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Herd Size Dynamics and Observations on the Natural History of Dugongs (*Dugong dugon*) in the Andaman Islands, India

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Abstract

In the last four decades, dugong (*Dugong dugon*) aggregations have been rarely reported from the geographically isolated, vast seascape of the Andaman Islands, India. The Indian Ocean tsunami of 2004, hunting, coastal development, and habitat loss are the major causes of this change in the social system of dugongs in the Andaman Islands. Our long-term monitoring study (2017 to 2022) reveals a changing trend in aggregating behaviour of dugongs. In an inclusive, collaborative effort, we engaged multiple stakeholders using two approaches: (1) creating a spatially spread citizen science network targeting sea-faring agencies—the fishers, forest department, SCUBA divers, and defence bodies (Indian Navy and Indian Coast Guard); and (2) conducting standardized questionnaire surveys (UNEP/CMS) with fishers. Our approach yielded reports of 63 herd sightings of dugongs from the Andaman archipelago. The fishers reported 73.01% of the sightings, followed by the defence bodies (20.63%), forest department (3.18%), and SCUBA divers (3.18%). Smaller herds in our study comprised three to six individuals, with a social structure of "adults only" and "adult–calf." The larger herds of seven to 13 individuals included an "adult–calf" combination with a greater number of adults accompanying two to three calves. More than 95% of these herd occurrences were reported from sheltered, coastal waters with resource concentrations (large seagrass meadows). Further, we present novel dugong occurrence reports from data-deficient regions like the Jarawa Tribal Reserve and the North Sentinel Island, along with dugong occurrences from Little Andaman, where the population was speculated to be locally extinct after the 2004 tsunami. These findings strongly advocate the involvement of multiple stakeholders as a cost-effective approach to monitoring the distribution and population of dugongs in larger seascapes like the Andaman and Nicobar Islands. Moreover, such an approach would be critical for sensitizing the local stakeholders regarding the conservation and management of large marine mammals such as dugongs.

Key Words: sirenians, dugongs, *Dugong dugon*, citizen science, anecdotal, seagrasses, bycatch, aquatic mammals

Introduction

Dugongs (*Dugong dugon*, Müller) are an elusive marine mammal species with a wide distribution range in Indo-Pacific tropical waters, spanning 39 countries (Marsh et al., 2011). Global decline in dugong populations, mostly due to bycatch, boat collision, hunting (indigenous/illegal), and habitat loss (Marsh et al., 2011; Hines, 2012), demands strong national/transnational legislative measures for conserving the remnant dugong population across its distribution range. In India, dugongs receive the highest legal protection under Schedule-I of the Indian Wildlife (Protection) Act of 1972, which prohibits their hunting and trade by law. Historically in India, dugongs occurred along the peninsular coastline's west and east coasts, except on the north-eastern coast (Hines, 2012). However, synchronous with worldwide threats, most of the local dugong populations were extirpated, restricting their present distribution to three locations. Two distribution sites are along the mainland Indian coast: (1) the Gulf of Kutch on the west coast (Arabian Sea) and (2) the Gulf of Mannar and Palk Bay on the east coast (Bay of Bengal). The third location is the Andaman and Nicobar Islands, where an insular population was reported (Mani, 1960; Lal Mohan, 1963; Das & Dey, 1999).

Between the mid-19th and the late 20th century, information on dugongs in India primarily relies on anecdotal reports by voyagers and on reports of stranded/dead dugongs in local newspaper

articles (Blyth, 1859; Kloss, 1902; Miller, 1902; Annandale, 1905; Prater, 1928; Pocock, 1940; Moses, 1942; Ellerman & Morrison-Scott, 1951). In a few instances, the species was misidentified as seals or as "fish resembling man caught" from the west coast of India (Silas, 1961, p. 264; see also Blyth, 1859; Mani, 1960). Gradually, research focused on the distribution, status, and *ex-situ* behaviour of dugongs (Jones, 1959, 1967, 1977, 1980, 1981; Mani, 1960; Silas, 1961; Lal Mohan, 1963; P. James, 1974; Nair et al., 1975; D. James, 1985; Silas & Fernando, 1985). However, these reports were mostly restricted to the mainland Indian coast, with the rarity of dugong occurrence reported from the insular waters of the Andaman and Nicobar Islands (henceforth, ANI), India.

