carried out, and the findings indicated that dugongs are now primarily distributed from Dhanuskodi to Idinthakarai in the Gulf of Mannar and from Dhanushkodi to Adirampattinam in Palk Bay. The likely maximum population was estimated at only 78 individuals in the Gulf of Mannar region and 80 individuals in the Palk Bay region, underscoring the small, fragmented, and highly vulnerable status of these populations (Sivakumar & Nair, 2013; Anand et al., 2015).

Sivakumar & Nair (2013) also provided a comprehensive assessment of dugong distribution, threats, and conservation priorities across India, with a major focus on Tamil Nadu. Using field surveys, interviews, and spatial data, the study found that dugong occupancy was highest in the Gulf of Mannar and Palk Bay, followed by the Andaman & Nicobar Islands, and lowest in the Gulf of Kutch. It revealed an alarming >85% contraction in the species distribution range nationally, with Tamil Nadu as the primary refuge. Critical Dugong Habitats were identified as a part of this report. Threats were identified, including loss and degradation of seagrass habitats, gillnet entanglement, poaching, and pollution. The report stressed that dugongs are also found outside protected areas, necessitating community-based management and "Dugong-friendly" fisheries. The study directly informed the government's Species Recovery Plan for dugongs, highlighting the urgent need for preventive measures and habitat conservation strategies.

3.2 Dugong population assessment through Aerial survey

Aerial surveys have become the standard scientific approach for estimating dugong abundance, distribution, and population monitoring across the world, as other methods have several shortcomings (Hodgson et al., 2013). The principal advantage of aerial surveys is their ability to detect animals effectively, cover vast areas rapidly and cost-effectively, thereby reducing the manpower and time required compared to boat-based surveys (Marsh, 1995; Miller et al., 1998). Dugongs are relatively accessible for aerial detection, as they inhabit shallow coastal waters and typically surface every two to three minutes for breathing, in contrast to other deeper-diving marine

mammals. This surfacing behaviour, coupled with their preference for clear and shallow sub-tidal waters, makes dugongs well-suited for detection from both manned and Unmanned Aerial Vehicles (UAVs). Strip transect methods, in which a drone/observer records all dugongs within a fixed-width transect along predetermined flight paths, are widely used for population estimation (Lanyon & Marsh, 1995).

3.2.1. Pilot Drone Surveys

In India, the systematic application of Unmanned Aerial Vehicles (UAVs) and high-resolution aerial imaging for dugong surveys remains largely unexplored. First pilot testing of aerial survey for detecting dugong and other marine megafauna was carried out by Wildlife Institute of India in Andaman Nicobar Islands (Rajpurkar et al., 2021), and the study recommended that light-weight UAVs can be effectively used to detect and estimate the population of a wide range of marine species, including dugongs. Subsequently, pilot drone surveys were also carried out in the Dugong Conservation Reserve of Tamil Nadu between 2021 and 2023 to develop and standardize an aerial monitoring protocol for dugong populations. We conducted a total of 56 aerial transects at 14 locations across the Dugong Conservation Reserve spaced 2 km apart from each other, which encompasses key seagrass habitats critical for dugong survival (Fig. 1). These surveys employed UAVs equipped with high-resolution Hasselblad cameras, systematically flying over both shallow coastal waters and slightly deeper seagrass beds to maximize detection probability.

The methodology was designed to test and refine essential survey parameters, including flight altitudes, transect spacing, and image resolution, optimal for the field conditions in Tamil Nadu. The pilot surveys were effective, with seven dugong sightings recorded during the study period (2021 - 2023). Each sighting was confirmed by cross-referencing aerial imagery with manual verification by two observers. The UAVs not only facilitated the detection of dugongs but also minimized the disturbance to the animals and their habitats. The successful detection of dugongs during these pilot surveys highlighted the utility and feasibility of UAVs for marine mammal monitoring in Tamil Nadu. Based on these surveys, the length of the aerial transects was standardised to 3 km, but it should depend on the drone specifications, battery life and other factors. The altitude of the drone, the camera angle and speed were similarly standardized for maximum effectiveness.

