# INDIAN OCEAN TURTLE NEWSLETTER

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The Indian Ocean Turtle Newsletter was initiated to provide a forum for exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. The newsletter also intends to cover related aspects such as coastal zone management, fisheries and marine biology.

The newsletter is distributed free of cost to a network of government and non-government organisations and individuals in the region. All articles are also freely available in PDF and HTML formats on the website. Readers can submit names and addresses of individuals, NGOs, research institutions, schools and colleges, etc. for inclusion in the mailing list.

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**Cover photograph:** Hawksbill turtle emerging to nest at Nakhiloo Island, Iran
Photo Courtesy: Asghar Mobaraki

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EDITORIAL

# EDITOR'S NOTE

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I hope that everyone has enjoyed a safe and healthy return to their usual sea turtle activities to date in 2022! As stakeholders in sea turtle research and conservation return to the field, IOTN36 brings to you articles about entanglement of olive ridley turtles in the Lakshadweeps and conservation activities on the Puducherry coast of India. A research summary spotlights two recently published papers highlighting advances and knowledge gaps in sea turtle research in the north-western and western Indian Ocean, and will be of interest to IOTN readers associated with the sub-regions and those wishing to stay informed about publications relevant to the wider Indian Ocean region encompassed by IOTN publications. There are two review articles: the first reviewing the impacts of sea turtle conservation on fisher communities in India, and the second summarising the roles of sea turtles in ecosystem processes and services. Review articles provide an insight into more focused topics and issues and can be of particular interest to early career professionals and educators.

It was good to see researchers from the region at the recent online 40th International Sea Turtle Symposium; be sure to read the Announcement at the end of this issue about the 41st Symposium, to be finally held in Cartagena in 2023 after needing to be postponed in March 2020. Safe travels to those who plan to attend.

In other news from the region, the 2021 Marine Turtle Specialist Group Regional Report for the Middle East and South Asia is available online (https://www.iucn-mtsg.org/regional-reports), as are reports from the 3rd Meeting of the Northern Indian Ocean Marine Turtle Task Force and the 1st Sub-Regional Meeting of the North-Western Indian Ocean are on the IOSEA MoU site (https://www.cms.int/iosea-turtles/en). The recent Assessment of the Conservation Status of the Hawksbill Turtle in the Indian Ocean and South-East Asia Region is also on the ISOEA MoU website.

## CALL FOR SUBMISSIONS

The Indian Ocean Turtle Newsletter was initiated to provide a forum for the exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. If you would like to submit a research article, project profile, note or announcement for Issue 37 of IOTN, please email material to iotn.editors@gmail.com before 1st November 2022. Guidelines for submission can be found on the last page of this newsletter or at http://www.iotn.org/submission.php.

ARTICLES

# OLIVE RIDLEY TURTLE ENTANGLEMENT IN GHOST NETS IN KAVARATTI LAGOON, LAKSHADWEEP ISLANDS, INDIA

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Marine megafauna such as sea turtles face multiple threats as they occupy different habitats at their breeding and foraging grounds (Lascelles *et al.*, 2014; Read *et al.*, 2014;), increasing their exposure to dangers across different life stages (Read *et al.*, 2006; Dulvy *et al.*, 2008; Wallace *et al.*, 2010). Of these, ghost nets have emerged as a severe threat, affecting marine life disproportionately (Richardson *et al.*, 2019a). Ghost nets are defined as discarded or accidentally abandoned fishing gear that are lost to the sea (Wilcox *et al.*, 2014), and which continue to 'fish' indiscriminately thereafter. According to Wilcox *et al.* (2014), nearly 6.4 million tonnes of ghost nets make their way into the oceans annually. Richardson *et al.* (2019a) estimated that about 6% of all fishing nets, 9% of all traps, and 29% of all lines are lost every year. Ghost nets get carried over long distances across different oceans (Stelfox *et al.*, 2014; Sayer & Williams, 2015), forming floating conglomerates and trapping large-bodied marine animals such as marine mammals, elasmobranchs, and sea turtles (Stelfox *et al.*, 2015). Sea turtle species such as the olive ridley (*Lepidochelys olivacea*) turtles are prone to entrapment in ghost nets due to their attraction to smaller organisms caught in such nets (Stelfox *et al.*, 2016). For instance, olive ridleys are associated with flotsam in the eastern tropical Pacific Ocean (Pitman, 1990) and are known to bask at the sea surface, increasing their vulnerability to ghost nets (Pitman, 1993). Juveniles tend to utilise floating algal mats for basking, and could potentially be using floating ghost net conglomerates for the same (Boyle & Limpus, 2008). Where these overlap, olive ridleys are at great risk of being caught in ghost net conglomerates drifting in the sea.

In India, olive ridleys mass nest synchronously in Odisha (Pandav *et al.*, 1994) and the Andaman and Nicobar Islands (Namboothri *et al.*, 2015), and nest solitarily elsewhere along the Indian coastline and in the Lakshadweep islands. The Lakshadweep islands are an offshore territory located between 8º-12ºN and 71º-74ºE in the Arabian Sea that serve as breeding and feeding grounds for olive ridleys, with nesting observed on some islands

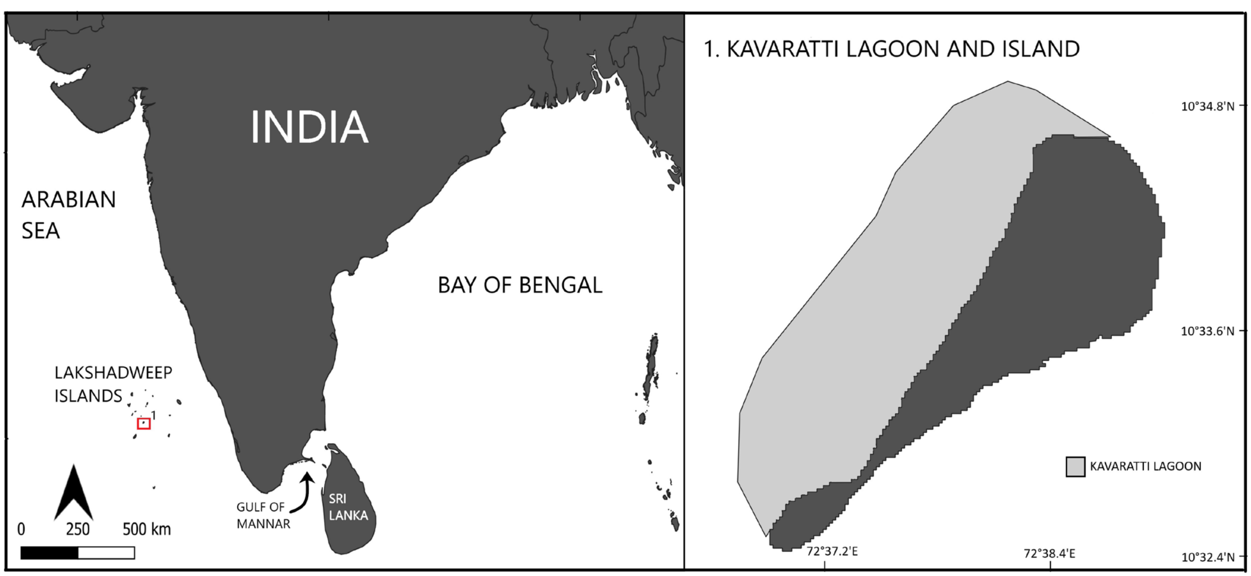


**Figure 1. Map of peninsular India depicting the Lakshadweep Islands (red inset box), Gulf of Mannar, Sri Lanka and the Arabian Sea; 1) Kavaratti lagoon (light grey) where entangled Olive Ridley turtles were observed in 2019 and 2021.**

**Figure 2. Olive ridley turtle was observed to be in distress after getting entangled in a floating ghost net in April 2021. (Photo credit: Nupur Kale)**

(Tripathy *et al.,* 2006). However, there is little information on the threats faced by olive ridleys, specifically the impact of their interactions with ghost nets in the islands.

In April 2019 and April 2021, we had two single-day chance encounters of three (two alive and one dead) and one (alive) olive ridley turtles respectively, trapped in ghost net conglomerates in the lagoon at Kavaratti Is. (Figure 1). We recorded the events photographically while freeing the turtles from the nets (Figure 2). We were unable to take morphometric measurements or determine the sex of the turtles as their removal from the water was not feasible. Based on the photographs, we estimated the curved carapace length (CCL) of the entangled turtles to be between 40-60cm. There were no signs of external injuries on their carapace, plastron and neck; however, we noticed some lacerations on the flippers during the removal, probably caused by the nets. After release, the live turtles swam away without apparent injury or fatigue.

In the last few years, the number of reports on marine turtles found entangled in ghost nets along the west coast of India has been on the rise (Tiwari, 2021; Kumar, 2022). Similarly, the Maldives also reported increasing incidents of marine turtles entangled in ghost nets, especially olive ridleys (Anderson *et al.*, 2009). Stelfox *et al.* (2020) noted that most olive ridleys found entangled in ghost nets in the Maldives belonged to the east Indian and Sri Lankan nesting populations. The origin of our turtles is unknown, but the Gulf of Mannar and Sri Lanka are known foraging sites for olive ridley turtles (Kannan, 2008; Rees *et al.*, 2012; Behera *et al.*, 2018), and it is possible that the turtles we found belonged to the Sri Lankan nesting population, or small nesting population of olive ridleys from the Lakshadweep islands. Given the low nesting numbers of olive ridleys in the Lakshadweep islands, any loss of turtles from this stock might impact the genetic diversity of this species in India. Improved monitoring and genetic assessment of individuals entangled in ghost nets in the north-western Indian Ocean will help understand the impact of ghost nets on olive ridley populations.

There has been an increase in marine litter found on the beaches and in the lagoons of the Lakshadweep Islands (Kaladharan & Anasukoya, 2020). In 2017, Kaladharan *et al.* (2017) surveyed ten islands in the Archipelago, recording an average of 1.61g/m$^2$ of litter on the beach, chiefly nylon threads and pieces of fishing net. In 2020, Kaviarasan *et al.* (2020) reported that nearly 45% of marine debris on three remote beaches of the Lakshadweep was discarded fishing gear. Even though tuna fishing using pole and line gear is the predominant form of fisheries in the Lakshadweep islands, nets and long-lines are also used to catch bait and lagoon fishes, and sharks respectively. Moreover, the commonly practiced fisheries in the Indian Ocean region and India are trawling, gill netting and seine nets, all of which rely heavily on different types of nets (Stelfox *et al.*, 2014). Therefore, while it is likely that some nets in ghost net conglomerates observed in the Lakshadweep islands may have originated from mainland India, the diversity of nets used at local and regional scales make it difficult to ascertain the exact origins of the nets (Stelfox *et al.*, 2019).

