Hamadryad Vol. 40 (1&2), pp. 37–49, 2023, ISSN: 2583-7818 (Online).

Interpreting sea turtle stranding with reference to the spatiotemporal analysis of hotspots along Maharashtra: implications for sea turtle conservation in Maharashtra, India

Prachi Hatkar[1*], Priyamvada Bagaria[2], Dinesh Vinherkar[3], Dhaval Kansara[3], Sagar Patel[3]

[1]Wildlife Institute of India, Dehradun Uttarakhand 248002.
[2]Ministry of Environment, Forests & Climate Change, Government of India, New Delhi-110003.
[3]*Wildlife Conservation and Animal Welfare Association* (WCAWA), Dahanu, Maharashtra 401601.
*Corresponding author: pprachi62@gmail.com

CITATION. Hatkar, P., Bagaria, P., Vinherkar, D., Kansara, D. and Patel, S. (2023) Interpreting Sea turtle stranding with reference to the spatiotemporal analysis of hotspots along Maharashtra: implications for sea turtle conservation in Maharashtra, India. *Hamadryad: 40, 37–49.*

ABSTRACT. Sea turtles are affected by various natural calamities and disasters apart from those caused by human-induced activities, including fishing operations. Stranded carcasses of marine megafauna can provide valuable information on the cause of death at sea. However, interpreting the results can be challenging because stranding probabilities are usually very low and highly variable in space and time. However, it is crucial for the management of such species. Knowledge of the spatial and temporal distribution of specific mortality sources is crucial for managing species vulnerable to human interactions. Beach cast carcasses represent an unknown fraction of at-sea mortalities. Data on stranded sea turtles were examined between 1981 and 2021 along the Maharashtra coast (N = 510) to detect spatio-temporal patterns and understand the factors that contribute to their mortality. We evaluated the distribution and magnitude of sea turtle mortality along the Maharashtra coast. These data are valuable for directing and implementing specific and local mitigation measures along the Maharashtra coast, such as avoiding bycatch hotspots through fleet communication programs or area- and season-specific closures, enforceable legislation, effective penalties, and proper waste management. This study highlights the importance of addressing these data gaps and provides a meaningful conservation tool that can be applied to stranding data on sea turtles along the Konkan coast of India.

KEYWORDS. Conservation tool, Maharashtra, management, sea turtle, strandings

Introduction

Marine turtles have been around for millions of years and have outlived dinosaurs. Being slow-growing and long-lived, turtles have played vital roles in maintaining the health of the oceans (Lovich et al. 2018). Their populations have experienced a global decline because of a history of intense commercial exploitation and harvest for eggs and meat (Tripathy and Choudhary 2007). Most of the work that has been carried out has focused on the conservation aspects of their biology and behaviour (Tripathy 2006). However, knowledge of mortality from natural events or anthropogenic threats is essential for conserving and managing marine organisms.

Five species of marine turtles are found in the Indian Ocean viz. the green turtle (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), loggerhead (*Caretta caretta*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*) (Kar and Bhaskar 1982). All are found along the Maharashtra coast (Andhare and Hatkar 2015). All sea turtle species are listed on the IUCN Red List, CMS, and the green sea turtle and hawksbill turtle are included in Appendix I under CITES. They are also protected under the Wildlife Protection Act 1972. Most research on the Olive ridley turtle in India has focused on the mass nesting populations, with little attention given to the solitary nesting populations (Phillott and Rees 2018; Ortiz-Alvarez et al. 2020). Sea turtle strandings and subsequent dying provide an important opportunity to study turtle mortality and identify threats for future mitigation and conservation actions. However, identifying potential causes of mortality of stranded sea turtles can be highly challenging due to the state of carcass decomposition and the lack of clear physical evidence of the cause of mortality (Hart et al. 2006; Koch et al. 2013).

A survey along nesting beaches in 2014 indicated that hawksbill, green, and olive ridley turtles are regularly seen in nearshore waters and probably congregate in selected areas off the Sindhudurg coast during a particular time of the year (Andhare and Hatkar 2015). The nesting of green turtles is comparatively lower than that of the olive ridley in Sindhudurg. In January 2022, the Mangrove Foundation recorded three green turtle nests at Devbaug — Tarkarli beach, Wayangani, and Wayari in Sindhudurg. Local fishermen reported sighting several young hawksbill turtles during the monsoon season in the Devgad area (Andhare and Hatkar 2015).

When marine animals unintentionally wash up on shore and are alive, the event is called beaching, (CMFRI 2014). Most sea turtle strandings are of dead animals, but live specimens can also strand. Live ones are rescued and sent back into the sea by the local forest departments along with local fishermen and organizations (Pinjarkar 2020). They usually die unless humans intervene and push them back to sea or move them to rehabilitation facilities (Jefferson et al. 2011). Morphometric records of the dead stranded turtles were not available except for a few since data is maintained by the local forest departments with necropsy reports. There is no estimated population, along Maharashtra coast that needs to be monitored for turtle abundance. It is suspected that deaths have been caused by incidental capture and drowning. The major threats to the marine turtles of Maharashtra are nest predation, plastic pollution, poaching of eggs and adults, bycatch in illegal gill nets and trawl fishing, habitat degradation and entangling in ghost nets in the offshore waters where turtles die as incidental catch (Giri and Chaturvedi 2003; Sanaye and Pawar, 2009; Andhare and Hatkar 2015). Ghost nets are those that have been discarded, abandoned, or lost in the ocean, and there are no nearby recycling facilities for nets yet (Ninaware 2021). These details are crucial for the spatial planning for biodiversity conservation and rational planning of marine ecosystems, including those for sea turtles under threat due to developmental activities. This paper represents the first published attempt to integrate data on sea turtle strandings.

Study area

Maharashtra comprises a 720 km long indented coastline, marked by significant estuaries and narrow creeks. It comprises the coastal districts of Thane, Raigad, Greater Bombay, Ratnagiri, and Sindhudurg. The main drainage in the coastal area trends in a general east-west direction and flows to the Arabian Sea in the west. Kankauli, Savantwadi, Kudal, and Vaibhavwadi talukas from Sindhudurg, and Devrukh and Chiplun talukas from Ratnagiri fall under Eco- Sensitive Zone One (Shirke and Amritkar 2012). The coastal region of Maharashtra is known as Konkan, and the Konkan belt receives 2000 to 3000 mm of rainfall annually (Kehimkar 2017). There are 15 rivers and five major creeks along the coast. All creeks and estuaries drain in an east-west direction, flowing into the Arabian Sea.