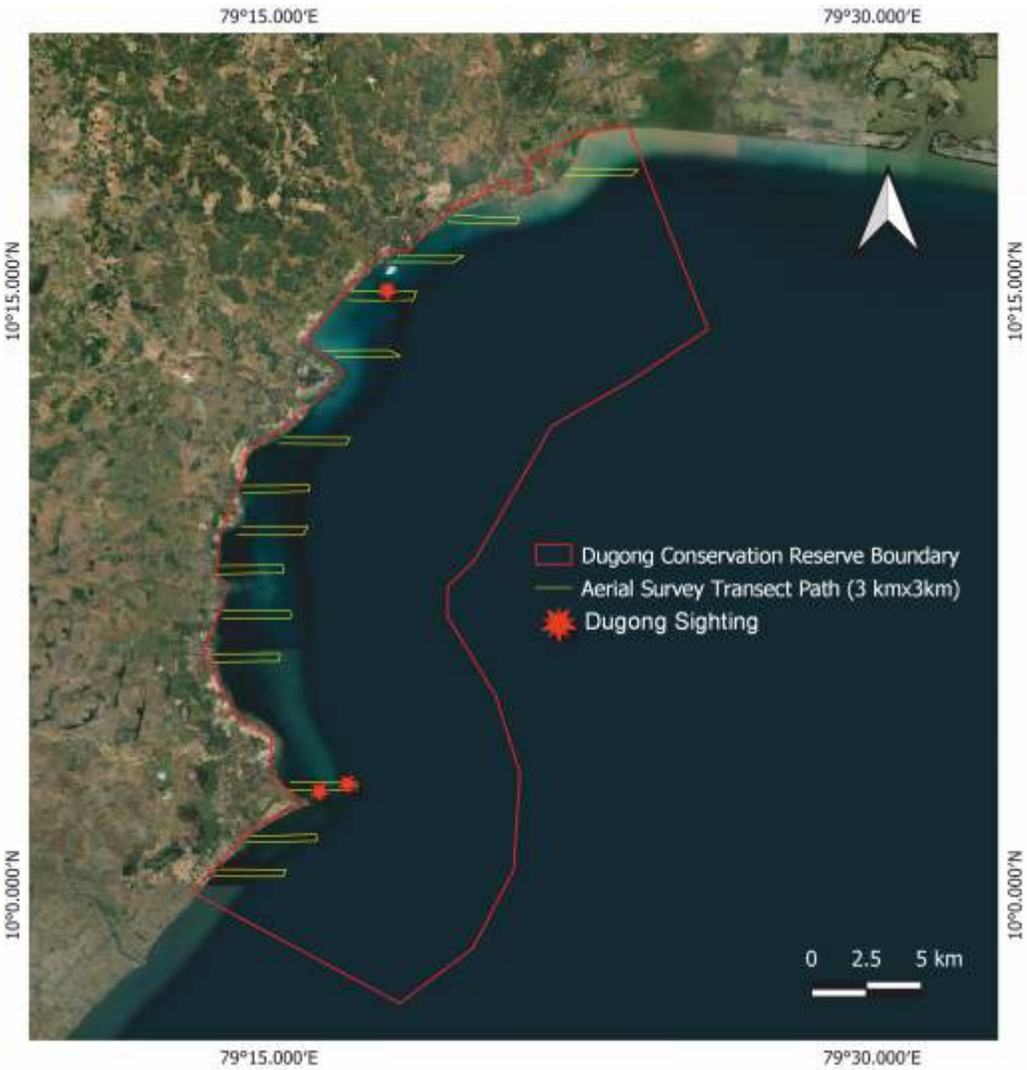


Figure 1. Aerial transects established in the Dugong Conservation Reserve during pilot testing of aerial survey.

3.2.2. Aerial survey training to Frontline Forest Staff

Subsequent to the pilot testing, realizing the potential of drone surveys in population monitoring and estimation, a large-scale synchronized survey was visualized. In order to execute the synchronized drone survey in Tamil Nadu, a series of hands-on training to frontline staff were conducted from August 2024 to March 2025 (Table 1). These hands-on drone training programmes were conducted specifically for the frontline staff of the Thanjavur, Pudukkottai and Ramanathapuram Forest Divisions in the Gulf of Mannar and Palk Bay regions (Fig. 2).

Table 1. Number of Drone training programs conducted for forest staff of the Gulf of Mannar and Palk Bay region, Tamil Nadu

Division	Period of Training	Participants	Number of staff trained
Thanjavur Forest Division	3rd August 2024 22nd January 2025	Forest Rangers & Frontline staff	30
Pudukkottai Forest Division	7th August 2024 23rd January 2025	Forest Rangers & Frontline staff	28
Ramanathapuram Forest Division	9th August 2024 7th March 2025	Forest Rangers & Frontline staff	28

Figure 2.
Glimpses of aerial survey training conducted for the frontline staff of the Gulf of Mannar and Palk Bay regions

04

METHODOLOGY ADOPTED FOR DUGONG POPULATION ESTIMATION USING DRONES

Based on the experience learned over the period, a synchronized drone survey was adopted for the estimation of dugong abundance. This method is a robust and systematic design to enhance the efficiency and precision of aerial detection of dugongs. In this synchronized survey method, we have operated three drones flying simultaneously in a fixed flight path and covered six transects at each session. This significantly increased the spatial coverage and efficient data acquisition rates. Survey locations were systematically spaced 4 kilometres apart across key seagrass habitats. At each location, two separate flights were executed, with each flight covering a 3-kilometre transect. Transects at each site were spaced 300 meters apart to maximize the likelihood of detection and to minimize overlap in coverage (Fig. 3). The entire flight planning and execution process was automated by the Litchi Hub application, which enabled precise coordination and repeatability of drone operations. The width of each transect was 130 meters (65 m on each side) throughout the survey.

The methodology strictly adhered to fixed-width transect sampling, in alignment with the standardized protocols recommended by Raoult et al. (2020) for sirenian surveys. Drones were flown at constant altitude and speed, maintaining a consistent strip width, with camera angles oriented vertically downwards to optimize detection of dugongs and minimize oblique distortion. Continuous video recording was performed on each transect, with footage systematically archived to external hard drives for subsequent, detailed analysis. This approach allowed for comprehensive post-survey analysis and verification by trained observers, supporting rigorous documentation of dugong sightings.

Local weather and environmental parameters were carefully controlled to ensure optimal survey conditions and data quality. Surveys were conducted only when sun glare affected less than 50% of the survey area and when sea state was between 0 and 4 on the Beaufort scale, thereby reducing the impact of surface reflections and water

turbulence on image clarity. Furthermore, flights were scheduled during morning hours (7:00-9:00 am) to maintain consistent ambient lighting and minimize the effects of environmental variability. This meticulous approach to survey design and execution enabled the collection of high-resolution, scientifically robust data, facilitating accurate assessment of dugong presence and habitat use in accordance with global best practices for sirenian research.

Trained Forest Department frontline staff accompanied the survey team to get accustomed to aerial survey protocols. This synchronized survey effort avoids sampling bias and the chance of re-sighting of the same individual in other transects.

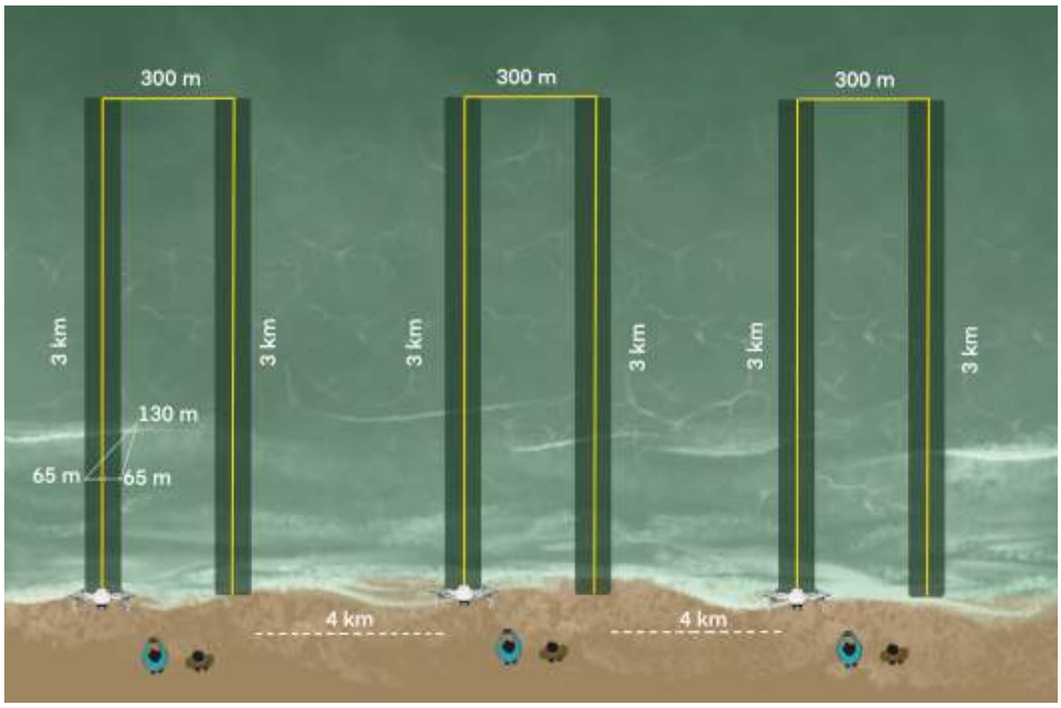


Figure 3.
Illustration of Drone Survey Protocol adopted for synchronized aerial survey with 3 drones flying simultaneously to estimate Dugong population.