Ghost nets pose a significant threat to all marine life. It is imperative that activities that improve net disposal and reduce plastic pollution and other forms of waste from the waters at both regional and global scales are implemented.

Tackling this issue will require a multi-faceted approach combining research, awareness, and preventive action. It is essential to determine the type of gear that is lost and find ways to minimise its disposal through dialogue with fishers and fisher unions (Stelfox *et al.*, 2019). Other measures include engaging with coastal enforcement agencies, fishers and other marine vessels in activities, and engaging them in rescue of sea turtles and other marine megafauna from ghost net entanglements. This will help in understanding how the distribution of floating nets along the coast is correlated to fishing practices at regional scales. While regular cleaning up of beaches, lagoons and retrieval of nets is important to tackle the threat of ghost nets, innovative measures such as regular monitoring and removal, incentivising fishers to practice recycling or reusing damaged nets and encouraging proper disposal of the gear in waste facilities on shore or ports will considerably reduce the threat of ghost nets (Richardson *et al.*, 2019a, b; Stelfox *et al.*, 2019). Fishers play a pivotal role in any initiative that aims to mitigate the threats of ghost nets. Therefore, creating awareness amongst the coastal communities and initiating collaborative efforts will drive a change in behaviour towards implementing sustainable practices in ghost net reduction and removal.

**Acknowledgements**

We would like to thank the Department of Environment and Forest, Lakshadweep Administration, for granting us permits to work in the Lakshadweep Islands.

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# CONSERVATION OF SEA TURTLES ALONG THE PUDUCHERRY COAST OF INDIA

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## INTRODUCTION

Of the five species of sea turtle reported from Indian waters, *Caretta caretta* (loggerhead turtle), *Chelonia mydas* (green turtle), *Dermochelys coriacea* (leatherback turtle), *Eretmochelys imbricata* (hawksbill turtle), and *Lepidochelys olivacea* (olive ridley turtle) (Tikedar & Sharma, 1985; Rajagopalan *et al.,* 1996) all except the leatherback have been reported offshore from the Union Territory of Puducherry (Kar & Bhaskar, 1982) on the east coast of India. Approximately 16km of the Puducherry coast is also utilised by nesting olive ridley (81.6%) and green turtles (16%) (Abraham, 1990; Bhupathy & Saravanan, 2006; Saravanan *et al.*, 2013).

Puducherry (11.882°-11.998° N, 79.750°-79.879° E), the regional capital and the second largest town of Puducherry Union Territory, is located along the Coromandel Coast

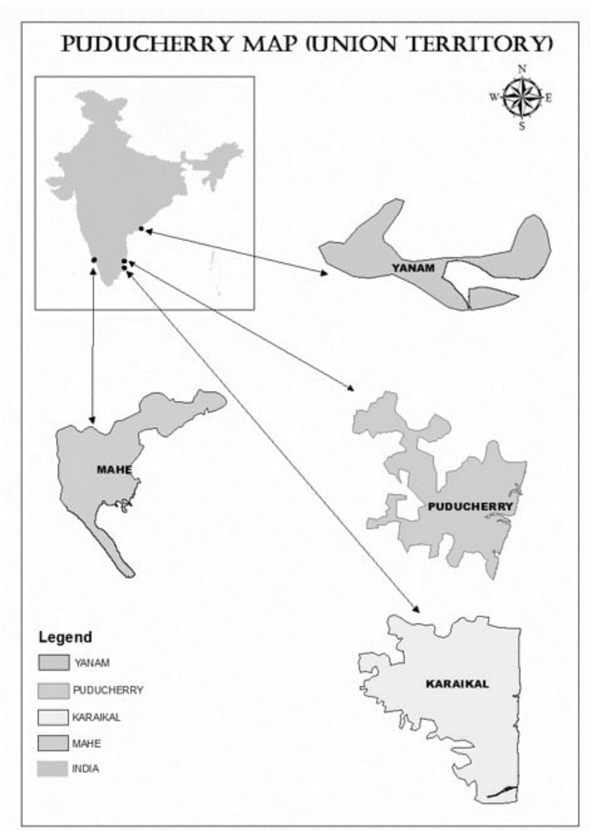


Figure 1. Union Territory of Puducherry.

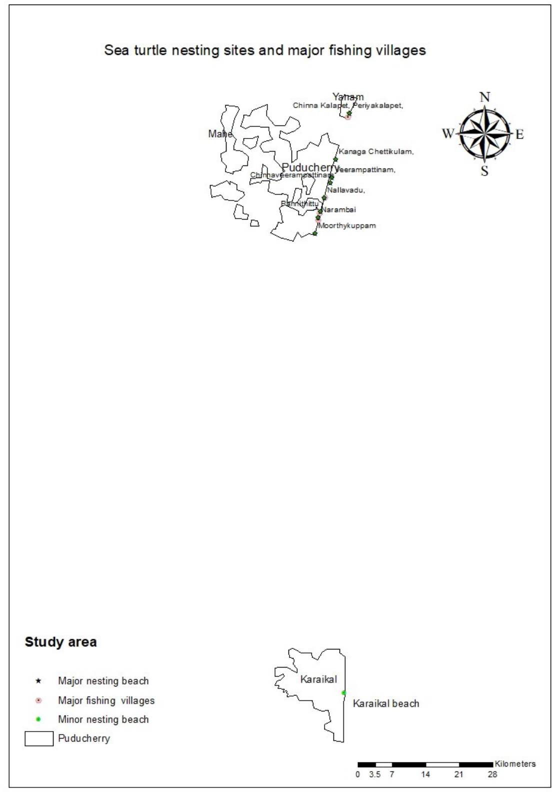


Figure 2. Sea Turtle Nesting Beaches and Fishing Villages of Puducherry Union Territory.

(Figure 1). On its 36km coastline, Puducherry has a wide range of ecosystems, including estuaries, lagoons, mangroves, backwaters, and sandy beaches. The climate of Puducherry is semi-arid, with a mean annual temperature of 30°C and annual rainfall of about 1200mm (Smith, 2010; Lakshmi *et al.*, 2012). Coconut and whistling pine (*Casuarina* sp.) plantations are observed along all beaches. Coastal plants such as morning glory *(Ipomea pescaprae*), Ravan's mustache (*Spinifex littoreus*), *Cyperus arenarius*, southwest thorn (*Prosopsis juliflora*), and wild indigo (*Teporosia purpurea*) are common and act as sand binders (Smith, 2010; Muthulingam *et al.*, 2013). During the northeast monsoon season, depressions and storms from the South Bay of Bengal cause heavy rain, thunderstorms, and gusty winds. Tidal waves flooding the low-lying coastal area accompany most of the storms.

## Turtle Nesting in Puducherry

Sea turtle nesting usually begins in November and ends in April (although it may extend to June), with most turtles nesting from January to March. Turtles nest on dry, sandy beaches, ~20-40m above the high tide line, as observed in other parts of the world (Smith, 2010). The major turtle nesting beaches in the Puducherry region are at Narambai, Nallavadu, and Moorthikuppam villages, with 30-40 nests annually on each beach. Minor nesting beaches are found at Vanjiur village, near the Arasalar River in the Karaikal region (Figure 2). Minor nesting, with an average of 12-17 nests per beach annually, also occurs at Kanaga Chettikulam, Chinnakalapet, Periyakalapet Veerampattinam, Chinnaveerampattinam, Nallavadu, Pannithittu, Narambai, and Moorthykuppam, Vanjiur villages scattered along the Puducherry coast (Hatkar *et al.*, 2016).

## Threats to Nesting Sea Turtles and Their Eggs and Beaches in Puducherry

Twenty-three years ago, there were reports of as many as the 100 nests on Nallavadu beaches (Banugopan & Davidar, 1999). In 2021, only 21 nests were protected by the Forest Department, fishers' ecological knowledge has also recognised a drastic decline in the turtles nesting on these beaches in the recent past (Jeyabaskaran & Kripa, 2018). All sea turtles in India are protected under the Wildlife (Protection) Act, 1972. However, during the nesting season, illegal take and sale of eggs, and exploitation of nesting turtles for meat, shell, flipper hide, oil, and fat have been significant threats. Until 2013, many villagers and fishers from Puducherry consumed turtle eggs and eggs were also sold in fish markets

(Banugopan & Davidar, 1999; Sankar *et al.*, 2016).

Additional threats are predators like jackals and feral dogs that depredate turtle eggs in the area (Kuppusamy *et al.*, 2016) and coastal erosion which has destroyed nesting beaches in Puducherry. Approximately 82% of the Coromandel coastline has experienced erosion due to the construction of ports and other development activities (Shanmugam *et al.*, 2014; Salghuna & Bharathvaj, 2015). Aquaculture and tourism along nesting beaches has also contributed to a decline in nesting numbers (Hatkar *et al.*, 2016).

**Conservation of Nesting Sea Turtles and Their Eggs and Beaches in Puducherry**

The Forest Department has initiated various turtle conservation actions, including preparing a turtle recovery plan for Puducherry, conservation of eggs during the peak nesting season (Figure 3), and involvement of villagers in turtle and nest protection. Forest Department officials faced a lot of difficulties while collecting eggs during the initial days. Miscreants would reach the beaches earlier than officials to take the turtle eggs. However, the Forest Department staff and youth volunteers reached out to fishers in coastal settlements such as Nallavadu, Pannithittu, Narambai, Moorthykuppam, and Pudukuppam about the importance of protecting turtles and their eggs. People who used to illegally take eggs and turtles have now been involved in protecting and monitoring turtles in Puducherry (Kishore, 2014).

**Figure 3. Collection of Eggs by Forest Department Personnel for Protection in a Hatchery. (Photo credit: T. Singaravelou.)**

For many years, the Forest Department and local volunteers have patrolled nesting beaches. The Forest department has built temporary hatcheries along beaches between Nallavadu and Moorthykuppam. Two to three teams are formed every November to visit the villages for just a few hours. One team collects eggs along the coast from Gandhi Statue to Chinna Verrampattinam, another second team takes charge of the coast from the Boat House in Chunnambar to Pudukuppam, and the remaining team covers from Pudukuppam to Narambai. Once the eggs are collected from these places, they are taken to the temporary hatcheries to be protected under the supervision of the local volunteers.

Milestone events in the conservation of nesting sea turtles and their eggs in Puducherry are:

In 2000-01, the first formal survey of Puducherry-Chennai (Tamil Nadu) was conducted. Seven nests were recorded along 60km of coastline in January-February 2001 (Bhupathy & Saravanan, 2006).