The Maharashtra coast is well known for the sporadic nesting sites of olive ridley (Giri et al. 2006). The sporadic nesters nest anywhere and anytime along the coastline (Plotkin 2007). However, it also has a few occurrences of nesting of green and hawksbill turtles (Giri and Chaturvedi 2003). More than 15 important Coastal and Marine Biodiversity Areas have

been identified in Maharashtra and included in the Coastal Regulation Zone (CRZ) -I. (Saravanan et al. 2013). The Ecologically Sensitive Zone (ESZ) refers to specific zones within the extended 'Eco-Sensitive Area' for which a particular set of regulatory or promotional activities have been proposed. Kankauli (N 16.2715, E 73.7127), Savantwadi (N 15.9114, E 73.8287), Kudal (N 15.9984, E 73.6790), and Vaibhavwadi (N 16.4981, E 73.7437) talukas from Sindhudurg, and Devrukh (N 17.0708, E 73.6211) and Chiplun (N 17.5345, E 73.5213) talukas from Ratnagiri fall under Ecological Sensitive Zone One via the Gazet of India Part II section 3 no. 3956 dated 4th October 2018 (Shirke and Amritkar 2012). Due to its high ecological importance, 29.12 square kilometres of the Sindhudurg Coastal and Marine Ecosystem (SCME) were designated as the Malvan Marine Sanctuary (M.M.S.) in 1987, and is one of 125 marine protected areas in India (Pisolkar and Chaudhary 2016).

Methodology

We compiled information on sea turtle strandings along the Maharashtra coastline from various published and unpublished sources, stranding networks, local forest departments, and newspaper reports from 1981 to 2021. We organized them into a single dataset. The relative data values presented across the timeline are dependent upon the data availability. In this study, any sea turtle found alive or dead on the beaches or floating in coastal waters was considered a stranding, except for nesting females (Foley et al. 2019). The following information was collected for each stranded turtle encountered — species, date, sex, and location (latitude and longitude). Live-stranded animals were transferred to the nearest sea turtle rehabilitation centre established by the Maharashtra Forest Department at Airoli and Dahanu. Information on the Dahanu coast was compiled and collected by the Dahanu-based non-governmental organization (N.G.O.) *Wildlife Conservation and Animal Welfare Association* (WCAWA) and the Dahanu forest department.

The data sourcing, compilation, and analysis were conducted as described below: The Sea Turtle rescue dataset was plotted in ArcMap 10.3. Grids of 10 x 10 km were generated. The rescue data points and grids were intersected to generate a count number in each grid, representing the number of rescue points in a single grid. Each grid's count of rescue points generated the sea turtle rescue heat maps. Furthermore, the stranding or rescue dataset was segregated into the pre-monsoon, monsoon, and post-monsoon seasons to represent the seasonal variation in sea turtle rescue. At the same time, the species-wise rescue maps were also generated to highlight the frequency of rescues in each species. We looked at the stranding records of sea turtles on decadal scales and visualized it on the R program using a bean plot package (Kampstra 2008).

Result

A total of 510 stranding records of sea turtles from the Maharashtra coast over the past 40 years from September 1981 to December 2021 were compiled (Table 1). The stranding peak season was observed in the monsoon season, i.e., June–August (Figures 1, 4, 5). High mortality of olive ridley turtles owing to incidental catch has become a regular annual phenomenon along the Maharashtra coast. During the study period nesting species such as olive ridley (N = 360), green turtle N = 127, were the highest and among non-nesting species hawkbill turtle N = 16, loggerhead turtle N = 5, and Leatherback turtle N = 3 were stranded with few reports along the Maharashtra coast (Figure 6). All stranded turtles that were caught were mostly females since males never return to the beach. The percentage of females and males in each of the species of stranded turtles were as follows: olive ridley females = 69.2%, males = 2.5%, unknown = 28.3%; green sea turtle females = 79.5%, males = 8.9%, unknown = 11.5%; hawkbill turtle females = 100%; loggerhead turtle females = 44.4%, males = 22.2%, unknown = 33.3%; and leatherback turtles unknown = 100% (Figure 3). The stranding of a non-nesting species in this area might indicate that the Maharashtra coastal areas are important foraging grounds or migratory pathways. Most sea turtles were caught in Dol net, hook, lines, gillnet, bag net, Rampani net, and ghost net. The highest stranding of sea turtle was observed during monsoon season (Figure 1, 7) compared to pre monsoon and post monsoon season (Figure 8, 9).

Table 1. Numbers of sea turtle strandings from 1984 to 2021

SN	Year	Number of sea turtles stranded/ injured/dead	Reference
1	1981	1	Karbhari, J.P. (1981)
2	1984	3	Karbhari, J.P. (1985)
3	1985	2	Karbhari, (1985); Karbhari, et al. 1986
4	1988	3	Katkar, (1989),
5	1991	3	Katkar 1988; Hotagi, (1992)
6	1995	2	Katkar, 1995.
7	1996	1	Jadhav (1996).
8	2000	29	Sahydri Nisarg Mitra
9	2000-2001	6	Sahydri Nisarg Mitra
10	2001	1	Sahydri Nisarg Mitra
11	2002-2003	2	Sahydri Nisarg Mitra
12	2003-2004	11	Sahydri Nisarg Mitra
13	2004	41	Katdare 2008, Sahydri Nisarg Mitra
14	2005-2006	8	Giri, V. (2006); *Giri, V. & Chaturvedi, N. 2006.*
15	2008	3	Sundaram and Josekutty (2009);
16	2011	2	Sahydri Nisarg Mitra
17	2012	1	Shiledar et al. (2012).
18	2013	6	Sundaram & Mane (2013); Dahanu forest dept and WCAWA
19	2014	28	Dahanu forest dept and WCAWA
20	2015	20	Dahanu forest dept and WCAWA
21	2016	24	Dahanu forest dept and WCAWA
22	2017	43	Dahanu forest dept and WCAWA; Singh V. A.(2017). Anonymous (2017)
23	2018	62	Dahanu forest dept and WCAWA Express News Service (2018)
24	2019	48	Hatkar, P et al. (2019); Dahanu forest dept and WCAWA
25	2020	59	Akshay Mandavkar pers comm; Dahanu Forest Dept and WCAWA, Shaunak Modi pers comm
26	2021	26	Umang Kale pers comm, Dahanu Forest Dept and WCAWA, Noah Shinde Pers communication

The stranding reports hotspots were Chikhale (N = 32), Nivati (N = 25), Chinchani (N = 23), Juhu (N = 23), Vengurla (N = 21), Dhakti Dahanu (N = 18), Khavane (N =14), Bordi (N = 12), and Dandi (N = 17) (Figure 2, 6). Of these turtles, 146 (54.8%) were released back into the sea after the rehabilitation process, 115 (43.2%) died during the rehabilitation, and five (2%) turtles were still in the rehabilitation process. Significant year-to-year variation in stranding rates was observed. This long-term study indicates that fishing-related or environmental factors might explain the temporal stranding patterns of marine turtles.

Spatial overlap was noted between potential mortality locations and gillnet and seine fisheries, providing important information for focusing future research on mitigating conflict between sea turtles and human activities. Turtles were entangled in ghost nets that had been discarded, abandoned, or lost in the ocean. Ghost nets pose a severe threat to marine megafauna

throughout the world. Improvised net disposal facilities in ports can help reduce gear loss.