4.1 Factoring dugong surface availability bias in the aerial survey

Across several decades of dugong research, surface availability has been quantified using different methods ranging from early visual assumptions to advanced dive-recording telemetry. Marsh & Sinclair (1989) provided the original basis for availability correction in aerial surveys, drawing on limited time-at-surface information to propose a broad correction range for perception and availability bias. Later, Marsh et al. (2011) synthesised regional datasets and dive observations from Australia and Southeast Asia, confirming that dugongs typically spend less than half of their time visible near the surface. Studies based on tagging and time-depth recorders (e.g., Preen, 2001) showed that dugongs frequently remain submerged while foraging on seagrass, producing more refined estimates of time-at-surface (around 0.40-0.55) and highlighting variation among habitats and behaviours.

Recent UAV-focussed work by Hodgson et al. (2013) introduced a standardized surface-availability assumption of 0.5, derived specifically for drone imagery and accounting for the improved overhead viewing angle and reduced perception bias relative to crewed aircraft. Although all previous studies collectively demonstrate the importance of correcting for undetected submerged individuals, the Hodgson et al. (2013) framework is currently the most appropriate for drone-based dugong surveys because it directly addresses visibility from UAV platforms and offers a practical, evidence-based correction factor for modern aerial monitoring. Further, this adjustment doubled the original detection count during the aerial survey, assuming that only 50% of the dugongs present on the surface were available to be seen during the aerial or surface-based survey.

05

SYNCHRONIZED DUGONG POPULATION ESTIMATION

5.1 Drone surveys in Palk Bay

Palk Bay is a semi-enclosed shallow water body situated between the southeast coast of India and Sri Lanka. It extends from Point Calimere in the north to Ramanathapuram in the south, covering a coastline of approximately 250 km (Kumaraguru et al., 2008). It is located between latitudes 9° 55'N - 10° 45' N and longitudes 78° 58' E - 79° 55' E. The width of the bay varies between 64 and 137 km, with an average depth of about 9 meters. Palk Bay covers a total of three districts of Tamil Nadu, namely Thanjavur, Pudukkottai and Ramanathapuram. Palk Bay experiences both the Southwest and Northeast monsoons, contributing to an annual rainfall of 762 mm to 1270 mm, and exhibits temperature fluctuations between 25°C and 31°C (Sivakumar, 2015). A total of 50 aerial transects were carried out in Palk Bay, including 18 in Dugong Conservation Reserve (Fig. 4).

5.2 Drone survey in the Gulf of Mannar region

The Gulf of Mannar, located south of Palk Bay, is India's first Marine Biosphere Reserve, established in 1989 (Azeez, 2016). It extends from Dhanuskodi to Kanyakumari, covering an area of approximately 10,500 km2 and comprising 21 islands with extensive coral reefs and seagrass meadows (Kumaraguru et al., 2006). The Gulf is characterized by high biodiversity, supporting over 3,600 species of flora and fauna, including 11 species of mangroves, 17 mangrove associates, and 196 species of flowering plants (Thangaradjou & Bhatt, 2018). The Ramanathapuram district (till Vembar) was systematically surveyed in the effort of 46 aerial transects at 23 locations spaced 4 kms apart from each other (Fig. 7).

06

DUGONG STATUS IN TAMIL NADU

Continuous videos recorded during the synchronized survey, and the data were analysed by experienced dual observers trained with dugong aerial transect datasets. The georeferenced locations of each dugong sighting were recorded and mapped in GIS. The number of detections obtained were used for calculating dugong density, and the obtained density score was extrapolated to the seagrass cover available in the respective sampling area.

6.1 Dugong population in Palk Bay region

In Palk Bay, a total of 50 transects, each measuring 3 km in length and 0.130 km in width, were laid across 25 sites (Fig. 4). Area surveyed in 1 strip transect is 0.39 (3 km x 0.13 km), therefore, the total area surveyed is 19.50 sq. km (0.39 sq. km transact x 50 transacts) across 150 km of transects (3 km × 50 transects). We encountered 4 individuals of dugongs in Palk Bay during this survey, including a calf and mother (Fig. 5 & 6). Based on the detection probability correction, the count was considered as 8, assuming 50% of the dugongs present on the surface were available for detection.

The dugong density was calculated by dividing the number of detections corrected by availability bias (n) by the total area surveyed (Hodgson et al., 2013). Thus, the dugong density obtained for the Palk Bay region is 0.41/ sq. km (8 individuals/ 19.5 sq. km). Further, the density of dugongs arrived in Palk Bay was extrapolated with the available seagrass cover in the Palk Bay (Table 2).