Captain Niblett of the steamer *Sydney* first reported dugong occurrence in the Andaman Islands in 1859 after he retrieved the lower jaw and bones of a subadult dugong from a hut of the indigenous tribe (Blyth, 1859). These specimens were exhibited in the Asiatic Society of Bengal in 1859 and later mentioned in the *Proceedings of the U.S. National Museum* (Miller, 1902). In the last two decades of the 20th century, a few sporadic reports documented dugong strandings from the ANI (Jones, 1980; Rao, 1990; Bhaskar & Rao, 1992). Pan-archipelago-wide systematic studies by Das (1996) and Das & Dey (1999) offered a critical understanding of dugongs and seagrass distribution in the ANI.

A recent five-decadal (1959 to 2008) examination of dugongs highlighted accidental net entanglements and hunting as significant threats to dugongs in the ANI, concurrent with the global scenario (D'Souza et al., 2010). Additionally, the 2004 Indian Ocean tsunami further critically impacted seagrasses, the only foraging grounds of dugongs (Thangaradjou et al., 2010), thus affecting their distribution range in the islands. A few post-tsunami studies highlighted sporadic dugong occurrence, *in-situ* behavioural observations, occupancy trends, habitat-use patterns, their ecological role, and threats in the ANI (D'Souza & Patankar, 2009; D'Souza et al., 2013, 2015; Sivakumar & Nair, 2013; Malakar et al., 2015; Sivakumar et al., 2021). These earlier studies broadly focused on understanding the dugong population, distribution, and habitats and were primarily based on sporadic records of dugong occurrences and limited underwater observations in the ANI.

The geographical vastness of the ANI, low population size, and the elusive nature of dugongs limit the probability of direct encounters through systematic surveys (D'Souza et al., 2013). The inaccessibility of sites to researchers (e.g., remoteness, entry-prohibited tribal areas) has rendered many regions within the archipelago data deficient in terms of dugong distribution (D'Souza et al., 2015). In a spatially vast seascape like the ANI, considering the limitations of conducting boat-based field surveys (i.e., limited funds, manpower, logistics), anecdotes from multi-stakeholder seafarers represent a cost-effective method to fill the existing data gaps in dugong research (Pardalou & Tsikliras, 2018). In this context, we created a marine citizen science network and interacted with the local fisher communities with two primary objectives: (1) to understand dugong occurrence hotspots, especially from data-deficient regions; and (2) to prioritize dugong research and conservation areas in the ANI. Herein, we present the effectiveness of anecdotal records received through a citizen science platform in understanding the herd size dynamics of dugongs in the Andaman Islands, India. We also report first-time records of dugong occurrences from data-deficient sites within the Andaman Islands with rare natural history observations on the potential sexual phase of dugong from India. The networking of multiple stakeholders provided us with a cost-effective approach to understanding the distribution, herd size dynamics, and rare natural history observations of dugongs in a larger seascape in the Andaman Islands, India.

Methods

Study Site

The ANI (6° 45' to 13° 41' N, 92° 12' to 93° 57' E) is a geographically isolated chain of 836 islands/rocky outcrops/islets situated in the Bay of Bengal, India. The total geographical area of the ANI is 8,249 km^2, which is further broadly divided into two island groups: (1) the Andaman archipelago (77.68% of the total geographical area) and (2) the Nicobar archipelago (22.32%), separated by the 10° channel (www.andaman.gov.in). The tropical islands of the ANI receive very high rainfall from the southwest (June to September) and the northeast (October to January) monsoon winds. Due to geographic isolation, the ANI supports high-value ecosystems like corals, mangroves, mudflats, intertidal regions, and seagrasses primarily preserved in pristine conditions. Of these, the seagrass meadows represent the only foraging area for mega-herbivores like dugongs.