Discussion

Sea turtles play a vital role in ocean ecosystems. As sea turtle populations decline, their ability to perform vital roles in maintaining the health of the oceans also decreases. There is a need to ensure that their populations recover. Sea turtle interactions are problematic in pelagic longline, gillnet, set net, pound net, trawl, purse seine, and demersal longline fisheries that operate in the range of sea turtles, especially in the tropics and subtropics (F.A.O. 2010). In recent years there has been increased attention on the increased stranding records of sea turtles along the Maharashtra coast. The number of sea turtles inhabiting the waters off the Maharashtra coast is uncertain. However, this is the first study to analyze regular beach monitoring efforts for stranding. The results of this study provide the first attempt to predict sea turtle mortality location. Stranded sea turtles were recorded along the entire coast of Maharashtra. Present data needs further examination of the possible forcing effect of nearshore current patterns and tidal fluctuation.

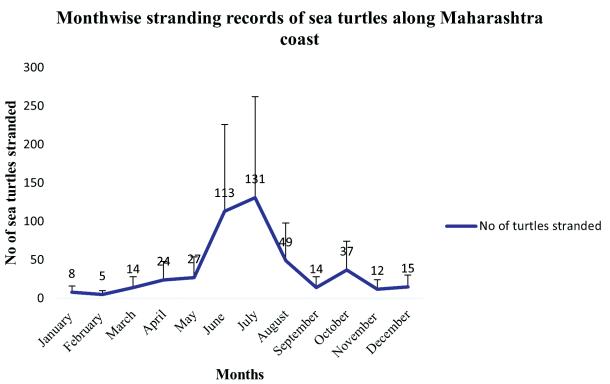

Figure 1. Monthly variation of sea turtle strandings along the Maharashtra coast

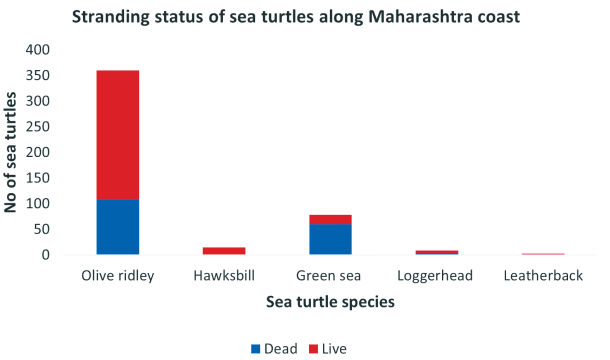

Figure 2. Stranding status of sea turtles along the Maharashtra coast during 1984–2021

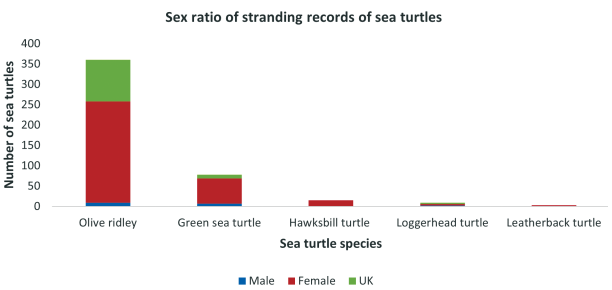

Figure 3. Sex ratio of stranding records of sea turtles along the Maharashtra coast 1984–2021

The olive ridley is the most abundantly found species along the Maharashtra coastline. The olive ridley and green turtles are frequently encountered as bycatch across the coast, suggesting a distribution in the West Coast's nearshore and offshore waters (Phillott and Rees 2018). The leatherbacks and loggerheads, on rare occasions, are encountered as bycatch in both the Arabian Sea and the Bay of Bengal (Shanker and Choudhury 2006; Hatkar et al. 2019). During the monsoon season, live-stranded female subadult hawksbill turtles (N = 16) were observed along Mumbai, Palghar, and Sindhudurg district coastlines. Local fishermen reported sighting several young Hawksbill turtles during the monsoon season in the Devgad area (Andhare and Hatkar 2015). Rarely, the leatherbacks and loggerheads are encountered as bycatch in the Arabian Sea. All female loggerhead turtles that were stranded live (N = 4), and dead (N = 1) were found along with Palghar and Sindhudurg districts during the monsoon season. Leatherback (N = 2) turtles were accidentally caught near Devbag near Malvan and Palghar district (Karbhari 1985; Karve 2020). Green turtles are stranded in nearshore waters, which are predominantly rocky with a luxuriant growth of seaweeds.

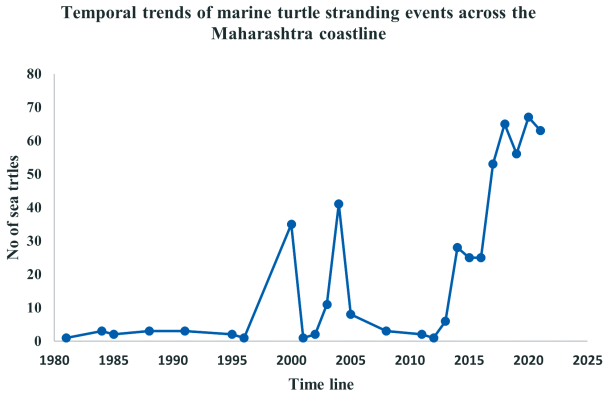

Figure 4. Temporal trends of marine turtles stranding across the Maharashtra coastline in the past 25 years

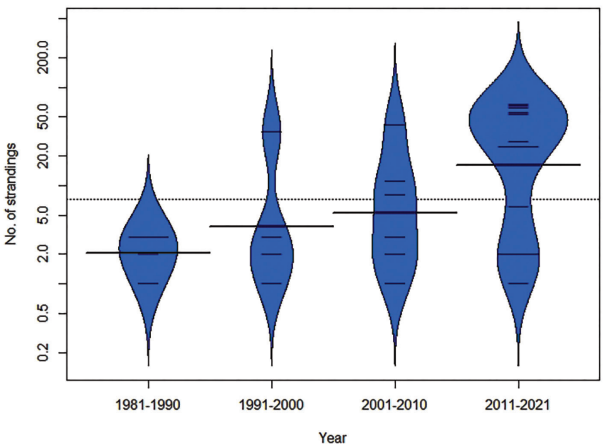

Figure 5. Decadal trends in sea turtle stranding events across the Maharashtra coastline

Halophila beccarii seagrass species are already recorded from Kolam, Tarkarli, Kalwall, and Achara (Bhosale 2003).