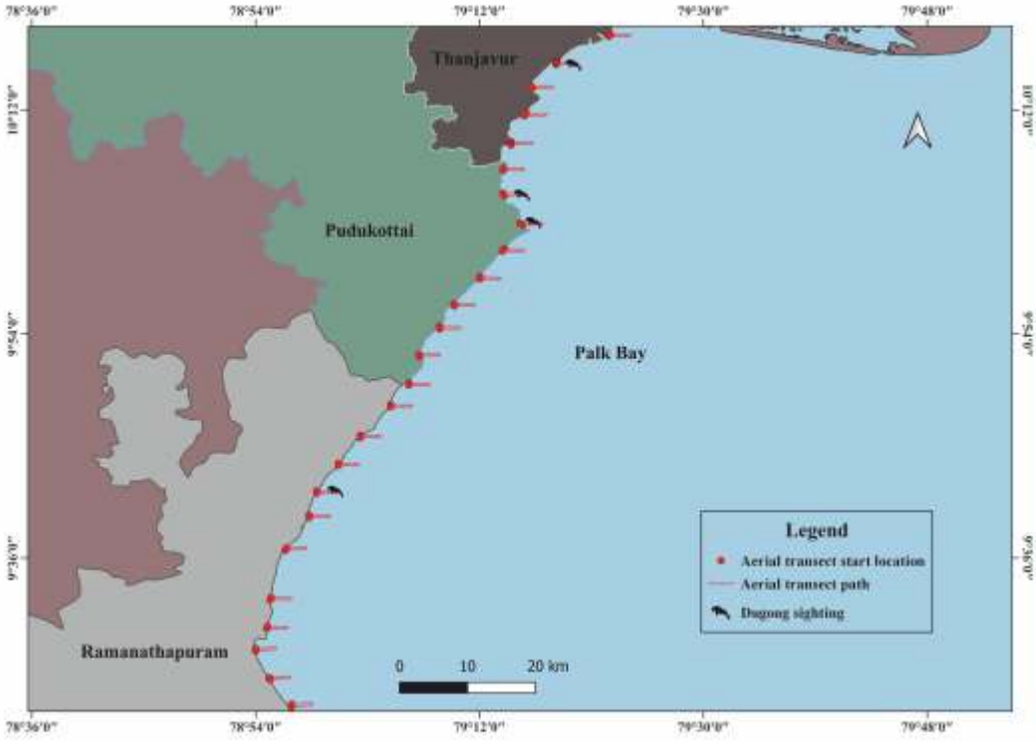


Figure 4.
Map showing aerial transect used during the synchronized survey and location of dugong detections in Palk Bay region, Tamil Nadu.

Figure 5.
Footage of dugong detection in some of the aerial transects in the Palk Bay region, as shown in figure A, B.

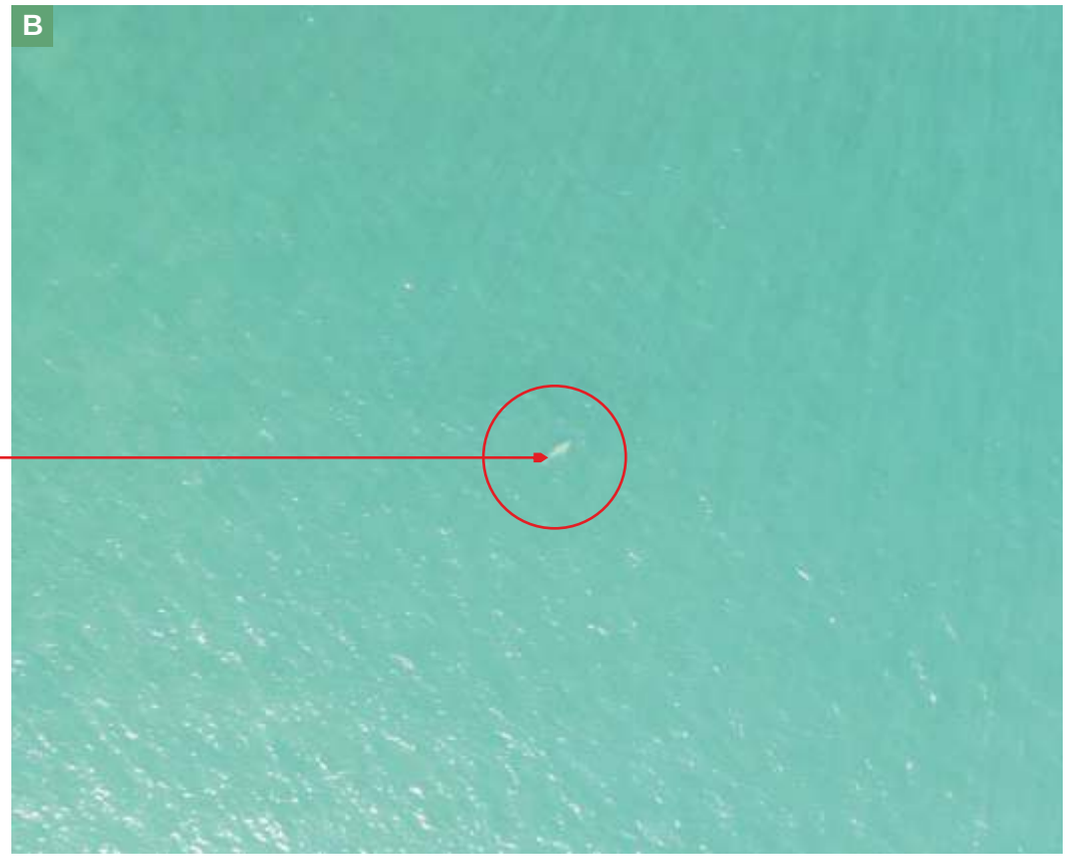
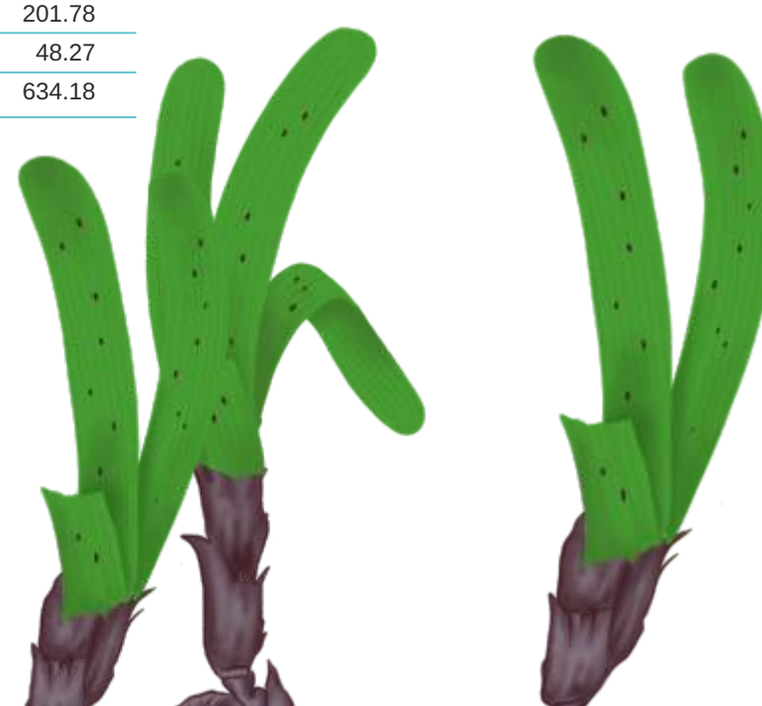


Figure 6.
Dugong mother and calf recorded during a systematic survey off the coast of Sethubavachattram village, Palk Bay.