The present study site was the Andaman archipelago, which comprises > 800 islands/rocky outcrops/islets of the ANI, of which 24 are inhabited. Four of the six indigenous groups of the ANI (Jarawas, Onges, Sentinelese, and Great Andamanese) inhabit the Andaman archipelago, along with immigrant "settler" communities from mainland India. The Andaman archipelago is divided into (1) the North and Middle Andaman

district and (2) the South Andaman district (www.andaman.gov.in; Figure 1). Further, to the east of South Andaman lies a cluster of 13 islands called Ritchie's archipelago, and 30 nmi to the south is Little Andaman; both are administratively part of the South Andaman district (Figure 1).

Approach

We collated dugong occurrence data from 2017 to 2022 via two approaches: (1) citizen science initiative targeting sea-faring stakeholders and (2) community interactions with local fishers through standardized questionnaire surveys (UNEP/CMS, 2010). We engaged potential sea-faring stakeholders such as local fishing communities, defence agencies (i.e., the Indian Navy and Coast Guard), forest department (frontline staff), and SCUBA divers. We encouraged the informants to report opportunistic sightings of dugongs and to photo-document them for verifiable evidence (whenever possible). Sightings were shared through social media apps (WhatsApp), personal meetings, or monthly follow-up phone calls. The resultant data were compiled as a database on dugong sightings and further used in the mapping platform *QGIS* to generate dugong distribution maps. The sighting records were segregated based on the number of individuals sighted at each instance. This article focuses only on the herd size of dugongs (minimum no. of individuals = 3); hence, sightings with a single animal or a pair were removed from the analysis.

Results

We obtained 63 herd sighting records from the Andaman archipelago from stakeholders. The fishers provided 73.01% of herd occurrence records, followed by the defence bodies (20.63%), forest department (3.18%), and SCUBA divers (3.18%). Sightings were spread across the North and Middle Andaman, South Andaman, Little Andaman, and Ritchie's archipelago (Figure 1). Herd size