In Mumbai, the olive ridley turtles usually nest at Backbay, Juhu Chowpati, Girgaon Chowpati, Governor's Gate, Shivaji Park to Mahim, Juhu to Versova Mud Island, Gorai, Marve, Manori, Worli, and Vashi Creek (Kar and Bhaskar 1981; Chhapghar 2005; Giri and Chaturvedi 2006). In Shiroda and Tambaldeg, fishermen reported that green turtles occur in the seagrass beds in the nearshore waters (Andhare and Hatkar 2015). Green turtle nesting was also observed in Tarkarli, Achara, Kunkeshwar, Nivati, and Tondavali (Giri and Chaturvedi 2003). The potential nesting beaches from which there are reports of nesting of olive ridley are Kelus, Neevati, Khavane, Tondavali, Talashil, and Achara in Sindhudurg district, and Nevare, Varavade, Vetye, and Ambolgad in Ratnagiri district (Giri and Chaturvedi 2003). Significant aggregation of olive ridley turtles was also observed at Bombay, and Dahanu, Gorai, Khim, Manori and Versova have also recorded nesting of olive ridley turtles (Shaikh 1984). Recently, one leatherback turtle was caught in a fishing net near Bhate jetty in Mumbai (Katdare 2022).

The total area within the Dahanu Taluka for the location of permissible industries will be restricted to a maximum of 500 acres within the industrial areas earmarked in the Master Plan as per MoEF&CC notification dated 20th June 1991. Various projects have led to the fragmentation and further degradation of the pristine areas of Dahanu Taluka. Threats to offshore sites include fishery bycatch in different fishing gears (Phillott and Rees 2018). The average percentage of incidental catch is four to five turtles per trawler per year (Giri and Chaturvedi 2003). Adults and immature sea turtles are accidentally captured in fisheries ranging from highly mechanized operations to small-scale fishers. Fishing is intensively carried out all along the Maharashtra coast. Turtles are injured by the boat's propellers and caught in fishing nets all over the coast. Motorized fishing vessels with outboard motors (O.B.M.) generally operate up to about 50–60 m from the coast using long lines or spreading their nets for a few hours throughout the day. (F.A.O. 2010). Turtles trapped in the trawl net are dragged over for one to three hours. As a result, their heads are bludgeoned.

Extensive nest protection measures and hatcheries are maintained across the mainland coast (Phillott and Rees 2018). Worldwide in situ conservation has potentially contributed to the successful conservation of few sea turtle populations (Mazaris et al. 2017). In Tamil Nadu the TREE foundation rescues and rehabilitates sea turtles — they rescued 35 sea turtles, among which 11 were released (Dharini and Sriram 2015). Reliable data on sea turtle abundance and the numerous causes of turtle deaths, which are necessary for accurate population assessments,

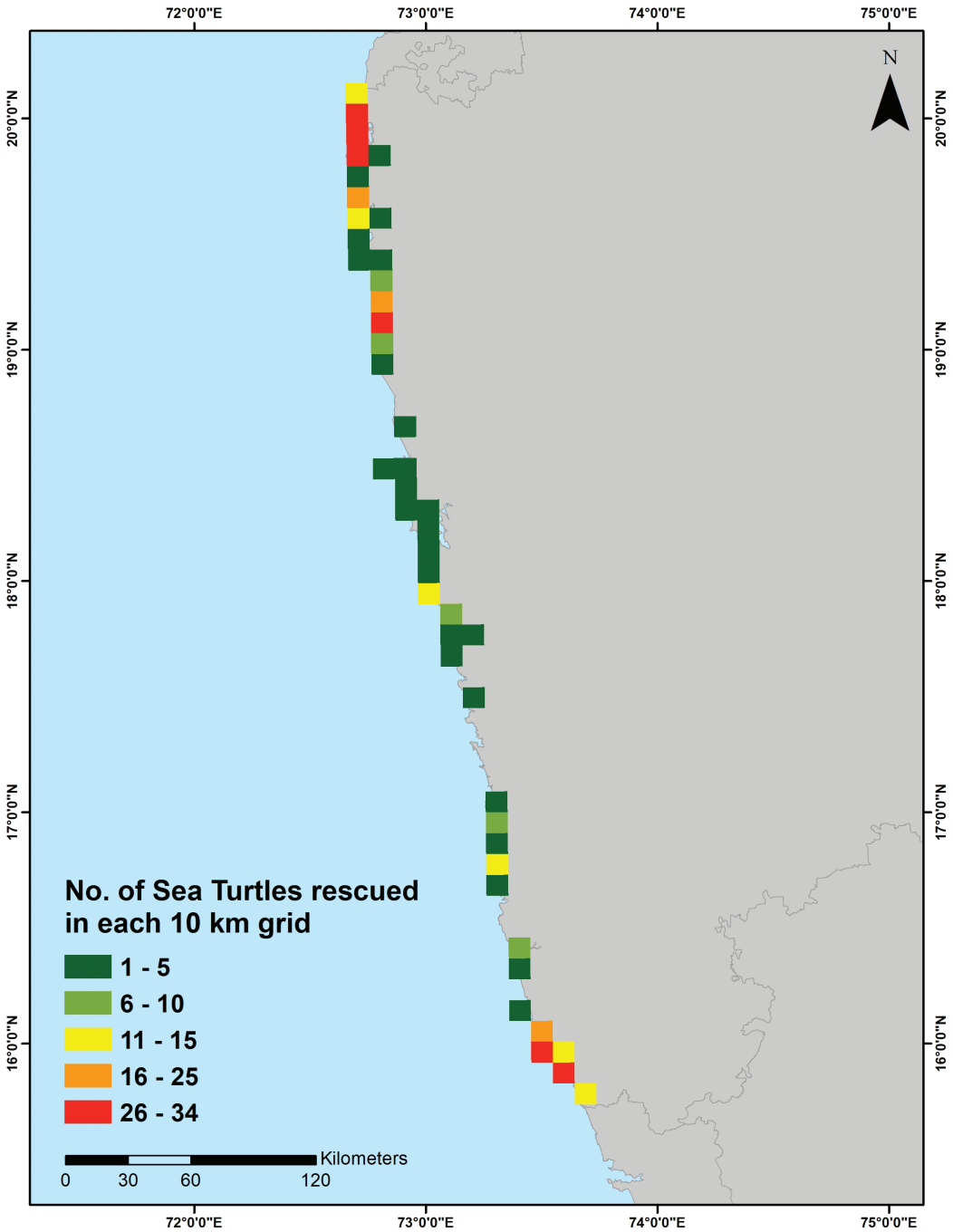

Figure 6. Spatio-temporal analysis of hotspots of sea turtle strandings along the Maharashtra coast

are generally unavailable (F.A.O. 2010). Actions that reduce interactions between fisheries and sea turtles and initiatives that address other threats to sea turtles may contribute to the recovery of turtle populations (F.A.O. 2010).