Table 2. Total estimated seagrass cover in Palk Bay and Gulf of Mannar regions according to Seal et. al. (2023).

Region	District	Area (km^2)
Palk Bay	Thanjavur	33.54
	Pudukottai	82.13
	Ramanathapuram	268.46
Gulf of Mannar	Ramanathapuram	201.78
	Thoothukkudi	48.27
	Total	634.18

According to Seal et al. (2023), the total seagrass cover in Palk Bay is approximately 385 km^2. Thus, extrapolating the observed density (0.41/ sq. km) and standard error (0.033) to this entire seagrass area yields an estimated dugong population size of 158 ± 13 individuals in the Palk Bay region (Table 3).



Dugong population in Dugong Conservation Reserve

Aerial surveys in the Dugong Conservation Reserve were conducted on two occasions between 2023 and 2025. A total of 28 strip transects were surveyed in 2023 and 18 in 2025. Each transect measured 3 km in length and 0.13 km in width, and transects were distributed across 14 sites in 2023 and 9 sites in 2025. The area covered by a single strip transect was 0.39 km² (3 km × 0.13 km), resulting in a total surveyed area of 10.92 km² in 2023 and 7.02 km² in 2025.

During the survey efforts, two dugongs were detected in 2023 and three in 2025. Dugong density was estimated by dividing the number of detections corrected for availability bias (n) by the total area surveyed (Hodgson et al., 2013). Based on this method, the corrected number of dugongs was four individuals in 2023 and six individuals in 2025, yielding an average dugong density of 0.6 individuals per km² within the Dugong Conservation Reserve.

Dugong density was further extrapolated using the estimated extent of seagrass habitat. According to the Environment, Climate Change and Forest Department G.O. (Ms). No. 165 (2022), the total seagrass cover within the Dugong Conservation Reserve is approximately 122.5 km² (12,250 hectares). Extrapolation of the observed mean density (0.6 individuals per km²) and its standard error (± 0.054) across this seagrass area resulted in an estimated dugong population size of 74 ± 6 individuals within the Dugong Conservation Reserve.

74±6 ESTIMATED POPULATION

6.2 Dugong population in the Gulf of Mannar region

In Gulf of Mannar, a total of 46 transects, each measuring 3 km in length and 0.130 km in width, were laid across 23 sites (Fig. 7). Therefore, a total of 17.94 sq. km area (0.39 sq. km transact x 46 transacts) and along 138 km transects (3 km × 46 transects) were surveyed in Gulf of Mannar for estimating the dugong population. We encountered 5 individual dugongs during this survey. Footage of dugong detection in the aerial transect in the Gulf of Mannar is given in Figure 8. Based on the detection probability correction, the count was considered as 10, assuming 50% of the dugongs present on the surface were available for detection.

The dugong density was calculated by dividing the number of detections corrected by availability bias (n) by the total area surveyed (Hodgson et al., 2013). Thus, the dugong density obtained for the Gulf of Mannar region is 0.56/ sq. km (10 individuals/ 17.94 sq. km). Further, the density of dugongs arrived in the Gulf of Mannar was extrapolated with available seagrass cover in the Palk Bay (Table 2). According to Seal et al. (2023), the total seagrass cover in the Gulf of Mannar region is approximately 201 km². Thus, extrapolating the observed density (0.56/ sq. km) and standard error (0.033) to this entire seagrass area yields an estimated dugong population size of 112 ± 9 individuals in the Gulf of Mannar region (Table 3).

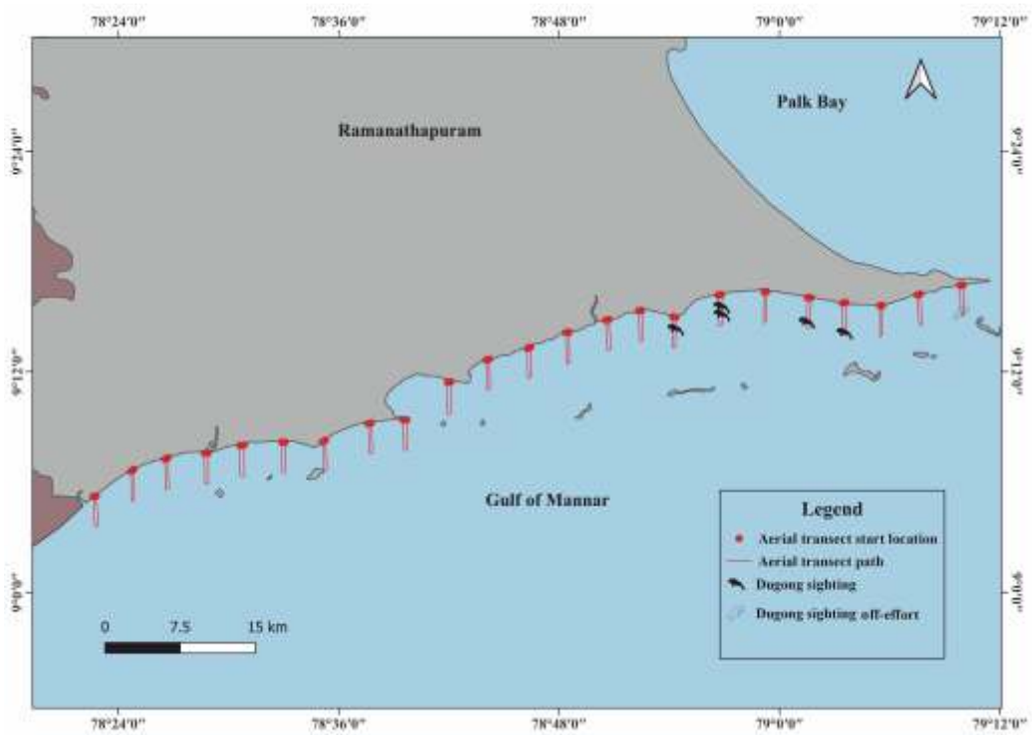


Figure 7.
Map showing aerial transects used during the synchronized survey and location of dugong detections in the Gulf of Mannar region, Tamil Nadu.