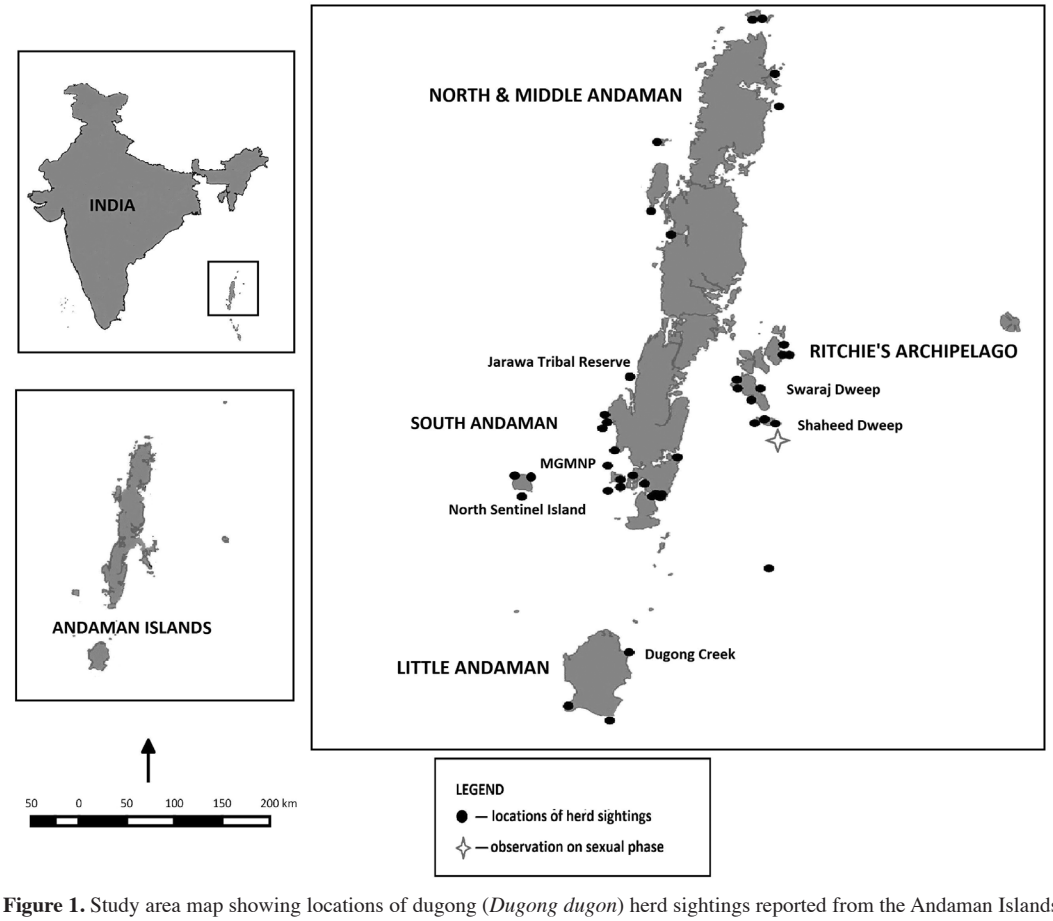

Figure 1. Study area map showing locations of dugong (*Dugong dugon*) herd sightings reported from the Andaman Islands from 2017 to 2022

ranged from a minimum of three to a maximum of 13 individuals. Small herds of three to six individuals were more frequently reported than large herds of eight to 13 individuals (Figure 2a). We categorized the social structure of herds as "adult–calf" and "only adults." Smaller herds represented both categories, and these groups were reported moving in shallow coastal waters (Figures 2b & 3a). However, in three instances, a herd of an adult dugong with two calves was reported.

The structure of large herds (8 to 13 individuals) involved only the first category: "adult–calf" (Figure 2b). Large herds comprised either a mother–calf group (herd of eight individuals: four adults and four calves) or a greater number of adults accompanying two to three calves. In such large herds, adults always occupied the group's periphery, with calves positioned at the center (Fishers, pers. comm., 23 January 2020). Calves remained closer to their mothers (< 1 to 2 m) when in herds with only mother–calf pairs (Figure 3b). Although > 95% of total sightings were from nearshore, shallow waters (~2 m water depth), one herd was sighted 40 km offshore in South Andaman (report by the Indian Coast Guard). In this report, a herd of 13 individuals, including three calves, was moving at the surface in a close-knit group (water depth ~100 m).

In the ANI, the local narratives from senior fishers implied that past occurrences of dugong herds (~15 to 20 individuals; 40 to 50 y ago) are uncommon at present. The previous extensive survey across the ANI that documented sightings of 15 individuals over 7 y (2007 to 2013) is also indicative of the sharp population decline in dugong numbers in the ANI (D'Souza et al., 2015). Similarly, > 40% of surveyed fishers perceived a decrease in the dugong population in the ANI in the past two decades. The primary cause for the decline in dugong numbers was attributed to the Indian Ocean tsunami in 2004, followed by accidental net entanglement, hunting, boat traffic, and a decline in foraging grounds (Figure 4).

Anecdotes shared by Dr. Himansu Das (pers. comm., 14 April 2022), who carried out extensive dugong and seagrass meadow surveys in the ANI (1994 to1997), also suggest that dugong herds (~10 individuals) were commonly observed in the 1990s in the shallow water of Ritchie's archipelago and in Dugong Creek, Little Andaman. Secondary information received on Onge dugong hunting practices also indicated that dugong herds were common in the Dugong Creek, Little Andaman, where Onges—an aboriginal community—have traditionally hunted dugongs at dusk with their canoes and spears (resource person from Andaman Adim Janjati Vikas Samiti [AAJVS], pers. comm., 6 March 2022). The dugong population at this site sharply declined following the 2004 Indian Ocean tsunami (resource person from AAJVS, pers. comm., 6 March 2022), after which dugongs in Little Andaman were speculated to be "locally extinct" (D'Souza et al., 2013). Elevated sedimentation rates and debris depositions on the seafloor post-tsunami led to massive loss of seagrass meadows in the Dugong Creek, Little Andaman, which affected the dugong population (resource person from AAJVS, pers. comm., 2 February 2022 & 6 March 2022). However, we have received recent (2019 to 2021) anecdotal records of dugong occurrence from Little Andaman, including from Dugong Creek (Figure 1). Because of this, our focused surveys provided the first photographic evidence and confirmed dugong presence from the southern coast (South Bay) of Little Andaman (Figure 3c).