In 2003-04, Mamallapuram-Puducherry beach (50km) was surveyed as part of the UNEP/CMS-IOSEA Project, A total of 540 nests were recorded, with peak nesting observed in the first fortnight of March (Bhupathy, 2007).

In 2004, 36 nests were recorded along 50km of Mamallapuram-Puducherry beach by Nethaji Snake Park Trust (NEST) volunteers (Saravanan *et al.*, 2013).

In 2008, a rapid survey was undertaken by TREE Roots and Shoots, an NGO, and local fishers to record nests laid along beaches of the Puducherry coast. Interviews revealed that locals saw 10-15 turtles nesting on beaches before sea walls were erected (Vimalraj & Dharini, 2013).

In 2009, local NGOs began relocating the eggs at Veerampattinam to hatcheries on the same beach. Seven clutches, comprising 750 eggs, produced 700 hatchings. Hatchlings entangled in vegetation were rescued and released into the sea (Anonymous, 2009).

During 2011-12, sea turtle nesting surveys were carried out by Nethaji Snake Park Trust (NEST) volunteers. The volunteers walked a 10km stretch of coast daily from Kanagachetikulam to Puranakuppam in Pondicherry. Six nests were located between January and March 2012 and relocated to a safe place on the same beach to avoid depredation. These nests were monitored day and night by NEST volunteers. World Wildlife Fund surveyed from Mamallapuram to Pondicherry and found 44 olive ridley nests, with most laid between the second week of February and March 2012 (Saravanan *et al.*, 2013).

In 2013-14, a total of 1,723 turtle eggs from six locations were relocated to temporary hatcheries in Nallavadu and Narambai (Forest Department, pers.comm.). The Forest Department involved villagers in finding nests and safeguarding the eggs.

During 2014-15 temporary hatcheries at 14 locations in Nallavadu and Narambai protected 1,800 eggs (Kishore, 2014; Prasad, 2016). Villagers helped the forest department to collect eggs (Prasad, 2016).

In 2015-16, A total of 888 eggs were collected between Kalapet and Kanniakoil coastal hamlets by forest officials and safely transferred to Narambai hatchery. The Forest Department and volunteers released 114 hatchlings into the sea at Narambai (Prasad, 2016).

In 2017-18, Puducherry Forest Department personnel and volunteers collected 11,500 eggs, the highest number in 15 years. Around 7,000 turtle hatchlings were released from hatcheries in Pudukuppam and Narambai under the supervision of local volunteers (Jeyabaskaran & Kripa, 2018).

During 2019-20, about 10,300 eggs were relocated to hatcheries in Narambai and Pudukuppam. The first batch of 240 hatchlings was released at Narambai in March 2020 in a joint initiative by the Forest Department and youth volunteers (Special Correspondent, 2020).

During 2020-21 the onset of the nesting season was delayed later than in previous seasons, possibly due to the influence of successive Cyclones Nivar and Burevi that swept through the eastern seaboard late 2020. Forest department officials and locals collected ~10,300 eggs for protection (Special Correspondent, 2020).

Even though such conservation initiatives can be productive, there is no systematic or structured management to protect the nesting beaches and hatcheries in Puducherry. Sea turtle nesting areas are declared Coastal Regulation Zone–I areas and considered ecologically sensitive. Maps have been prepared for the Union Territory of Puducherry by the Institute of Remote Sensing (IRS), Anna University, and approved by the Ministry of Environment Forest & Climate Change (Anonymous, 2019). As per the coastal regulation zone, 0.19km$^2$ area is categorised as ecologically sensitive areas of turtle nesting ground (CRZ- IA) by the Coastal Zone Management Plan. In such areas, no development or new construction can occur.

**Threats to In-water Sea Turtles and Their Habitats**

The number of sea turtles inhabiting waters off the Pondicherry coast is uncertain. Light pollution has been disrupting the movements of adult turtles and disorienting hatchlings. The bycatch of sea turtles in fisheries is a serious and growing threat along this coastline (Sankar *et al*., 2016) and needs to be quantified. Drowning in trawl nets along the Pondicherry coast is the primary cause of the decline of sea turtle populations (Sankar *et al*., 2014). Once sea turtles have been entrapped in the trawl net, they can be dragged over for 1-3 hours; as a result, turtles often receive injuries to their head and elsewhere (Donnelly, 2008). Sometimes, fishers cut off the flippers to remove turtles from the fishing net. Analysis of ghost nets recovered from the Puducherry coast from August to September 2013 showed they were constructed of monofilament and made of high-density polyethylene (Stelfox *et al*., 2015).

In 1998-99, preliminary surveys carried out from December 1998 to April 1999 found 54 carcasses of turtles on Puducherry beaches. Fishers admitted that trawler operations were responsible (Banugopan & Davidar, 1999).

In 2003-04, 139 turtle carcasses were found within a 3km stretch of coast from Mamallapuram to Pondicherry (Bhupathy *et al*., 2006).

From 2003-05, carcasses of 135 olive ridley and five green sea turtles were found on the Puducherry beaches (Bhupathy *et al*., 2007).

From December 2011 to March 2012, 143 carcasses of olive ridley turtles were reported in the Karaikal region (Vinoth & Sandilyan, pers. comm.). Also, in 2011-12, 139 olive ridley turtle carcasses were found along the Mamallapuram to Pondicherry coast (Saravanan *et al*., 2013).

In December 2013, ~100 stranded dead turtles along the Nagapattinam coast were reported by Tree Foundation (Jha, 2014).

A detailed study of the nesting and carcasses of turtles was not available in Puducherry till 2013 (Pande, 2014). In 2013-14, 47 turtles were found dead around the Pudducherry coast (Table 1). Many were found near the Nallavadu estuary (Forest Department, pers.comm.).

From 2013-15, the Forest Department observed the highest mortality of sea turtles in the month of January, when fishing peaked. Before and during January each year, turtles aggregate in shallow water s near the beach for breeding. These same waters are also substantial gillnet fishing grounds (Bhupathy *et al*., 2006).

In 2014-15, another 111 dead turtles were found along the Puducherry coast (Table 2), most from Nallavadu, Narambai, Veerampattinam, and Pannithittu. The carcasses found on the beach of Narambai had carapace damage from being hit by boat propellers. Bycatch rates

**Table 1. Turtle mortality in Puducherry during the peak of the 2013-14 nesting season. (Data source: Forest Department of Puducherry.)**

| Date | # Dead Turtles | Location |
|---|---|---|
| 20-12-2013 | 1 | Narambai |
| 27-12-2013 | 1 | Pudukuppam |
| 29-12-2013 | 1 | Panitthitu |
| 03-01-2014 | 3 | Nallavadu |
| 09-01-2014 | 2 | Nallavadu |
| 11-01-2014 | 1 | Pannithittu |
| 12-01-2014 | 1 | Nallavadu |
| 13-01-2014 | 1 | Nallavadu |
| 17-01-2014 | 4 | Vallavarmedu |
| 28-01-2014 | 2 | Narambai |
| 28-01-2014 | 4 | Murtthykupam |
| 29-01-2014 | 11 | Nallavadu |
| 31-01-2014 | 4 | Pudukuppam |
| 02-02-2014 | 1 | Pillaichavady |
| 13-02-2014 | 1 | Nallavadu |
| 23-02-2014 | 2 | Pillaichavady |
| 06-03-2014 | 2 | Pudukuppam |
| 12-03-2014 | 2 | Valluvarmedu |
| 13-03-2014 | 2 | Gandhi statue |
| 15-03-2014 | 1 | Narambai |
| TOTAL | 47 | |

of sea turtles have not been studied in this area yet.

Many of the carcasses found in the studies above were decomposed, and post-mortem examination could not conclusively determine the cause of death.

## Conservation of In-water Sea Turtles and Their Habitats

Most turtle mortality along the Puducherry coast, excluding areas off the coast of Mahe, Karaikal, and Yanam, occurs from December to April (Jeyabaskaran & Kripa, 2018). Srivastava & Ahuja (2002) suggested that TEDs should be implemented along the coast (excluding the named areas) from December to April. The Fisheries Department has issued directions for fishers to cut their nets to free trapped turtles, and the Forest Department and Fisheries Department are exploring the possibility of compensating the fishers to release entangled sea turtles. Fishers having proof of a sea turtle entangled in their net and released alive can claim compensation (Jeyabaskaran & Kripa, 2018).

Local NGOs such as Temple Reef Foundation have been conducting ghost net and beach clean-up activities (Jagannathan, pers.comm.). National Institute of Ocean Technology designed and implemented the pilot project 'Restoration of Puducherry Beach' in March 2017. Construction of northern wedge reef was completed in August 2018. Sand nourishment has been carried out in parallel, and is to be continued. Construction of the southern reef is yet to commence (Anonymous, 2017).

One stranded, female olive ridley turtle was rescued from Murthikuppam beach in December 2018 and was released successfully after treatment by a local veterinarian (Staff Reporter, 2018). Currently, there are no facilities or rehabilitation centres to treat stranded or bycatch turtles.

## RECOMMENDATIONS

The number of sea turtles inhabiting waters off the Puducherry coast is uncertain. There is no information about the spatial occupancy and movement pattern of sporadic sea turtle populations nesting on the beaches of this coast, which is crucial for spatial planning for biodiversity conservation and rational planning of marine ecosystems, including sea turtles are under threat due to developmental activities.