Temporal changes and their impact on Land Use and Land Cover (LULC) concerning habitats are not mapped (Pisolkar and Chaudhary 2016) in Sindhudurg. Due to education and awareness-raising activities, fishermen and locals have started actively participating in turtle

conservation. Training courses on Turtle Excluder Devices and bycatch reduction devices should be conducted for fishermen. Locals earn their livelihood through tourism and thus benefit financially from extending protection to marine turtle nests. Ideally, attempts to investigate stranding patterns should account for factors that affect the initiation and duration of carcass buoyancy (e.g., turtle size, carcass decomposition rate, water temperature, and presence of scavengers) and the probability of carcass landfall (e.g., direction, intensity and seasonality of prevailing winds, surface and near-bottom current regimes, lunar tides, and the spatial proximity of mortality sources to shore) (N.R.C. 1990; Crowder et al. 1995; Epperly et al. 1996; Lewison et al. 2003). The all-India average of the monthly mean wind speed based upon 171 stations for 1961–2008, was the highest in June (10.6 kmph) and lowest in November (5.0 kmph) during (Jaswal and Koppar 2013). Mumbai, Thane, Ratnagiri, and Raigad were identified as the cyclone hotspot districts in Maharashtra (Jaswal and Koppar 2013). However, this information is not always available or known. Similarly, winter wind regimes may initiate net offshore flow in shelf waters, thus precluding or reducing carcass landfall (Epperly et al. 1995). Oceanic conditions that produce nearshore currents could facilitate the stranding of drifting turtle carcasses (Crowder et al. 1995) and partially explain the increased number of strandings observed during the monsoon seasons along the Maharashtra coast.

Potential causes of stranding of live or dead sea turtles can be assessed in live sea turtles and in case of carcasses in the early stages of decomposition, with the help of necropsy and external examination. Entanglement in lines, ropes or nets results in characteristic wounds or scars that entirely or partially encircle the front flipper and neck. Amputation of limbs may occur if turtles have been entangled in ghost gear for extended periods (Phillot and Godfrey 2019).

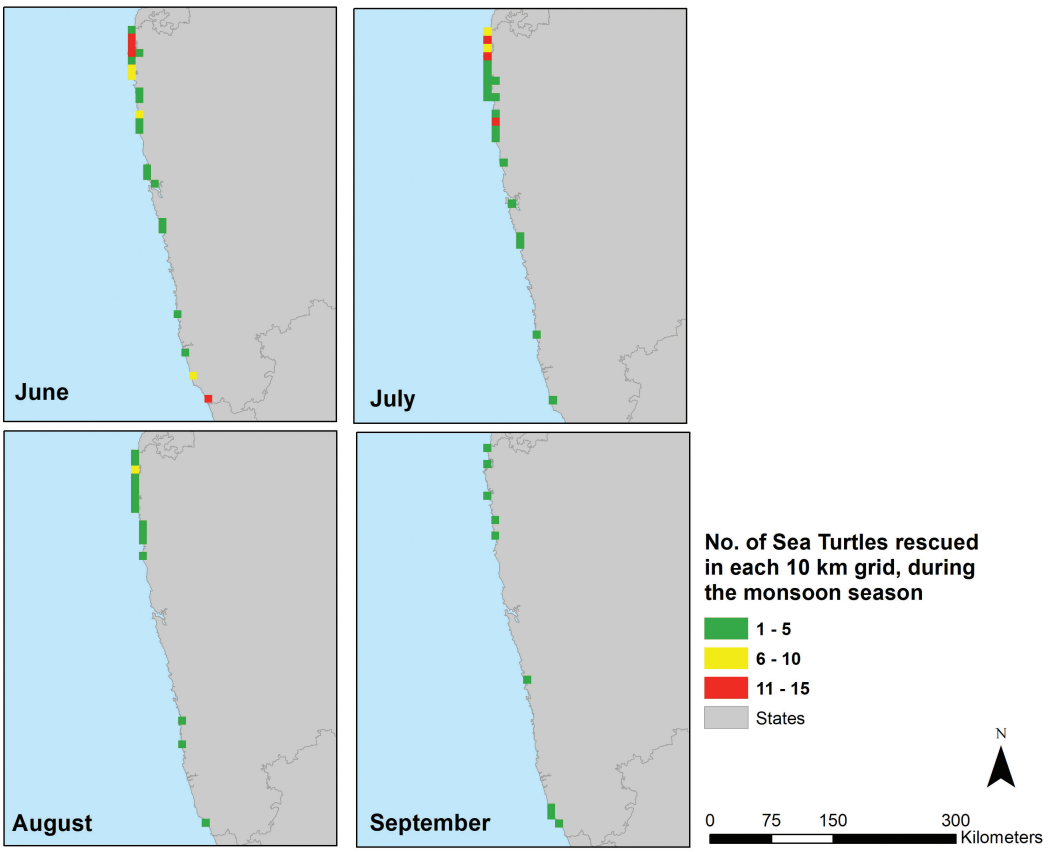

Figure 7. Sea turtle stranding during the monsoon season along the Maharashtra coast

Fishermen in Malvan and nearby villages know that turtles are endangered; hence, they actively participate in turtle conservation. If the turtles are caught in the fishing nets, they are immediately released. Further networking with fishing hamlets and deliberations with the fishermen about sea turtle conservation will certainly help enhance their appreciation and participation in saving these sea turtles.

Future directions

There is a dearth of information about the spatial occupancy and movement patterns of sea turtles that have been nesting on the beaches of this coast. The Wildlife Institute of India proposed tagging studies on the sea turtles inhabiting the Sindhudurg and Ratnagiri coasts to understand their post-nesting migration routes. Seven female olive ridleys have been tagged and tracked along Guhagar, Velas, and Anjarle. Rescue and rehabilitation centers are now established at Dahanu and Airoli, and will be established in Alibag, Dapoli, and Malvan. The tracking information will highlight the habitat use, movement, and nesting patterns of the turtles residing in the Arabian Sea. Hence, collecting information about stranded sea turtles, including the date, location, species, sex, carapace length, stage of decomposition, and potential cause and condition of each injury, can contribute to a broader assessment of the threats to sea turtles in regional and national waters. The Mangrove Foundation has already paid Rs. 40.48 lakhs to fishermen as compensation for releasing marine sea turtle species such as olive ridley (N = 138) and green sea turtles (N = 67), since December 2018 (Express News 2022). Due to education and awareness-raising activities through the local forest departments, the Mangrove Foundation, and local N.G.O.s such as Wildlife Conservation and Animal Welfare Association (WCAWA), Sahyadri Nisarg Mitra Sansthan, and RAWW (Resqink Association for Wildlife Welfare), with the local fishermen and