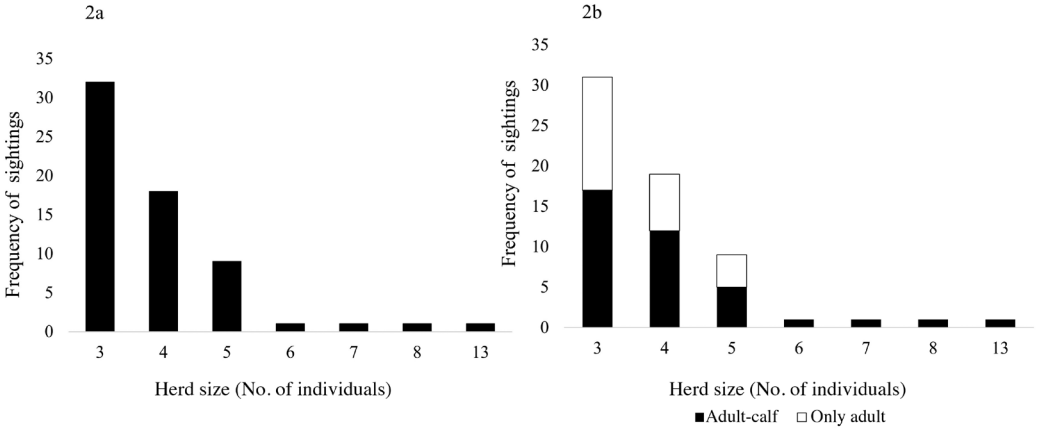

Figure 2. (a) Herd size-specific frequency of sightings reported in the present study, and (b) social structure of dugong herds