1. Human activities on the beach should be highly regulated during the breeding season to avoid illegal take. The turtle nesting sites of Puducherry need to be identified and mapped and declared as ecologically sensitive areas or 'Community or Conservation Reserves'. Such reserves should be managed with the active participation of local communities for the long-term conservation of sea turtles in Puducherry.
2. Hatchery management practices need to be reviewed and regulated. Hatching success needs to be evaluated, and accurate records must be maintained.
3. Regular beach cleaning activities should be conducted through government and private organizations to increase public awareness; proper collection and disposal of marine debris to maintain nesting beaches and nearby coastal areas should be practiced. Incentive schemes should be given to locals and fishers to protect the sea turtles.
4. The government of India is developing a policy to deal with marine species that frequently get stranded on shores. The policy will help identify the hotspots where marine stranding is taking place. Once that is completed, a Rapid Response Team and veterinary and medical facilities will be deployed to treat these

**Table 2. Turtle mortality in Puducherry during the peak of the 2014-15 nesting season. (Data source: Forest Department of Puducherry.)**

| Date | # Dead Turtles | Location |
|---|---|---|
| 10-12-2014 | 1 | Pudukuppam |
| 12-12-2014 | 3 | Narambai |
| 20-12-2014 | 1 | Mahendira Hotel |
| 21-12-2014 | 1 | Narambai |
| 26-12-2014 | 1 | Hotel Sea Gulls |
| 27-12-2014 | 1 | Auro Beach |
| 02-01-2015 | 1 | Chief Secretariat |
| 03-01-2015 | 1 | Nallavadu |
| 04-01-2015 | 2 | Pannithittu |
| 06-01-2015 | 2 | Veerampattinam |
| 07-01-2015 | 1 | Mahedira hotel |
| 08-01-2015 | 4 | Nallavadu |
| 09-01-2015 | 2 | Narambai |
| 09-01-2015 | 2 | Nallavadu |
| 10-01-2015 | 2 | Auro beach |
| 11-01-2015 | 7 | Veerampattinam |
| 11-01-2015 | 2 | China Veerampattinam |
| 13-01-2015 | 1 | Lay Pandai |
| 17-01-2015 | 4 | Veerampattinam |
| 21-01-2015 | 1 | Narambai |
| 21-01-2015 | 1 | Valluvar Medu |
| 21-01-2015 | 1 | Pannithittu |
| 21-01-2015 | 1 | Pannithittu |
| 21-01-2015 | 1 | Nallavadu |
| 21-01-2015 | 1 | Pudukuppam |
| 23-01-2015 | 2 | Veerampattinam |
| 23-01-2015 | 1 | China Veerampattinam |
| 23-01-2015 | 6 | Nallavadu |
| 23-01-2015 | 3 | Pannithittu |
| 23-01-2015 | 3 | Narambai |
| 24-01-2015 | 6 | Mahedira Hotel |
| 24-01-2015 | 1 | Nallavadu |
| 27-01-2015 | 1 | Beach Resort |
| 28-01-2015 | 1 | Pudukuppam |
| 29-01-2015 | 4 | Narambai-Nallavadu |
| 30-01-2015 | 2 | Nallavadu |
| 30-01-2015 | 4 | Pannithittu |
| 01-02-2015 | 1 | Veerampattinam |
| 05-02-2015 | 4 | Pudukuppam |
| 05-02-2015 | 3 | Nallavadu |
| 05-02-2015 | 3 | Nallavadu |
| 05-02-2015 | 2 | Pannithittu |
| 05-02-2015 | 3 | Narambai |
| 10-02-2015 | 4 | Narambai |
| 10-02-2015 | 2 | China Veerampattinam |
| 12-02-2015 | 1 | Nallavadu |
| 12-02-2015 | 1 | Narambai |
| 16-02-2015 | 1 | Valluvar Medu |
| 19-02-2015 | 1 | Pannithittu |
| 23-02-2015 | 2 | Pannithittu |
| 23-02-2015 | 2 | Nallavadu |
| 23-02-2015 | 2 | Narambai |
| 01-02-2015 | 1 | Veerampattinam |
| 05-02-2015 | 4 | Pudukuppam |
| 05-02-2015 | 3 | Nallavadu |
| 05-02-2015 | 3 | Nallavadu |
| 05-02-2015 | 2 | Pannithittu |
| 05-02-2015 | 3 | Narambai |
| 10-02-2015 | 4 | Narambai |
| 10-02-2015 | 2 | China Veerampattinam |
| 12-02-2015 | 1 | Nallavadu |
| 12-02-2015 | 1 | Narambai |
| 16-02-2015 | 1 | Valluvar Medu |
| 19-02-2015 | 1 | Pannithittu |
| 23-02-2015 | 2 | Pannithittu |
| 23-02-2015 | 2 | Nallavadu |
| 23-02-2015 | 2 | Narambai |
| 20-03-2015 | 1 | Puducherry |
| TOTAL | 111 | |

species and put them back in the water. Morphometric records of the strandings need to be maintained since the morphological analysis of characteristics can impart information about the life of the turtles.

5. Wildlife Institute of India has advised the Puducherry Government to initiate the 'Marine Turtle Scholarship' to school-going children of poor fishermen communities to strengthen the involvement of fishermen communities in Marine Turtle Conservation. The children would become

'Turtle Ambassadors' and promote conservation.

6. Hotspots of fisheries interactions with sea turtles need to be identified. Turtle excluder devices should be strictly implemented, and the ban on nearshore mechanised fishing and fishing in high-use areas or migratory or foraging grounds should be strictly enforced to reduce bycatch rates and mortality of sea turtles.

7. The Wildlife Institute of India formed an action plan for conservation to address these issues and regulate the conservation actions for the onshore and offshore natural and anthropogenic threats to the sea turtles. However, when done correctly and in accordance with all laws, nourishment may create suitable habitats for rare or threatened organisms like sea turtles (Speybroeck *et al.*, 2006). Beach nourishment is generally only beneficial to sea turtles in areas with less degraded nesting habitats. Department of Science, Technology and Environment is proposing to prepare a geospatial database on the coastal resources of Puducherry under the Integrated Coastal Zone Management Project, which will help the planners in identifying and addressing the key issues.

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# SUB-REGIONAL REVIEWS OF THE SEA TURTLES OF THE NORTH-WESTERN AND WESTERN INDIAN OCEAN

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Summaries of our understanding of the distribution and status of sea turtle populations in the western and north-western Indian Ocean were first compiled and presented at the *World Conference on Sea Turtle Conservation* in the US in 1979. The summaries were subsequently published in 1982 in the *Biology and Conservation of Sea Turtles*, edited by Karen Bjorndal. Containing now forty-year-old data, these seminal chapters formed the foundation of our understanding, and for decades were the go-to resources to obtain an overview of our understanding of turtles in the wider region. Ross & Barwani (1982) presented an extensive review of what was known from the Arabian region, for example, highlighting the regionally important nesting populations of green turtles in Saudi Arabia, Oman and Yemen and the globally significant loggerhead nesting population of Masirah Island in Oman. Each country (Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar, United Arab Emirates, Oman, Yemen) and the grouped entry covering the Red Sea had a dedicated description on turtle status including known nesting abundance and threats. Frazier (1982) similarly reviewed the central western Indian Ocean, covering Somalia, Kenya, Tanzania, Seychelles, Mayotte, Comores, and the British Oversea Territories. He described nesting by green and hawksbill turtles, with the green turtle being more numerous but only moderate to low numbers of nests by either species. Completing the western Indian Ocean region, Hughes (1982) presented the situation for turtles in the remaining two continental countries (Mozambique and South Africa) together with Madagascar, Réunion and Mauritius. It again indicated the distribution of nesting populations, including green, hawkbill and loggerhead turtles and the only regular leatherback nesting population of the region, present in the mainland, transboundary Maputo Reserve. Hughes' chapter had more of an emphasis on establishment and utility of protected areas or reserves to aid conservation of turtles than Ross & Barwani (1982) and Frazier (1982).

For more recent regional reviews we must jump forward to the late 2010s when the Regional Reports published by the IUCN Marine Turtle Specialist Group (MTSG) were compiled. *Sea Turtles in the Middle East and South Asia Region: MTSG Annual Regional Report 2021* (Phillott & Rees, 2021), the most recent version for that sub-region of the Indian Ocean, summarised our understanding of sea turtle conservation status in all (21) territories of the region, starting at Djibouti and countries bordering the Red Sea, and eastwards to Yemen and Oman and the countries bordering the Persian Gulf. The report also covered countries making up south Asia. *Sea Turtles in the East Africa and the West Indian Ocean Region: MTSG Annual Regional Report 2020* (Dalleau *et al.*, 2020) is the most recent version of the report for that subregion. It contained chapters from seven of the 14 territories in the region (Kenya, Tanzania, South Africa, Seychelles, France – Reunion Island, France Eparses Islands, British Indian Ocean Territories – Chagos) with France-Mayotte, Somalia, Mozambique, Madagascar, Comoros, and Mauritius not represented. These MTSG Regional Reports were formatted to present individual country-chapters detailing aspects such as nesting and in water distribution and abundance of the sea turtle species present together with threats and conservation actions per species Regional Management Unit (Wallace *et al.*, 2010) per country. An overview chapter in each report summarised the individual country chapter contents, highlighting the most pertinent findings.

Now, in 2022, comprehensive reviews of sea turtles of the north-western Indian Ocean and those of continental eastern Africa have been published. The paper covering the north-western Indian Ocean is authored by Al Ameri and 21 other experts (Al Ameri *et al.*, 2022). The thorough review synthesises over 250 primary and grey literature sources. It, together with the extensive supplemental material, presents data on turtle occurrence, nesting biology, morphology, foraging areas, population status, threats, and relevant national legislation from 13 countries with significant coastlines in the region. Furthermore, the review highlights the perceived most significant threats to turtles in the region together with the most critical knowledge gaps, impediments to practical conservation, and essential strengths and opportunities in the region. Al Ameri *et al.* (2022) concludes that up-to-date information, such as nest abundance, are lacking for many locations across the north-western Indian

Ocean and calls for local actors to focus to address these gaps through new initiatives and publication of existing data. In doing so, together with the synthesis of threat distributions, best practices can be targeted in areas requiring most conservation interventions. van de Geer's paper (van de Geer *et al*., 2022) also includes 21 additional, expert co-authors in the review covering sea turtles of the five continental eastern African countries (Somalia, Kenya, Tanzania, Mozambique, and South Africa). Using a mixed methods approach, data on nesting (abundance and distribution), foraging and migrations of five species of sea turtle, together with relevant anthropogenic threats, were compiled from systematic literature searches with additional input from the identified experts. The collected information, which is available in the extensive supplemental material published with the review, is synthesised into a clear and contextualised precis. Knowledge gaps and conservation initiatives are discussed, and the article concludes that-despite progress in the region over the last two decades-significant gaps remain which hinder better insight into the status of turtle populations in continental eastern Africa. It is suggested that conservation and research of sea turtles should feed into ecosystem-based approaches, which consider coastal peoples and their cultures and hence achieve sustainability for all threatened species.