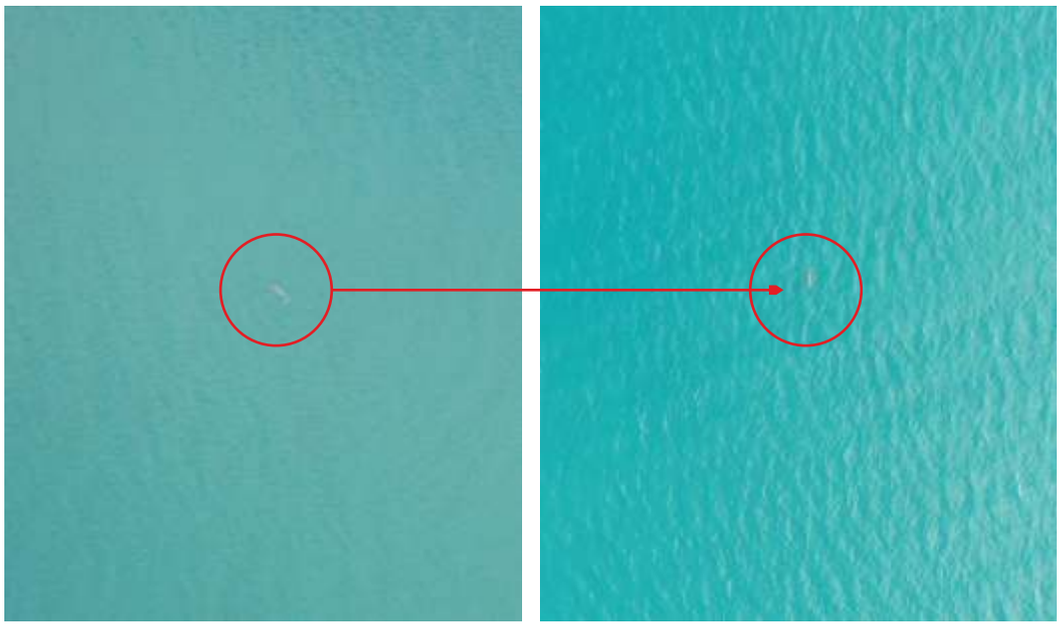


Figure 8.
Footage of dugong detection in some of the aerial transects in the Gulf of Mannar region

Based on the synchronized population estimation exercise carried out between March and April 2025 at Palk Bay and Gulf of Mannar dugong population is estimated as 270 ± 16 individuals, which is higher than the earlier estimate done based on the interview-based survey conducted in 2012 and 2013. The earlier estimated dugong population in Palk Bay and the Gulf of Mannar region was about 175 individuals (Sivakumar & Nair, 2013; Anand et al., 2015). However, the present dugong numbers (270 ± 16 individuals) derived based on aerial survey detection indicates dugong population in Palk Bay and the Gulf of Mannar region is doing well, and these areas remain the stronghold of the dugong population in India. This is mainly due to proactive dugong conservation measures implemented by the Tamil Nadu Forest Department with the support of the CAMPA Dugong Recovery Programme of MoEFCC. The details of dugong numbers derived based on the aerial detections at Palk Bay and the Gulf of Mannar region are summarized in Table 3 and infographic Figure 9.

Table 3. Summary of survey details and dugong population estimate achieved through aerial surveys in Palk Bay and the Gulf of Mannar region, Tamil Nadu.

Survey Area	Gulf of Mannar	Palk Bay
Total No. of Survey Locations	23	25
Total No. of Aerial Transects	46	50
Width of Survey Strip (km)	0.130	0.130
Length of Aerial Transect (km)	3	3
Distance Between Survey Points (km)	4	4
Area Surveyed per Strip (sq. km)	0.390	0.390
Total Area Surveyed (sq. km)	17.94	19.50
Total Survey Effort (km)	138	150
No. of Dugongs Sighted	5	4
Estimated Density (dugong/km²)	0.5574	0.410
Estimated Abundance	**112 ± 9**	**158 ± 13**
Total dugong population in Tamil Nadu	**270 ± 16**	


Thanjavur
Tamil Nadu
Pudukkottai
Palk Bay
Ramanathapuram
Gulf of Mannar

Figure 9.
The infographic information on the Dugong population estimates in Tamil Nadu coasts.

Legend

Acrial transect location

Dugong sighting locations

POPULATION STATUS OF DUGONGS IN TAMIL NADU

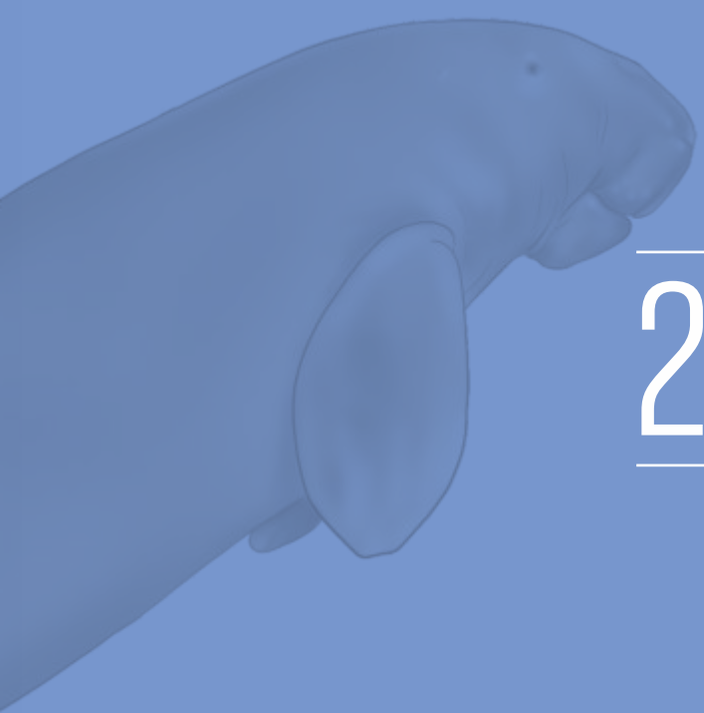
96 AERIAL TRANSECTS

37.44 SQ. KM AREA SURVEYED

288 SQ. KM SURVEY EFFORT

9 DUGONGS SIGHTED

270±16 ESTIMATED POPULATION



Surveys were conducted across 48 locations using 96 aerial transects, covering 37.44 sq. km with a total flight effort of 288 km. A total of 9 dugongs were sighted on effort. These observations yielded an overall abundance estimate of 270±16 dugongs for Tamil Nadu.