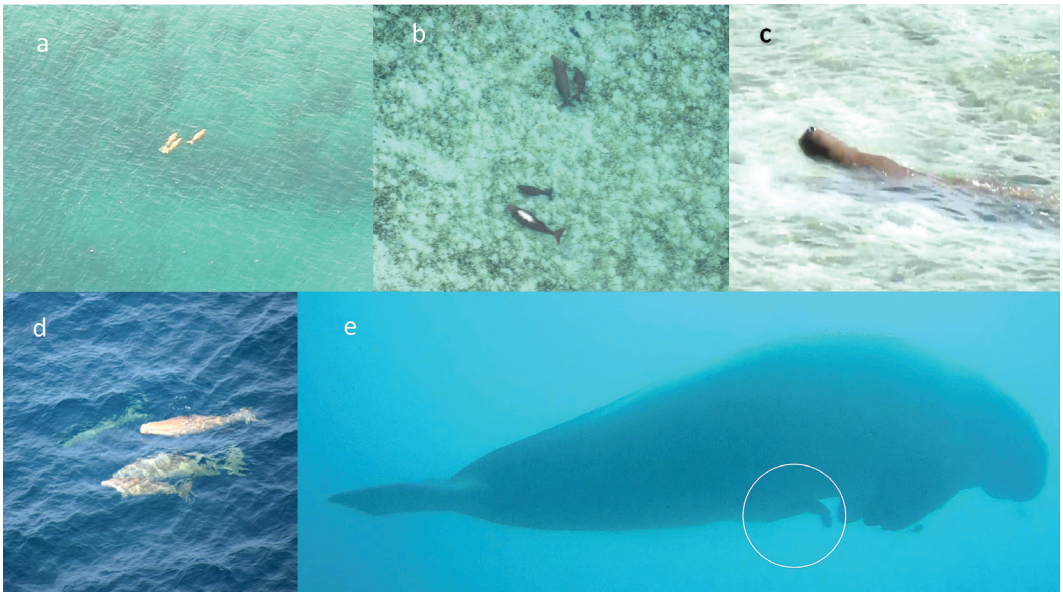

Figure 3. (a) A herd of three dugong individuals reported from the Jarawa Tribal Reserve (*Photo credit:* Indian Navy); (b) a herd of two mother and calf pairs reported from the Jarawa Tribal Reserve (*Photo credit:* Indian Coast Guard); (c) direct encounter of a dugong adult from Lighthouse (South Bay), Little Andaman (*Photo credit:* Sumit Prajapati); (d) a herd of four individuals in a close-knit movement reported from South Andaman (*Photo credit:* Indian Coast Guard); and (e) potential sexual phase of a male adult dugong with a visible erect male reproductive organ (in white circle) reported from Shaheed Dweep, Ritchie's archipelago (*Photo credit:* Adventure SCUBA).

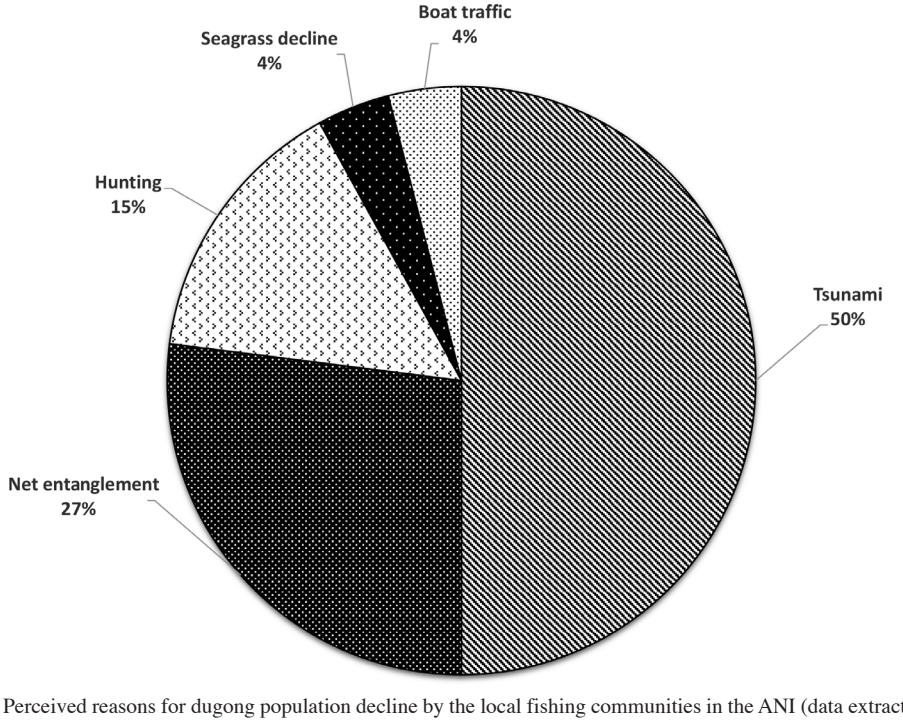

Figure 4. Perceived reasons for dugong population decline by the local fishing communities in the ANI (data extracted from UNEP/CMS, 2010, questionnaire survey conducted by the Wildlife Institute of India in the ANI)

In addition to herd sightings, we also received reports of new dugong distributional records from tribal protected areas, such as the Jarawa Tribal Reserve (JTR; $n = 7$) and North Sentinel Island ($n = 3$), from the Middle and South Andaman (photo-documented reports from Indian Navy and Indian Coast Guard during aerial sorties; Figures 1, 3a, & 3d). Lastly, we received a report of rare anecdotal evidence, provided by a SCUBA diver informant, on the potential sexual phase of a male adult dugong from Shaheed Dweep, Ritchie's archipelago (Figure 3e). A 1-min video from December 2019 showed a ~2.5-m-long male adult with an erect penis protruding from its body. The individual was observed passively swimming in the shallow waters of Shaheed Dweep. Although a one-time observation, it is notable that this is the first documentation of a potential sexual phase of dugong from Indian waters.