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# CONFLICTS IN CONSERVATION: A REVIEW OF THE IMPACT OF SEA TURTLE CONSERVATION ON FISHER COMMUNITIES IN INDIA

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## INTRODUCTION

Conservation and management of wild species and resources requires a thorough understanding of ecological factors and effective engagement and contribution by different stakeholders, including local communities that co-habit or utilise similar space and resources (Ban *et al.*, 2013). As the world has become largely human-dominated, conservation planning and activities are increasingly taking into consideration the welfare of local communities. However, conservation of wild species can result in conflicts, especially when a local community's access to a resource or space is prohibited, and in the absence of any suitable alternatives (Berkes, 2004). Consequently, this can turn many people against biodiversity conservation efforts, resulting in a lowered respect for the value of wildlife and, sometimes, negative interactions with the species (Naughton-Treves *et al.*, 2003; Agarwala *et al.*, 2010; Skogen, 2015). It can also lead to clashes between different stakeholders when communities regard the governments or park managers as possessing the "ownership" of wildlife (McCoy, 2003) that has the potential to harm their (communities') interests. If conflict arises, its resolution often revolves around a complicated mix of ecological, cultural, and economic factors (Marshall *et al.,* 2007; White *et al.,* 2009; Dickman, 2010). Ecological factors include wildlife behaviour and may or may not impact humans and their property. Economic factors include the monetary value of the loss or damage to human property, if any, and cultural factors determine human response/s to wildlife conflict (McCoy, 2003; Dickman, 2010). Therefore, devising an effective mitigation strategy to ensure a peaceful co-existence requires an in-depth look at the types of interactions between humans and wildlife and the factors just described.

Conservation in the marine ecosystem mainly focuses on improving quality of different habitats, reducing take of marine wildlife resources, and lessening fisheries-marine fauna interactions. In the context of fisheries, regardless of the intended target species, marine species such as the sea turtles can be accidently captured in fishing nets, what is known as bycatch. For sea turtles, fisheries and specifically bycatch have emerged as a major threat contributing directly or indirectly to the decline of many populations (Putman *et al.*, 2020). What complicates the issue further is that sea turtles are highly migratory, and interactions with fisheries become inevitable in most regions.

Of the five species of sea turtles found in India, olive ridley (*Lepidochelys olivacea*) and green (*Chelonia mydas*) turtles often interact with humans, mainly fisher communities in regions where turtles occur in abundance. In the past, all sea turtle species were hunted for their meat, eggs, carapace (shell), and fat/oil for sale or local consumption (Shanker *et al.,* 2012). There were even specific markets for sea turtle meat in West Bengal and Tamil Nadu, and in the Andaman and Nicobar Islands (Frazier, 1980; Kar & Bhaskar, 1982; Vijaya, 1982), and turtles were killed for oil in Gujarat and the Lakshadweep islands. Turtle eggs were widely consumed by communities along the entire coastline (Shanker & Kutty, 2005). Cultural factors such as religion played a role in prohibiting some communities from consuming turtles. For example, turtles are considered an incarnation of the deity Vishnu, the protector, in Hindisum; therefore, certain communities did not hunt and/or consume sea turtles (Shanker & Kutty, 2005). In Islam, turtles are believed to be 'haram' and unsuitable for consumption, but eggs and other products can still be utilised (Shanker & Kutty, 2005; Rusli *et al.,* 2020). An additional factor that reduced turtle consumption in territories like the Lakshadweep islands was an increase in supply and availability of other food items (Anonymous, pers. comm., 2018). However, it was mainly after the Wild Life Protection Act (WLPA) of 1972 came into force, that most turtle hunting activities ceased (Shanker & Kutty, 2005) except for that by the Scheduled Tribes of the Nicobar Islands whose rights remained protected under Section 65 of the Act.

However, the WLPA had implications for communities that lived alongside sea turtles. While actions to reduce threats and improve sea turtle populations were being implemented, certain stakeholders in coastal communities found these strategies to be detrimental to their subsistence and livelihoods. This paper will provide an overview of two cases where sea turtle conservation has affected fisher communities, collated using studies and ethnographies from India. It will also describe different causes of conflicts, the direct and indirect impacts on local communities and their livelihoods, and potential steps that could be employed by conflict managers and conservationists to strike a balance between enforcing conservation and safeguarding local livelihoods.

## PROTECTING TURTLES = HARMING LIVELIHOODS? OLIVE RIDLEY TURTLES AND FISHERIES IN ODISHA

### Sea Turtle Legislation in Odisha

Odisha (formerly known as Orissa) has historically been home to three important mass nesting sites of olive ridley turtles on mainland India: Gahirmatha beach, Devi River mouth, and Rushikulya River mouth. The olive ridley turtle breeding season at these sites lasts from October to May; mating occurs in offshore waters from October to December and nesting from January to May (Behera & Kaiser, 2020).

Between 1980-90, an increase in the export of shrimp to developed countries led to a rise in trawler fisheries in India, and the latter won governmental support because of the revenue it generated (Ramesh, 2021). As most trawling, gill-netting, and other forms of fisheries occurs in near-shore areas, there tended to be frequent interactions with marine megafauna such as sea turtles, dolphins etc that also utilised these habitats (Ramesh & Rai, 2017). Increased observations of dead turtles were attributed to drowning after accidental capture in gillnets and trawler nets (Rajagopalan *et al*., 1996; Pandav *et al*., 1997, 1998; Chadha & Kar, 1999; Behera *et al*., 2013, 2016). Other potential causes of turtle mortality due to fisheries were suggested to be injuries due to entanglement, propellor strikes, and/or the increased use of monofilament nets (Sridhar, 2005).

The first level of protection to olive ridley turtles was already provided by the WLPA listing it as a Schedule I species. Secondly, under the Orissa Marine Fisheries Regulation Act (OMFRA) passed in 1982, the Odisha State Government reserved the rights to regulate, restrict or prohibit all forms of fishing in different areas. OMFRA regulations further required that only 1,000 mechanised fishing vessels could be licensed to operate along the Odisha coast. Furthermore, in 1997, Gahirmatha rookery was declared a Marine Sanctuary (Gahirmatha Marine Sanctuary; GMS) under Section 26(1)(b) of the WLPA, protecting a total area of 1,435km$^2$ (core area of 725.50km$^2$ and buffer zone of 709.50km$^2$) and serving as a spatio-ecological solution to safeguard the olive ridley turtle population. The core area is located near the coastline and extends 10km out to sea, while the buffer zone is located in waters between 10-20km seawards. As per the marine sanctuary stipulations, catamarans and other crafts using motors less than 10 horsepower and employing monofilament nets were permitted within the buffer zone; however, all fishing activities were prohibited in the core zone (Sridhar, 2005).

In addition to fishing restrictions in the GMS, the Government of Odisha imposed a seasonal ban on trawler fishing within a 20km seaward radius in areas between the Jatadhar River mouth, Devi River mouth, and Chilika River mouth, and Rushikulya River mouth from 1st January 1998 to 30th May 2000. The seasonal ban continues to be enforced every year since. The OMFRA, 1994, also made installation of Turtle Excluder Devices (TEDs) mandatory for trawler nets; failure to comply resulted in cancellation of licenses. Later in 2001, the rule was amended to require compulsory usage of TEDs by all 'mechanised fishing vessels'. In 2003, a new directive was issued by the Central Empowered Committee (CEC) of the Supreme Court and the State High Power Committee (HPC) to ban all gillnet operations within 5km of the three mass nesting sites and completely prohibit trawling and gillnet fishing operations in Dhamra, Devi, and Rushikulya River mouths from 1st November 2003 to 31st May 2004 respectively (Sridhar, 2005).

To check if the aforementioned rules were being followed, the CEC of the Supreme Court made a site visit to Odisha and passed three more orders in 2004. The first order was that traditional, non-motorised gillnet vessels should use only small-mesh, monofilament nets with a maximum length of 300m within 5km from the coastline, and these vessels be allowed only in limited numbers within the areas where olive ridley turtles congregated for mating. The second order permitted motorised vessels deploying gillnets within 5km of the coastline except in the 5km restricted area near Devi and Rushikulya River mouths. These vessels were permitted to use only small-mesh, monofilament nets of a maximum length of 300m and not multifilament large-mesh nets. The third order prohibited the usage of sting ray nets, ring seine nets, sea bass nets, and all nets measuring 140mm and above in mesh size, whether monofilament or multifilament, along the entire Odisha coastline. Additional restrictions included that the area 5km from the shore could only be used by non-mechanised traditional crafts whereas mechanised vessels up to 15m length were allowed to operate 5km off the coastline. Any mechanised vessel weighing 25 gross tonnes and over or more than 15m in length, was permitted only beyond 10km from the shore (Sridhar, 2005).

## Implications for Fishers

The declaration of the GMS had come with its own set of problems. Its declaration was a move by the government with the following intentions: 1) to show the World Trade Organisation (WTO) that the government was dedicated towards the protection of the olive ridley turtle breeding population and 2) to serve as a counteraction to the USA's decision to ban shrimp imports from India due to environmental concerns (Ramesh, 2021). As the protection of olive ridley turtles through the GMS was considered a means to an end, it is possible that the ramifications of such a declaration were not fully considered.

After its declaration, a lot of the fishers did not have clarity on the precise rules and restrictions to operate within the GMS. There was also ambiguity over what was categorised as mechanised (with inboard engines and propulsion systems) and motorised (boats with outboard motors or transportable inboard engines) vessels and gear, which caused further confusion over permissible form of fishing within the buffer zone (Sridhar, 2005). This worsened as the Forest Department officials patrolling the region had no understanding of vessels and gears, resulting in clashes with fishers in the region.

In addition, the demarcation of the core area and the buffer zone of the GMS was such that, in order to access the buffer zone, fishers had to pass through the core zone. While there was a provision that allowed safe passage to traditional fishers through to the buffer zone, it brought into question the rationality with which the core area had been assigned (Sridhar, 2005). Another point of contention was the year-round ban on fishing and prohibition of activities in the core zone considering that turtle breeding (congregating, mating, and nesting) lasted for 6-9 months in an entire year. Fishers argued that the GMS did not even ensure complete protection of olive ridley turtles as breeding congregations were observed further northeast and outside the designated area (Ram, 2000). Therefore, any fishing restrictions imposed in the GMS predominantly affected the small-scale fishers who were already struggling to earn a livelihood, leading to a belief that turtle conservation efforts were 'anti-poor' (Ramesh, 2021).

The trawler industry also strongly opposed many of the conservation measures. Trawler owners complained that a year-round fishing ban in the GMS was unjustified as the turtle breeding season lasted only nine months (Sridhar, 2005). Moreover, as per the Government requirements, it was mandatory for trawlers to use TEDs which, according to the trawler industry, resulted in a considerable loss in fish catch. Additionally, TEDs were to be used year-round even though the turtle season lasted for nine months. Trawler operators were open to modifying the TEDs to ensure that there was minimal fish loss. While institutes like Central Institute of Fisheries Technology (CIFT) made changes to the TEDs (Boopendranath *et al.*, 2006), these modified designs were not assessed for efficiency and trawler operators remained unconvinced about their efficacy (Shanker & Kutty, 2005). Consequently, as the implementation of TEDs was not monitored by the enforcement agencies (Shanker *et al.,* 2004), trawlers continued operating as per usual which did not help the cause of turtle protection. The trawler operators also pointed out that threats such as light pollution, habitat destruction, and depredation were left unchecked while the trawler industry was unfairly blamed for all or most turtle mortality on the Odisha coast (Behera, 2006).