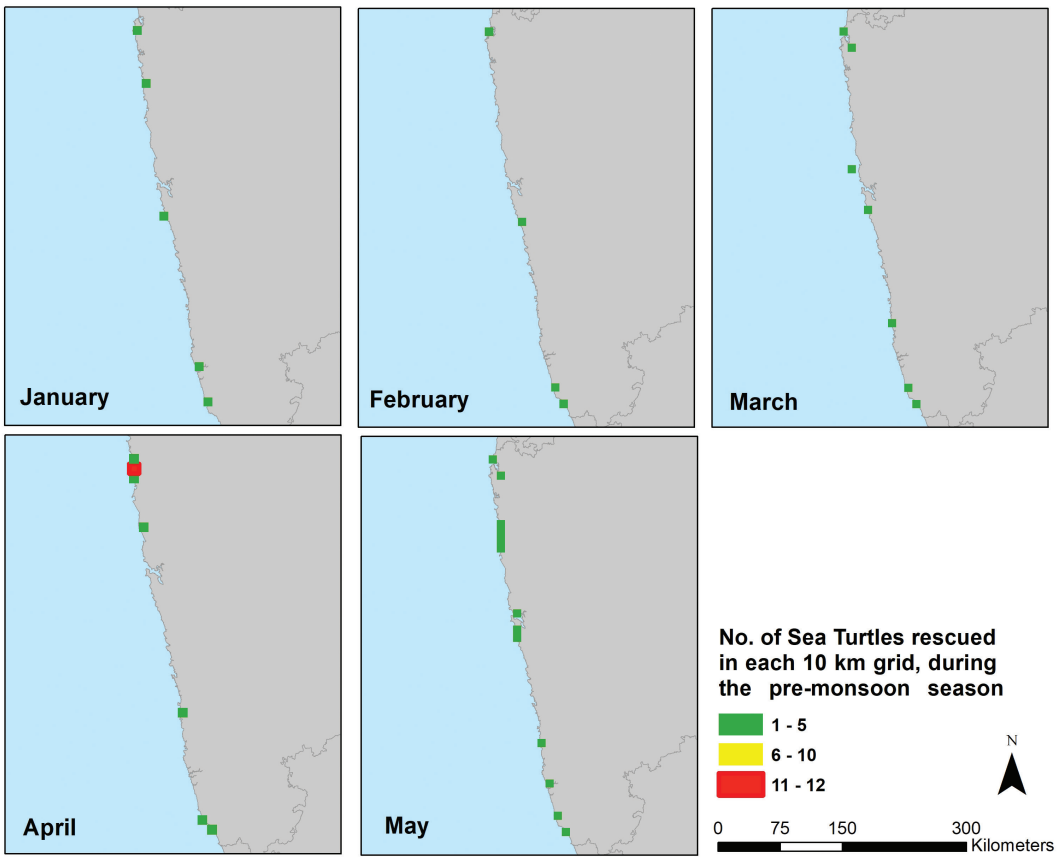

Figure 8. Sea turtle strandings during the pre-monsoon season along the Maharashtra coast

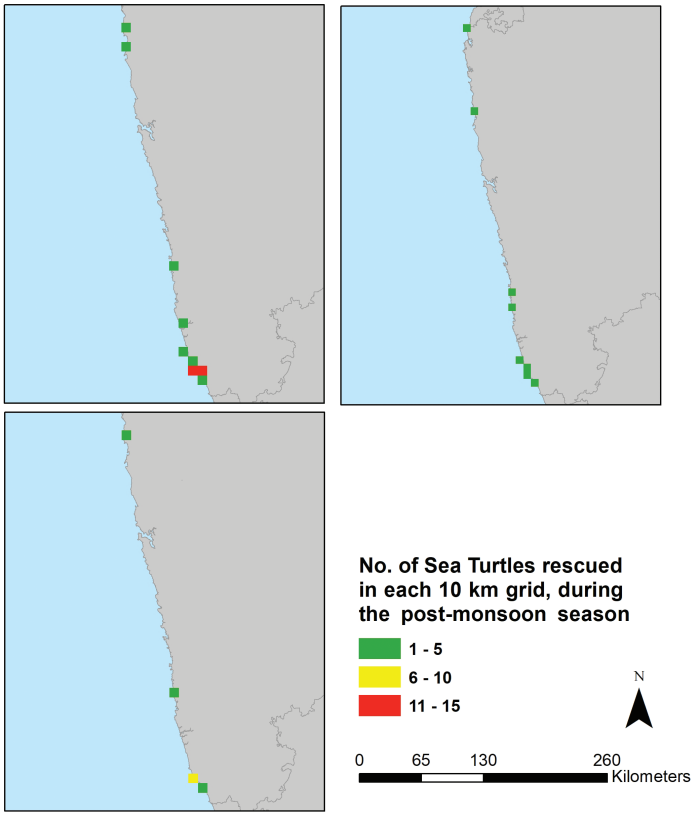

Figure 9. Sea turtle strandings during the post monsoon season along the Maharashtra coast

residents of those regions have started actively participating in turtle conservation.

Awareness among fishermen about not dumping ghost nets and plastic in the sea needs to be improved, and methods for solid waste management and processing of unused nets needs to be established. Proper net disposal facilities at each port need to be developed. These practices will help to reduce net disposal in the open ocean. Training for handling, stranding, or releasing sea turtles should be provided to the local residents and the local frontline staff. The turtle excluder device is still not being used along the Maharashtra coast. There is an additional need to assess the degree to which trawlers and long liners threaten turtles in Maharashtra. More proactive conservation measures are needed to protect sea turtles and rebuild their populations to healthy levels so that they can fulfil the whole extent of their roles in ocean ecosystems. More accurate documentation of factors that contribute to sea turtle stranding hotspots in Maharashtra will help researchers and conservationists influence and propose policies and work with local communities and fishermen to mitigate threats.

Acknowledgements

The authors thank Abhishek Satam, Sunil Belvekar, Noah Shinde, Amit Patil, Ajju Ambre, Govind Dhuri, Jagdish Todenk, Suraj Bhosale, and Shri. Vaibhav Borate, Sagar Maldkar, Shaunak Modi, Swapnil Tandel, Pradip Dingankar, Mohan Upadhyay, Akshay Mandavkar, Ganesh Nakhwa, Prof. Amol Handore, Dr. Swapnaja Mohite, Prof. Sumedha Korgaonkar, for providing local information on stranding sea turtles along Maharashtra coast.

We are also thankful for the support from Dahanu forest officials, Divisional Forest Officer Madhumita S., Chief Conservator of Forests T. Ramarao, and Maharashtra Principal Chief Conservator of Forests (PCCF) Shri. Y.L.P.Rao.

References

ANDHARE, V. & HATKAR, P. (2015) A survey of sea turtle nesting beaches and their occurrence in the offshore waters off the coast of Sindhudurg district, Maharashtra. *Proceedings of Emerging trends of sustainable development* (ed) Subhash Donde 62-64 pp.