Discussion

Primary understanding of dugong aggregation behaviour is dominantly reported from regions with large dugong populations, such as Australia, Arabian Gulf waters, Africa, and Southeast Asia, that are aided by advanced survey techniques (e.g., aerial surveys) (Preen, 2004; Garrigue et al., 2008; Findlay et al., 2011; Ichikawa et al., 2012; Ponnampalam et al., 2015; Dunshea et al., 2020). However, information on dugong herds from low-population regions like Indian coastal waters is almost unavailable. An earlier study speculated that the social system of dugong occurrence in herds had broken down in the ANI owing to multiple pressures that induced population decline and loss of habitat (D'Souza et al., 2015). Further, small dugong herds (5 to 7 individuals) were much more common historically (30 y ago); however, dugong sightings in recent years were restricted to solitary individuals or pairs in the ANI (D'Souza et al., 2015).

Contrary to the rarity of dugong herd sightings from the ANI reported in the past, our stakeholders and citizen science findings reveal the repeated occurrence of herds from the Andaman Islands. Although dugong aggregations are non-cohesive and known to be unstable in nature (O'Shea et al., 2022), we believe that dugong herd occurrences in the present study are significant. Despite dugongs having a simplified social structure (Marsh et al., 2011), herd size dynamics are essential in studying their social behaviour (O'Shea et al., 2022). Our findings, therefore, provide valuable evidence to prospective sociality studies on the species in the Andaman Islands.

Recent seagrass exploratory surveys have confirmed seagrass presence from the locations of calf sightings in the present study (Sivakumar et al., 2021). Further, O'Shea et al. (2022) suggested that the strongest social bonds in sirenians are between a mother and nursing calves. Based on spatial distribution trends in herd sightings and the frequency of calves reported in our study (> 50% of the herds included calves), we speculate that the southwestern coast of South Andaman and pockets of Ritchie's archipelago are critical for dugongs, especially calving mothers. These sheltered waters with resource concentrations (seagrass meadows) are possibly used by dugongs primarily for calf protection. The southwestern Andaman coast is highly protected as a part of the Mahatma Gandhi Marine National Park (MGMNP), which extends north into the tribal-protected Jarawa Tribal Reserve. However, two of the islands of Ritchie's archipelago (Shaheed Dweep and Swaraj Dweep), which have a significant number of dugong herd sightings, are tourist hotspots and are exposed to coastal habitat alteration (infrastructure development) and boat traffic (inter-island shipping lanes, high-speed boats, water jet skis). We suggest that these regions with a substantial interface of human-dominated dugong habitats be of priority for their conservation value. Lastly, we do not draw any conclusive trends for herds comprised of only adults documented in the present due to a lack of behavioural data. Still, these observations will inform research studies in the future.

Studies worldwide have highlighted the role of stakeholder-targeted marine citizen science programs and the engagement of local communities in assessing species distribution and monitoring (Bruce et al., 2014; Cigliano & Kliman, 2014; Embling et al., 2015), marine litter (Hidalgo-Ruz & Theil, 2013), policymaking (Hyder et al., 2015), and delineating priority marine research and conservation areas (Hauser et al., 2006; McKelvey et al., 2008; Cigliano & Kliman, 2014; Embling et al., 2015). However, the reliability of these anecdotal observations is uncertain if not supplemented with verifiable evidence (McKelvey et al., 2008). Our study, which extensively relied on secondary observations, is complemented by photographs from the defence patrolling agencies (Indian Navy and Indian Coast Guard) and SCUBA divers. By targeting these novel agencies, our work highlights the effectiveness of an inclusive strategy to engage relevant stakeholders in citizen science initiatives. Moreover, this study provides rare dugong sightings from deficient data locations, filling research gaps on dugong distribution in the Andaman Islands. Also, as the seagrass meadows in the ANI reportedly rebound after the significant loss following the 2004 Indian Ocean tsunami, this offers optimism for dugong population recovery. Therefore, a seagrass status

assessment is strongly advocated, especially in regions historically known for dugong occurrence. Lastly, our approach of engaging people from non-scientific backgrounds to share anecdotal occurrence reports could be a significant way forward towards community-based dugong monitoring and conservation in the Andaman and Nicobar Islands.

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