The conflict was further fuelled by instances of violence initiated by both fishers and State Forest Department guards. Forest guards alleged that trawler crews would often intimidate them by employing scaring tactics such as throwing dynamite (Wright & Mohanty, 2006). In 2003, forest guards were 'abducted' by gill netters, and one guard died after being pushed overboard (Wright & Mohanty, 2006). It was reported that two fishers were shot dead by guards in 2005/06, which led to a public uproar over treatment of fishers by the enforcement agencies (ICSF, 2009).

Fishers also reported that forest guards would stop and seize catch from gill netters and trawlers even though the fish were caught outside the sanctuary boundary, where fishing was permitted (Chhotray, 2016). Similar complaints were raised by trawler operators who said that the Forest Department would try to charge hefty penalties, not comparable to the value of catch that was seized. Their complaint indicated that the Department would go against the CEC's recommendation of auctioning the fish seized in the sanctuary in the presence of the trade union representatives (Wright & Mohanty, 2006). There were several cases of fisher suicides due to loss of livelihoods and inability to pay back debts reported from Kendrapara district till 2006. These restrictions also had larger implications for fisher families, as women who were involved in post-harvest and marketing activities were also impacted. Furthermore, other community members that earned their daily income through crab collection and fishing in the creeks and mangroves near Bhitarkanika Wildlife Sanctuary and GMS were adversely affected due to lack of access to these habitats (ICSF, 2009).

In addition to the declaration of GMS, various seasonal and gear bans were imposed with the intention of protecting olive ridley turtles; however, it had adverse impacts on fishers as these restrictions along the coast reduced their access to fishing grounds. As there were no studies conducted on the impact of different gears or fisheries on sea turtle mortality, there was no justification to the specifications provided under the rules (Sridhar, 2005). The usage of the ambiguous terms and phrases in these regulations further exacerbated the situation (Shanker & Kutty, 2005):

a) When 'gill netters' was mentioned, the type of craft was not specified, and therefore, enforcement agencies interpreted this as any vessel using a gillnet was not permitted. However, all boats except trawlers used gillnets, and, thus, it impacted vessel owners that were permitted under the general vessel type rules; and,

b) There was lack of clarity in legislation over the meaning of terms 'mechanised, 'motorised', and 'traditional' while referring to vessels and types of fisheries.

Often, the State Forest Department would penalise (via fine and confiscation of nets) traditional fishers using monofilament nets in the Rushikulya area. The terrestrial-centric training of the guards in the Forest Department meant that they could not distinguish between different types of gears, nets, and vessels leading to unpleasant interactions. It finally culminated into a conflict in 2003 when a ban on the usage of gillnets was proposed for Devi and Rushikulya River mouth areas as well. As the ban resulted in distress within the fisher community, the Orissa Traditional Fishworker's Union (OTFWU) brought forward their issues to the Odisha government and the CEC. The lack of consultation prior to the declaration of GMS made the fishers fear that if the Rushikulya and Devi River mouth areas were declared as marine sanctuaries, it would further reduce accessible fishing grounds and harm their livelihoods. In addition to prohibiting mechanised fishing near the Devi and Rushikulya River mouths within 20km of the high tide line between 1st November and 31st May of every year, there was also the annual fish breeding season ban from 15th April to 31st May (Sridhar, 2005). Therefore, along with reduced access to fishing grounds, fishers were also unable to fish in months when economically important fishes such as hilsa were abundant. While the use of mechanised vessels in the nearshore waters was banned in all coastal states of India in order to safeguard traditional fisher livelihoods, the strict imposition for turtle protection was viewed as a turtle vs. people rule (Shanker & Kutty, 2005).

### Recommendations Towards Mitigating the Conflict

Over the years, there has been considerable attention given to fisheries impacts on olive ridley turtle mortality in Odisha. While it is well known that interaction with fisheries is one of the major threats to sea turtle mortality across the world (Swimmer *et al.,* 2006; Lewison *et al.*, 2014), in there needs to be sufficient information on how the different types of nets, gears and fisheries contribute to this mortality in Odisha. Moreover, the singular focus on fisheries has negated the need to assess and mitigate other threats, including light pollution that causes dis- and/or mis-orientation in hatchlings and disturbance to nesting turtles, nesting habitat degradation due to sand mining and beach armouring, development activities on nesting beaches, and egg depredation by feral animals (Pandav, 2000; Sridhar & Shanker, 2007). There is also a need for better coordination between different agencies of the Government, such as the Fisheries and Forest Departments, in the monitoring and conservation of sea turtles and reducing threats, as well as in framing legislation that fall under the purview of both bodies (Sridhar, 2005). Deriving from the ethnographies of the GMS and Rushikulya, Ramesh (2021) also suggested that conservation practitioners and managers must consider development activities in the region keeping in mind larger political economy and determine different ways of collaboration for conservation.

As Shanker & Kutty (2005) explained, the intense focus on olive ridley turtles in Odisha created a rift between fishers and conservationists, and the flagship status of the turtles ended up creating a "polarised and politicised battle". Conservation regulations can pit conservationists and the State against local stakeholders such as fisher communities as these measures can impact livelihoods, cause harassment and violence by all sides, and result in other complications that stem from 'fortress conservation' (Sridhar & Shanker, 2007).

## MORE TURTLES, MORE PROBLEMS: GREEN TURTLES AND LAGOON FISHERS IN THE LAKSHADWEEP ISLANDS

### Sea Turtle Legislation and an Improvement in Green Turtle Numbers

The Lakshadweep islands lie approximately 200km off the southwestern coast of mainland India. The islands and adjoining lagoons serve as breeding and foraging grounds for green turtles (Tripathy, 2002, 2007). Earlier records showed low numbers of green turtles utilising these habitats (Bhaskar, 1978), potentially as a result of local harvest to obtain oil used to caulk boats and eggs for consumption. However, between 1995 and 2000, a remarkable rise in green turtle numbers was noted in the lagoon of Agatti Island (Tripathy *et al.*, 2002, 2007; Kelkar *et al.*, 2010). This was potentially the result of: 1) successful conservation activities such as nesting beach protections, hatchery programmes, and reduction in bycatch in the Indian Ocean (Arthur *et al.*, 2013); 2) intensive fishing of turtle predator, the tiger shark (*Galeocerdo cuvier*), in the region (Heithaus *et al.*, 2008; Arthur *et al.*, 2013); and/or, 3) change in the type of material used to construct boats (wooden to fibre) lowering the demand for turtle fat-based oil, and consequently, turtle hunt; and 4) increased availability of food coming from the mainland in the Lakshadweep islands reducing turtle egg consumption (Kale *et al*., 2022). The increased turtle numbers in the Lakshadweeps continues to be observed across space and time (Lal *et al.*, 2010; Kelkar *et al.*, 2013; Kale *et al*., 2022).

In 2008, Lal *et al.* (2010) observed that the high densities of green turtles were overgrazing seagrass meadows and causing changes such as reduced blade densities, canopy height, and biomass, especially of *Thalassia hemprichii* and *Cymodocea rotundata* species in Agatti island. As these seagrass characteristics reduced, the density and biomass of fish such as *Lethrinus harak* and *Parupeneus berinus*, that relied on seagrass meadows as habitats for feeding and protection, also reduced (Kelkar *et al.*, 2010). Similar trends in green turtle and seagrass densities were also observed in Kadmat (2013) and Kalpeni (2016) islands (Kale *et al*., 2022), which could have potentially impacted the lagoon fish density and biomass there as well.

### Implications for Fisher Resources and Livelihoods

Local fishers first experienced the effects of high green turtle densities on seagrass meadows and fish populations around 2004 (Kelkar *et al.*, 2014). The direct impact of increased turtle numbers included material losses in the form of destruction of fishing nets due to entanglement and/or breakage of nets, and disturbance of fish. The indirect impact was reduced catch of fish that were used as bait and for consumption. This caused considerable economic losses for fishers due to the costs incurred in buying and/or repairing nets, and fish catch loss and hence, sale or consumption. As the turtles harmed their livelihoods, fishers developed antagonistic feelings towards green turtles. It resulted, on rare occasions, in fishers killing or hurting adult sea turtles, destroying nests, and being verbally hostile about green turtles (Arthur *et al.*, 2013). Fishers, for most part, refrained from inflicting fatal harm to green turtles due to their protected status in the WLPA and strict monitoring by the local authorities (Anonymous, pers. comm., 2019).

Arthur *et al.* (2013) conducted a study to understand the logic that the fishers used to link green turtles with fish loss at Agatti and Kadmat Islands. Fishers at both locations described similar direct and indirect impacts of the increase in green turtle abundance. Interestingly, fishers at Agatti felt more strongly about the losses incurred and put more blame on the turtles. In comparison, while fishers at Kadmat also attributed their losses to green turtles, they believed that there were additional reasons for reduced fish catch, e.g., increasing number of fishers. When asked to suggest ways to reduce interactions or losses caused by green turtles, fishers' responses ranged from extreme measures such as culling of turtles, to methods to control their numbers, to changes in netting methods or target fish species. Fishers at Kadmat also provided neutral responses based on the understanding that there was no effective solution to this issue and that, once the seagrass regrew, the turtles would return, and this cycle would continue. Arthur *et al.* (2013) also measured fish catch and recruitment biomass which showed that the fisher perceptions of green turtles affecting seagrass abundance which in turn, diminished fish species aligned with the ecological patterns.

In 2014, it was observed that, despite green turtle densities reducing at Agatti, fisher perceptions had not changed and they continued to blame turtles for their loss of gear, the rates of which had also reduced (Kelkar *et al.*, 2014). Simultaneously, and even though Kadmat had experienced a dramatic rise in turtle numbers and fall in seagrass and fish resources, fishers at this location continued to have few negative feelings towards green turtles. Some considered the lagoon being cleared of seagrass as a good thing and felt it made catching fish easier, reduced seagrass entangling in nets, and made the lagoon look clean (Kelkar *et al.*, 2014).