ANONYMOUS (2017) Long-term monitoring community-based conservation of sea turtles in Maharashtra, India. Dakshin Foundation,1-17 pp Accessed from https://mangroves.maharashtra.gov.in/Site/SiteInfo/Pdf/Long%20term%20monitoring%20_%20community%20based%20conservation%20of%20sea%20turtles%20in%20Maharashtra,%20India.pdf

ANONYMOUS (2017) 2 halves of 42-ft whale wash ashore at Mumbai's beaches Available from https://www.mid-day.com/mumbai/mumbai-news/article/photos-two-halves-mon-

ster-dead-42-feet-whale-wash-ashore-mumbai-juhu-beach-aksa-beach-18270191 /(6th January 2020)

BADRI, C. (2017) Marine animal carcasses found on Mumbai's beaches raise alarm, https://www.hindustantimes.com/mumbai-news/marine-animal-carcasses-found-on-mumbai-s-beaches-raise-alarm/story-ghRFEjFag8rxYozOX65XnN.html/ (26th December 2020)

BHOSALE, L.J. (2003) Malvan, Chapter 2, Bioresources: Status in Select Coastal Locations NBDB, New Delhi and MSSRF, Chennai.62–82.

CHHAPGAR, B.F. (2005) *Marine life in India. The Gentle Giants. Oxford University Press. 306–310.*

CENTRAL MARINE FISHERIES RESEARCH INSTITUTE CMFRI. (2014) *Training manual Dealing with Marine Mammals Stranding in India, 1–109.*

CROWDER, L.B., HOPKINS-MURPHY, S.R. & ROYLE, J.A. (1995) Effects of turtle excluder devices (TEDs) on loggerhead sea turtle strandings with implications for conservation. *Copeia* 773–779.

DHARINI, S. & SRIRAM, R. (2015) Tree foundation's rescue and rehabilitation centre for sea turtles in Chennai, Tamil Nadu and Nellore Andhra Pradesh, India. *Indian Ocean Turtle Newsletter* 22, 30–32.

EPPERLY, S., BRAUN J. & VEISHLOW, A. (1995) Sea turtles in North Carolina waters. *Conservation Biology* 9(2), 384–394.

EPPERLY, S., BRAUN, J., CHESTER, A., CROSS, F., MERRINER, J., TESTER, P. & CHURCHILL, J. (1996) Beach strandings as an indicator of at sea mortality of sea turtles. *Bulletin of Marine Science* 59 (2), 289–297.

EXPRESS NEWS SERVICE (2018) Dead Green Sea turtle washes ashore at Versova, Accessed from https://indianexpress.com/article/cities/mumbai/dead-green-sea-turtle-washes-ashore-at-versova-5167333/ (12th October 2020)

EXPRESS NEWS SERVICE (2022) Fishermen got Rs 40 lakh in 3 years for releasing marine life from net Accessed from https://indianexpress.com/article/cities/mumbai/fishermen-got-rs-40-lakh-in-3-years-for-releasing-marine-life-from-net-7734369/(12th May 2022)

F.A.O. (2010) Marine turtle status and conservation in the Indian Ocean (Kartik Shanker)Available from: http://www.fao.org/docrep/007/y5750e/y5750e06.htm

http://www.fao.org/docrep/007/y5750e/y5750e06.htm (14th July 2016).

FOLEY, A.M., STACY, B.A., HARDY, R.F., SHEA, C.P., MINCH, K.E. & SCHROEDER, B.A. (2019) Characterizing watercraft-related mortality of sea turtles in Florida. *The Journal of Wildlife Management* 83(5), 1057–1072.

GIRI, V. (2006) The status of sea turtles on the Maharashtra and Goa coasts. In: *Monitoring and networking for sea turtle conservation in India: a UNEP CMS project report* (eds. K. Shanker & H. Andrews). Centre for Herpetology/Madras Crocodile Bank Trust.

GIRI, V. & CHATURVEDI, N. (2003) Status of marine turtles in Maharashtra, India, *Kacchapa: A Newsletter for the Indian ocean on sea turtle conservation and management* (8) 11–15.

GIRI, V. & CHATURVEDI, N. (2006) *Sea turtles of Maharashtra and Goa. K. Shanker and Choudhury, B.C. (Editors). Marine Turtles of the Indian subcontinent. 147–145.*

GIRI, V., KATDARE, V., FERNANDES, D. & RAHMANI, A. (2006) The status of sea turtle populations on the Maharashtra and Goa coasts of India. *Towards Integrated and Collaborative Sea Turtle Conservation in India* – a UNEP/CMS-IOSEA Project, 45–57.

HART, K.M., MOORESIDE, P. & CROWDER, L.B. (2006) Interpreting the spatio-temporal patterns of sea turtle strandings: Going with the flow. *Biological Conservation* 129, 283–290.

HATKAR, P., VINHENKAR, D. & KANSARA, D. (2019) Rescue and rehabilitation of loggerhead sea turtles *Caretta caretta* from Dahanu Coast, Maharashtra, India. *Marine Turtle Newsletter* 156, 26–29.

HOTAGI, J.S. (1992) On a marine turtle *Lepidochelys olivacea* landed at basseein Kolliwada in Maharashtra. *Marine Fisheries Information Service, Technical and Extension Series* No. 118, 19.

JADHAV, D.G. (1996) On an olive ridley turtle stranded at Janjira Murud coast, Maharashtra, *Marine Fisheries Information Service, Technical and Extension Series* No. 145, 17.

JAMES, N.J., SALEEM, A. & SUNDARAM, S. (2019) Stranded olive ridley turtle on Edakkazhiyur beach, Chavakkad, Kerala, India. *Indian Ocean Turtle Newsletter* 30, 11–13.

JASWAL, A. & KOPPAR, A.L. (2013) Climatology and trends in near-surface wind speed over India during 1961-2008. *Mausam* 64(3), 417–436.

JEFFERSON, T.A., WEBBER, M.A., & PITMAN, R.L. (2011) *Marine mammals of the world: a comprehensive guide to their identification*. Elsevier. 328 pp

KAMPSTRA, P. (2008) Beanplot: a boxplot alternative for visual comparison of distribution. *Journal of Statistical Software* 28, Code Snippet 1, 1–9.

KAR, C.S. & BHASKAR. S. (1982) *Status of sea turtles in the Eastern Indian Ocean. In: Bjorndal, K. (Editor). Biology and conservation of sea turtle. Smithsonian Institution press, Washington, D.C. pp* 365–372.

KARBHARI, J.P. (1981) *On the rare occurrence of a giant-sized Hawksbill turtle off Elephanta caves (near Bombay). Marine Fisheries Information Service Technical and Extension Series* No. 33, 17.

KARBHARI, J.P. (1985) Leather-back turtle caught off Devbag near Malwan. *Marine Fisheries Information Service, Technical and Extension Series*, No. 64, 23.

KARBHARI, J.P., PROSPER, A., JOSEKUTTY, C.J. & DIAS, J.R. (1986) *Some observations on marine turtles landed along Maharashtra coast. Marine Fisheries Information Service, Technical and Extension Series*, 70. pp. 20–21.