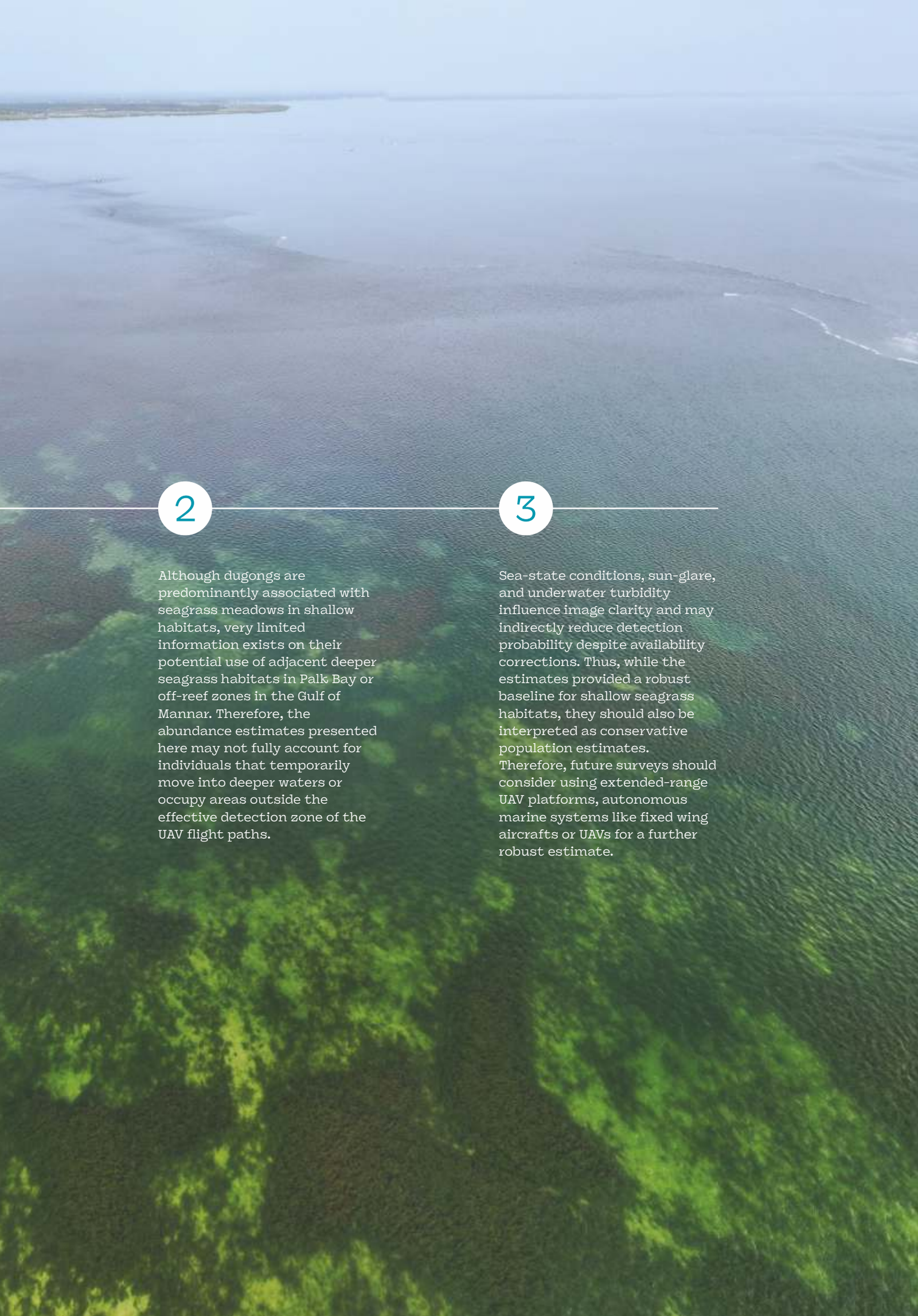
07

LIMITATIONS

While this study represents a significant advancement in dugong population assessment, it also has some methodological limitations as listed below:

1

The present UAV-based surveys were restricted to a fixed transect length of approximately 3 km, determined by drone endurance, battery life and operational safety requirements in coastal conditions. Consequently, the survey effort was primarily concentrated within shallow seagrass-dominated coastal waters where dugongs are known to occur, and areas located farther offshore or in deeper waters could not be systematically surveyed, due to limitations of flight duration and battery life.



2

Although dugongs are predominantly associated with seagrass meadows in shallow habitats, very limited information exists on their potential use of adjacent deeper seagrass habitats in Palk Bay or off-reef zones in the Gulf of Mannar. Therefore, the abundance estimates presented here may not fully account for individuals that temporarily move into deeper waters or occupy areas outside the effective detection zone of the UAV flight paths.

3

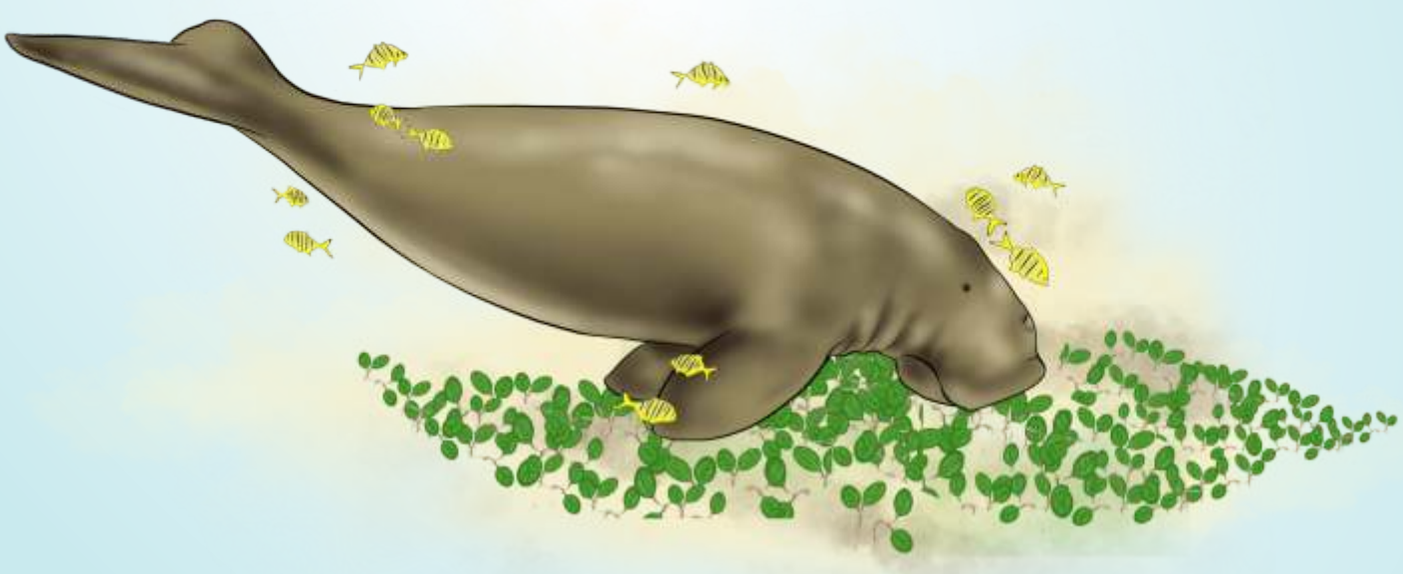
Sea-state conditions, sun-glare, and underwater turbidity influence image clarity and may indirectly reduce detection probability despite availability corrections. Thus, while the estimates provided a robust baseline for shallow seagrass habitats, they should also be interpreted as conservative population estimates. Therefore, future surveys should consider using extended-range UAV platforms, autonomous marine systems like fixed wing aircrafts or UAVs for a further robust estimate.