As the turtle population size changed across islands over time, it was believed the conflict would eventually resolve itself (Arthur *et al.*, 2013). There was also the belief that the conflict would 'migrate' along with the turtles that were moving from one island lagoon to another for foraging, and perhaps antagonise fishers on other islands as well. This showed that drastic management measures were required to resolve the first-order conflict between turtles and fishers. The second-order conflict, because of the reduced fish numbers, could be mitigated by allowing seagrass meadows to recover to a sufficient density and canopy. The study highlighted the need to focus on active habitat or ecosystem conservation and management to allow for regrowth in seagrass and fish numbers and reduce other anthropogenic stressors such as dredging, sedimentation, pollution etc. (Arthur *et al.*, 2013). This case also emphasised that taxa- or species centric conservation can have adverse impacts and lead to habitat collapse due to green turtles overgrazing seagrass (Christianen *et al.*, 2014). Furthermore, to allow fishers to cope with the loss in fish catch as turtles continued to overgraze seagrass, resource managers and conservationists would have to help them adapt to targeting non-seagrass associated fish species such as *Gerres* or *Trachinotus* spp. (Arthur *et al.*, 2013). Gangal *et al.* (2021) also suggested regulating shark fisheries to improve seagrass populations by controlling the increase in green turtle numbers through predation.

### Lessons from the Lakshadweep Conflict

While most conflict management is aimed at solving the direct conflict caused by sharing of resources and is often easily quantifiable, there is also a need to consider the indirect impacts or second-order conflicts in devising management plans. Moreover, community perceptions and reactions are often ignored by managers who consider it biased or difficult to quantify and do not incorporate this dimension while forming management strategies. These opinions and perceptions, however, were useful in understanding the human perspective of the human-wildlife interface and determining the drivers behind a conflict. The Lakshadweep scenario shows that the fisher concerns were valid and sufficiently backed by ecological evidence that green turtles were the primary reason for reduced seagrass and fish biomass (Arthur *et al.*, 2013). It also showed that the same conflict can illicit different reactions in local communities (Kelkar *et al.*, 2014) and, therefore, conflict management requires a deep understanding of ecological mechanisms in conjunction with equal consideration towards human attitudes and perceptions to devise mitigation strategies.

## SUMMARY

Sea turtles have a wide habitat range and, therefore, interactions with a coastal population of nearly 560 million people in India are inevitable. In the past, cultural significance of sea turtles has been crucial in ensuring a peaceful co-existence between the two. However, the inefficacy of dated conservation techniques, where spatial separation or legal protection for wildlife can often be ineffective, or compensatory schemes to recover losses incurred by the communities too inadequate to cover the full costs of the conflict (Dickman *et al.*, 2013), defeats the purpose. The situation worsens when the livelihoods of an already impoverished community are threatened, resulting in hostility. The two cases from India presented in this paper highlight common themes and shortcomings caused by wildlife conservation actions that consequently resulted in the conflict scenarios. These conflicts show that there is a greater need for different stakeholders to work together while strategising ways to conserve a wild species. There should be a thorough assessment to identify relevant stakeholders, which include not only those that will be involved in the active conservation but also groups that may be affected by conservation plans. Further, if conflict arises, detailed studies must be conducted on relevant ecological, social, and economic factors to determine the most effective means of resolution. Prior to implementation of any laws, awareness campaigns can also be held to inform the community about the need to protect wildlife. This will also increase engagement between the State, conservationists, and the community which could be important for a transition as the conservation legislation comes into effect. In conclusion, the two cases provide different insights into the 'what to do' to avoid a conflict scenario due to wildlife conservation and the proposed mitigation methods must be considered by conflict managers to deal with potential future conflicts.

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# THE ROLES OF SEA TURTLES IN ECOSYSTEM PROCESSES AND SERVICES

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## INTRODUCTION

There have been promising reports of the recovery of sea turtle populations around the world due to conservation actions that have reduced bycatch rates and threats to nesting turtles and their eggs (Mazaris *et al*., 2017). However, current populations of sea turtles are still likely to be 15-30% less than historical numbers (Jackson *et al*., 2001; McCauley *et al*., 2015) and this decreased abundance has wider implications than just for population trends. Sea turtles have important ecological roles (functions of an organism in ecosystem processes) that contribute to the ecosystem services or benefits that people receive- and rely on- from ecosystems.

There are four main categories of ecosystem services: cultural, provisioning, regulating, and supporting (MEA, 2003). While there is a moral reason for conserving species for their intrinsic value (Wallach *et al*., 2018), the ecological roles of sea turtles and their contribution to ecosystem services can make a more powerful argument when trying to initiate action and influence policy for their conservation. In this review, we summarise the importance of sea turtles in marine ecosystem processes and services for easy reference by researchers, conservation practitioners, and educators. Where possible, we have drawn examples from countries bordering the Indian Ocean and in Southeast Asia.

## CULTURAL SERVICES

Cultural ecosystem services are the non-material benefits that can be derived from an ecosystem and are considered to be life-enriching and life-affirming contributions to human well-being (MEA, 2003; Satz *et al*., 2013). Sea turtles provide a host of cultural services to the communities that engage with them.

### Symbols

Sea turtles serve as important sociocultural symbols to the communities that they closely co-exist with, and to other stakeholders such as conservationists, fishers, policy makers etc. One such symbol is that of a "cultural keystone species", which Garibaldi & Turner (2004) define as "culturally salient species that shape in a major way the cultural identity of a people". An example of turtles as a cultural keystone species is seen in the Torres Strait, Australia, where the species are an essential component of culture, identity, and sea life (Kwan *et al*., 2001).

Another symbol often used to signify the cultural and ecological importance of a species is that of a "flagship species", the term bestowed on well known, charismatic animals that can act as representatives of the area they inhabit. Recognition as a flagship species is based less on the biology or ecology of the species, and more on public perception, appreciation, and approval (Dietz, 1994; Frazier, 2005). Sea turtles are flagship species, depicted on the coins, paper currencies and postal stamps of numerous countries around the world (Lopez, 1996; Frazier, 2005).

### Identity

The reverence for sea turtles has deep historical roots, as human-turtle interactions have occurred for centuries and spans areas across the globe ranging from South and Southeast Asia, Greece, Latin America, and the Pacific and Caribbean Islands. Millennia-old examples have been found in the Middle East and the Arabian Peninsula, where cylinder seals, decorative stamps for food, reliefs on palace walls, and other cultural artefacts clearly depict sea turtles (Frazier, 2005).

The cultural importance of sea turtles and other species is often expressed by sublimation into a source of identity for the community or region where close human-turtle interactions occur. At a macro-level, sea turtles are regarded as the emblematic animal for the Indian Ocean region (Chandrasekar & Srinivasan, 2013). Contributions of turtles to micro-level community identity can be seen in idols in religious context in the Penghu Islands of Taiwan (Balazs *et al*., 2000), and use of eggs and meat in religious (Voudou) ceremonies in West Africa (Chandrasekar & Srinivasan, 2013).

When the cultural importance of a species and/or practice involving sea turtles is so interwoven with the cultural and religious identity of a community, practices that are harmful to the existence of the turtles are often revered. This can lead to failure of conservation measures undertaken to curb such practices for the protection of the species; for example, a ban on consumption can do little to curb consumption itself as it may be perceived as a threat to the community's identity. This was observed in Baja California Sur, Mexico, where turtle meat was traditionally served at weddings, religious holidays (Christmas and Easter), and other celebrations (Mancini *et al*., 2011). Despite a total ban on the consumption and sale of sea turtles by the government in 1990, officials publicly consumed sea turtles. The meat continues to be a symbol of power among people with authority, and illegal trade of sea turtle products can sometimes be tied to drug trafficking in the country (Mancini & Koch, 2009; Senko *et al*., 2011).

### Diplomacy/ Political Significance (Resource Governance)

The cultural significance of sea turtles has facilitated large-scale and trans-border co-operation and conservation efforts. International environmental agreements are signed by numerous signatory states, an example being the Memorandum of Understanding on the Conservation and Management of Marine Turtles and Their Habitats of the Indian Ocean and South-East Asia (IOSEA MoU), with 35 signatory states in 2020 (CMS, 2020).

Sea turtles can also aid national level diplomacy. For example, Butler *et al*. (2012) found that the species' cultural value influenced the level of co-management and power-sharing between authorities and local communities in the Torres Strait region of Australia. The wide variety of local, national, and international beneficiaries led to an expansion of stakeholders among governing bodies, an example being expansion of the Torres Strait Protected Zone Joint Authority (PZJA) to include Torres Strait Islanders in addition to government representatives. In addition, the cross-cultural resource governance of the flagship sea turtles encouraged co-management of keystone species, which have essential ecological roles but are less publicly recognised, such as sea cucumbers and *Trochus* sea snails. Thus, sea turtles can play an important role in shaping local governance, formulating international policy, and even in facilitating multilateral relations.

## PROVISIONING SERVICES

Sea turtles provide a multitude of provisioning ecosystem services, i.e., tangible resources or goods at a micro- to macro-scale, that enrich human lives. Historically, sea turtles have provided food (meat, eggs, and oil) and other commodities (including shell, bone, leather, and medicine) to coastal peoples (Chandrasekar *et al*., 2013). With recent conservation efforts, most countries now regulate the consumptive use of sea turtles in these ways. However, illegal harvest and exploitation still occurs due to poor knowledge of existing laws, poor policy implementation and/or enforcement, and lucrative black-market opportunities.

### Food

The most used consumptive resources from sea turtles in current times are eggs and meat. Eggs can be harvested directly from the beach or purchased from collectors or markets, and the motive for consumption may be nutritional and/or cultural (Frazier, 2005; IOSEA, 2014). Meat usually originates from bycatch turtles (e.g., Sri Lanka; Rajakaruna *et al*., 2020), but targeted fisheries also operate (e.g., Madagascar; Golding *et al*., 2017). Consumption of turtle meat may also be for nutritional (IOSEA, 2014) and/or ritual (e.g., Madagascar; Lilette, 2006) purposes, and can be culturally regulated to minimise the risk of chelonitoxism (turtle poisoning) (Limpus, 1987; Aguirre *et al*., 2006).

### Ornaments

Tortoiseshell combs, jewellery, sunglasses and other items, and taxidermied turtles have been available for sale throughout the region (e.g., Islam, 2001; Tisdell & Wilson, 2003; IOSEA, 2014). Traditional ornamental and ceremonial (and utilitarian) uses of tortoiseshell in Papua New Guinea is also known (Kinch & Burgess, 2009). Japan imported ~114,500kg of raw bekko (Japanese for tortoiseshell) for carving and ~160,500kg of worked bekko (mainly stuffed hawksbill turtles) for ornaments from 1979-1981 alone, including from countries in the Indian Ocean and southeast Asia region (e.g., Indonesia, Kenya, Maldives, Philippines, Seychelles, Singapore, and Tanzania) (Mack, 1983). (See also Miller *et al*. (2019) and section on Trade below.)

### Medicine

Medicinal uses of sea turtle by-products include oil in Tanzania (West, 2010) and Eritrea (Mebrahtu, 2013), blood in India (Silas & Rajagopalan, 1984), and meat in Tanzania (West, 2010).