KARVE, H., MANJREKAR, M., VASUDEVAN, N. & SOMARAJ, N. (2020) Incidental capture of leatherback sea turtle off Bharadkhol, Maharashtra, India. *Indian Ocean Turtle Newsletter* No.32 41–42.

KATDARE B. (2008) Five years of marine turtle conservation in Maharashtra, India (2002 – 2007) *Indian Ocean Turtle Newsletter* No. 7 25–26.

KATDARE P. (2022) 150 kg turtle caught in fishermen's net in Bhate Port in Bhayander Available from https://marathi.abplive.com/photo-gallery/news/mumbai-150-kg-turtle-caught-in-fishermen-s-net-in-bhate-port-in-bhayander-1121979/(5th May 2022)

KATKAR, B.N. (1989) *On Olive ridley turtles landed along Ratnagiri coast. Marine Fisheries Information Service Technical and Extension Series*, 95, 9.

KATKAR, B.N. (1995) Turtles and whale shark landed along Ratnagiri coast, Maharashtra. *Marine Fisheries Information Service Technical and Extension Series*.141, 20.

KEHIMKAR, I. (2017) *Introduction to coastal and marine biodiversity of Maharashtra,* Indo-German Biodiversity Programme, New Delhi*,* 1–160.

KOCH, V., PECKHAM, H., MANCINI, A. & EGUCHI, T. (2013) Estimating At-Sea Mortality of Marine Turtles from Stranding Frequencies and Drifter Experiments. *PLoS O.N.E.*, 8(2)1–10,

LEWISON, R.L., CROWDER, L.B. & SHAVER, D.J. (2003) The impact of turtle excluder devices and fisheries closures on loggerhead and Kemp's ridley strandings in the western Gulf of Mexico. *Conservation Biology* 17 (4), 1089–1097.

LOVICH, J.E., ENNEN, J.R., AGHA, M. & GIBBONS, J.W. (2018) Where have all the turtles gone, and why does it matter? *BioScience* 68(10), 771–781.

MAZARIS, A.D., SCHOFIELD, G., GKAZINOU, C., ALMPANIDOU, V. & HAYS, G.C. (2017) Global sea turtle conservation successes. *Science Advances* 3(9), 1–7.

NATIONAL RESEARCH COUNCIL (N.R.C) (1990) *Decline of Sea Turtles: Causes and Prevention. National Academy Press*, Washington, DC. 280 pp.

NITAWARE HIMANSHU (2021) Accessed from https://www.thebetterindia.com/265328/fishing-gear-ghost-nets-ocean-waste-dsm-engineering-environment-surf-boards/

ORTIZ-ALVAREZ, C., PAJUELO, M., GRADOS, D., ABREGO, M.E., BARRAGÁN-ROCHA, A. R., BARRANTES, M., SÁNCHEZ, C. A., FONSECA, L.G, ESPINAL, V.G., MANGEL, J.C., RGUEZ-BARON, J.M., SANTIDRIAN-TOMILLO, P., SARTI L., SANTANA-HERNÁNDEZ, H., SHILLINGER G., PRADO, M., WALLACE, B., WILLIARD, A. S., ZAVALA-NORZAGARAY, A. A. & ALFARO-SHIGUETO, J. (2020) Rapid Assessments of Leatherback Small-Scale Fishery Bycatch in Internesting Areas in the Eastern Pacific Ocean. *Frontiers in Marine Science*, 6, 813.

PINJARKAR, V. (2020) Mah forest dept has come a long way in conserving sea turtles, Accessed from https://timesofindia.indiatimes.com/city/nagpur/mah-forest-dept-has-come-a-long-way-in-conserving-sea-turtles/articleshow/75901833.cms/(18th June 2023)

PISOLKAR, Y. & CHAUDHARY, N. (2016) The Prob-

lems of Coastal Tourism, Environment and Local Sustainable Development along Sindhudurg District, Coastal Maharashtra India. *Annual Research Journal of Symbiosis Centre for Management Studies*, Pune, 4, 101109.

PHILLOTT, A.D. & REES, A.F. (EDS.) (2018) Sea Turtles in the Middle East and South Asia Region: MTSG Annual Regional Report 2018. Draft Report of the IUCN-SSC Marine Turtle Specialist Group, 2018.

PLOTKIN, P.T. (2007) *Biology and Conservation of Ridley Sea Turtles*, JHU Press, 230pp.

SARAVANAN, K., CHOWDHURY, B.C. & SIVAKUMAR, K. (2013) Important coastal and marine biodiversity areas on East coast of India. *In* Sivakumar, K. (Ed.) *Coastal and Marine Protected Areas in India: Challenges and Way Forward, ENVIS Bulletin: Wildlife & Protected Areas* (15) 292–298 pp.

SHAIKH, K.A. (1984) *Distribution of nesting sites of sea turtles in Maharashtra. In, Proceedings of the Workshop on the Sea Turtle Conservation. E.G., Silas (Editor). Central Marine Fisheries Research Institute, Kochi, Special Publication 18, 109–115.*

SHANKER, K. & CHOUDHURY, B.C (2006) (Editors) *Marine turtles of the Indian subcontinent*. Universities Press, Hyderabad. India pp 400.

SHILEDAR, B., MAINKAR, K. & SUNDARAM, S. (2012) Green turtle, *Chelonia mydas* rescued from Dabholi-Waingani Landing Centre, Maharashtra. *Marine Fisheries Information Service; Technical and Extension Series*, (213) 12–13.

SHIRKE, A. & AMRITKAR-WANI, K. (2012) Understanding report of the Western Ghats ecology expert panel Maharashtra Perspective, *ENVIS newsletter* April – June, 12–13.

SINGH V.A. (2017) Five carcasses wash up on Juhu beach in one month, Available from https://www.dnaindia.com/mumbai/report-five-carcasses-wash-up-on-juhu-beach-in-one-month-2433064 (18th June 2023)

S.N.M. (2022) Available from http://www.snmcpn.org/marine-turtles/conservation-efforts

SUNDARAM, S. & JOSEKUTTY, C.J. (2009) On the rescue operations and rehabilitation carried out on three olive ridley turtles from Mumbai, Maharashtra, India. *Indian Turtle Newsletter* No. 10, 24.

SUNDARAM, S. & MANE, S. (2013) Green turtle, *Chelonia mydas* stranded at Malvan, Maharashtra. *Marine Fisheries Information Service; Technical and Extension Series*, (215), 39–40.

TRIPATHY B. (2006) Sea turtle research, biology and conservation in India. *Journal of Indian Ocean Studies* 14(1), 114–124.

TRIPATHY, B. & CHOUDHURY, B.C. (2007) A review of sea turtle exploitation with special reference to Orissa, Andhra Pradesh and Lakshadweep Islands, India. *Indian Journal of Traditional Knowledge* 6(2), 285–291.

Date submitted 20/12/2022
Date accepted 12/04/2023
Available online