08

CONCLUSIONS

The present study provides the first systematic, UAV-based population estimate for dugongs in Tamil Nadu, covering the Palk Bay, including the Dugong Conservation Reserve and the seagrass habitats of the Gulf of Mannar region. The application of standardized fixed-width strip transects, synchronized drone deployments, and availability-bias correction produced reliable density and abundance estimates comparable with international best practices. The result indicates an estimated dugong population size of 74±6 individuals in Dugong Conservation Reserve, 158 ± 13 individuals in the entire Palk Bay region and 112 ± 9 individuals in the Gulf of Mannar region, extrapolated specifically to mapped seagrass habitats, yielding a combined population of 270 ± 16 individuals in Tamil Nadu coasts. This study confirms that Palk Bay and the Gulf of Mannar together represent the largest remaining viable dugong population of India. This population recovery is mainly due to the implementation of the Dugong Recovery Programme through CAMPA funding support and the Tamil Nadu Forest Department's proactive involvement in Dugong Conservation in the Palk Bay and Gulf of Mannar Region.

The confirmed presence of a mother-calf pair provides preliminary evidence of breeding and adding significance conservation value to these habitats. At the same time, the prevailing fishing pressure on dugong habitats, this species remains Critically Endangered within Indian waters and highly susceptible to stochastic mortality events, with fisheries interface and seagrass loss continuing to be the most immediate threats. Thus, continuous community engagement towards dugong conservation is essential. In addition to biological inference, this work successfully standardizes a UAV-based dugong survey protocol for India, demonstrating feasibility, repeatability, and practical utility for long-term monitoring of Dugongs and other marine megafauna in the country.



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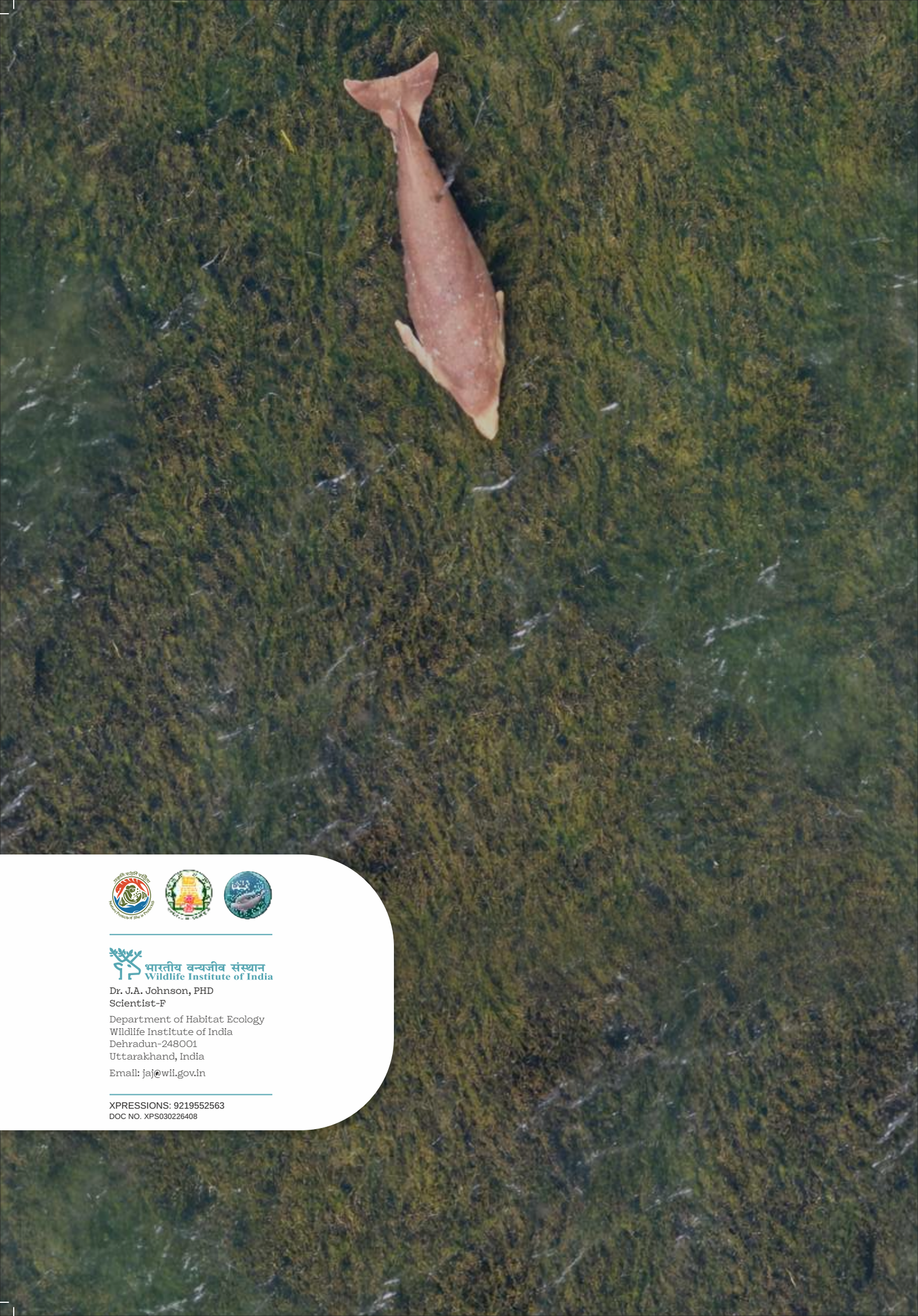

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