## Trade

Traditional products from sea turtles (Frazier, 1980) and emerging products, including hatchlings for the pet trade in Pakistan (Kiani *et al*., 2021), can be lucrative sources of income. Trade in sea turtle products can result from traditional practices, factors like poverty and lack of food security, and/or the desire for economic gain. Sea turtles may be caught deliberately or accidentally (as bycatch) and then traded legally or illegally for their numerous consumptive uses. Illegal markets may be local, regional, and international in scale (see Senko *et al*., 2011). Such a wide scale of markets might result in dependence of local communities on provisional services provided by the sea turtles, and even act as a primary source of income for the members of such coastal communities.

## Tourism

Meletis & Campbell (2007) propose that tourism is another consumptive use of sea turtles, as the industry consumes/extracts environmental resources. Sea turtle tourism has delivered economic, conservation, and/or education benefits in many countries, including Australia (Tisdell & Wilson, 2001; Wilson & Tisdell, 2001, 2003), India (Katdare, 2012), South Africa (Poultney & Spenceley, 2001) and Sri Lanka (Tisdell & Wilson 2003). Similar ecotourism initiatives have also been proposed for countries such as Indonesia (Haryati *et al*., 2016; Budiantoro *et al*., 2019; Nurhayati *et al*., 2022), and Oman (Al Busaidi *et al*., 2018). Note that the conservation benefits of some sea turtle tourism, such as hatcheries in Sri Lanka which operate illegally but openly and have long been an important local tourist attraction and source of income, has been questioned (Richardson, 1996; Hewavisenthi, 2001; Rajakaruna *et al*., 2013; Phillott *et al*., 2017).

## Curative Agent/Sealant

Oil or fat from turtles was historically used as a curative agent and/or sealant for wooden boats in the Indian Ocean region (see Bhaskar, 1979; Frazier, 1980; Thorbjarnarson *et al*., 2000). There have been no recent reports of continued use for this purpose.

## REGULATING SERVICES

Sea turtles contribute to regulating services, which are benefits derived from ecosystem processes that moderate natural phenomena and include biodiversity regulation and habitat modification.

## Biodiversity Regulation

Sea turtles play the role of regulators as they shape ecosystem structures through top-down modifications. Healthy seagrass beds are maintained by green turtles through grazing (Bjorndal & Jackson, 2002; Teelucksingh *et al*., 2010; Heithaus *et al*., 2014; Lovich *et al*., 2018). The consumption of seagrass results in increased water flow and aeration of sediments, thereby preventing sediment anoxia (Heithaus *et al*., 2014; Johnson et al., 2017). The removal of seagrass biomass through consumption also decreases self-shading (Teelucksingh *et al*., 2010), and reduces the likelihood of eutrophication by lowering the availability of organic matter that might support algal and epiphyte blooms (Christianen *et al*., 2012; Heithaus, 2013; Heithaus *et al*., 2014). By consuming the seagrass, sea turtles provide an alternate pathway for decomposition of organic matter, thereby allowing for a quicker detritus cycle (Thayer *et al*., 1982). Note also that overgrazing by sea turtles, due to high population numbers, can have negative impacts on seagrass beds (reviewed by Heithaus, 2013).

Hawksbill turtles play a similar role in regulating reef ecosystems through spongivory. Through selective feeding on sponges, they can affect succession and reef diversity by influencing competition for space and other resources (Bjorndal & Jackson, 2002; Teelucksingh *et al*., 2010). As sponges are competitively superior to corals, this allows for improved coral health and species richness (Lovich *et al*., 2018).

The same applies to leatherback turtles that predominantly prey on jellyfish. Owing to overfishing and other threats to marine vertebrates, jellyfish are positioned to dominate marine ecosystems; however, predation by leatherbacks acts as a check on their populations (Teelucksingh *et al*., 2010).

By reducing the populations of species of seagrass, sponges and jellyfish, these consumptive activities of sea turtles also have indirect effects on organisms that may be dependent on these species, thereby producing trophic cascades within ecosystems (Heithaus, 2013).

## Habitat Modification

Sea turtles also carry out habitat modifications through their foraging and nesting behaviours. The processes of body pitting, egg chamber construction, and filling in the nest all result in soil disturbance as well as the uprooting, burial and damage of coastal vegetation (Lovich *et al*., 2018). Seedlings near the edges of dunes can be dug up, and thus, prevent the encroachment of vegetation near the shoreline (Heithaus, 2013). Some organisms even use sea turtle nests as habitats (Madden *et al*., 2008), such as machrochelid mites (Mast & Carr, 1985) and seed corn maggots (Saumure *et al*., 2006).

Modification of benthic environments occurs during sea turtle foraging. Loggerhead turtles have been observed practising infaunal mining to find prey (Bjorndal & Jackson, 2002). While digging deep pits, they feed on invertebrates that are displaced from the sediment (Lovich *et al*., 2018). This can have the effect of uncovering fresh substrate and/or restructuring benthic communities (Teelucksingh *et al*., 2010). It also facilitates bioturbation, whereby reduced particle sizes and greater surface area of prey remains leads to reduced decomposition times, thereby maintaining high biological activity in marine sediments. In addition to this, the foraging behaviour of sea turtles displaces invertebrates, small particles, and pieces of prey that are consumed by a variety of fish that follow them, including pilot fish and angelfish (Heithaus, 2013).

## SUPPORTING SERVICES

In addition to the direct benefits that humans can derive from sea turtles, the species' also play supporting roles that facilitate other ecosystem services.

### Host to Epibionts, Parasites and Pathogens

Sea turtles act as hosts to parasites and pathogens and as substrates to epibionts (Bjorndal & Jackson, 2002). These roles provide a food source for a variety of cleaning organisms, including fish that consume parasites, dead skin or algae that grows on sea turtle carapaces. In offshore waters, some bird species use sea turtles as perching platforms and feed on fish that gather under them (Heithaus, 2013).

### Prey Item

Owing to their high biomass, sea turtles serve as prey to other species (Lovich *et al*., 2018). Eggs, hatchlings, post-hatchlings, and small juvenile turtles are predated upon by a variety of species, including insects, birds, mammals, large lizards, crocodiles and crabs. On entering the ocean, hatchlings also face threats from birds, sharks and other fish, and squid. Predation of adult sea turtles by non-human species is infrequent because of their large size. However, their recorded predators include terrestrial mammals such as jaguars, crocodiles, marine mammals such as monk seals and killer whales, and, most frequently, sharks. As they constitute a large part of the diets of a variety of predator species, sea turtles play an important role within food chains and their removal from ecosystems can result in trophic cascades (Heithaus, 2013).

### Nutrient Transport and Nutrient Cycling

Sea turtles are important biological transporters, introducing marine nutrients and energy to nutrient-stressed coastal ecosystems, including islands. They carry out cross-ecosystem transport in the form of eggs deposited on nesting beaches that carry nutrients from widely dispersed foraging grounds (Lovich *et al*., 2018). Though a proportion of these nutrients and energy return to the marine ecosystem as hatchlings, the remains in the nests are incorporated into the nutrient cycle through detritivores and decomposers, nest predators, and plant roots (Bouchard & Bjorndal, 2000). Marine-derived energy and nutrients are important additions to beach habitats as they support dune vegetation and predator populations (Heithaus, 2013). Sea turtles also partake in nutrient cycling within foraging grounds, consuming older and less productive seagrass biomass, and redistributing digested nutrients throughout the habitat as faeces (Teelucksingh *et al*., 2010).

## ENSURING SEA TURTLE POPULATIONS FULFIL ECOLOGICAL ROLES AND PROTECT ECOSYSTEM SERVICES IN THE INDIAN OCEAN AND SOUTHEAST ASIA

Ongoing conservation and monitoring efforts are important, even if sea turtle populations appear stable and/or increasing (see Mazaris *et al*., 2017). In the Indian Ocean and Southeast Asia region, recent examples of these efforts include: investigating consumption of turtle eggs in Malaysia (Poti *et al*., 2021) and turtle meat in Madagascar (Rothamel *et al*., 2021), and the call for a complete ban on egg trade in Terengganu (Mohd Jani *et al*., 2020); assessing vulnerability of sea turtles to the Indian Ocean tuna fisheries (Williams *et al*., 2018); using tracking data to understand migratory pathways and habitat usage by sea turtles (Pilcher *et al*., 2020, 2021a, b; Fossette *et al*., 2021) and inform conservation policy and management (Hays *et al*., 2019, 2021); identifying interventions to curb illegal harvest, use and trade in sea turtle products (Lopes *et al*., 2022); assessing threats of anthropogenic structures (Wilson *et al*., 2019), industry operations (Whittock *et al*., 2017), marine debris (Yaghmour *et al*., 2021), persistent organic pollutants (Yaghmour *et al*., 2020), oil spills (Yaghmour, 2020) and light pollution (Wilson *et al*., 2018, 2022) to sea turtles; and, facilitating collaborations among researchers, conservation practitioners, and civil society for sea turtle research, conservation and monitoring

(Stelfox *et al*., 2021). Conservation and monitoring in the region, such as demonstrated in the examples above, is also important because the largest groups of sea turtle regional management units (RMUs) in the Indian Ocean and Australasia (which includes Southeast Asia) have been scored as high risk-high threat (Wallace *et al*., 2011), and nesting populations of olive ridley turtles in Pakistan (Khan *et al*., 2010) and leatherback turtles in Malaysia (Liew, 2011) have been extirpated.

Research to understand past and present role(s) of sea turtles in the ecosystem has been identified as a global research priority (Hamann *et al*., 2010) in need of quantitative studies of all species in oceanic, neritic, and terrestrial habitats (Rees *et al*., 2016). Recent research in the region addresses green turtles as ecosystem engineers in the Lakshadweeps (Gangal *et al*., 2021; Kale *et al*., 2022), loggerhead and leatherback turtles as nutrient transporters in South Africa (Le Gouvello *et al*., 2017), and the role of green turtles as consumers in the Seychelles (Stokes *et al*., 2019), Western Australia (Stubbs *et al*., 2022), and Indonesia (Tapilatu *et al*., 2022), and olive ridley turtles in Oman (Rees *et al*., 2021). More work across different species, life stages, and locations is needed to understand the importance of ecosystem services provided by sea turtles (summarised in Table 1) in the Indian Ocean and Southeast Asia.

**Table 1. A summary of the ecosystem services provided by sea turtles.**

| Category of Ecosystem Service | Sea Turtle Contribution |
|---|---|
| Cultural | Symbol<br>Identity<br>Diplomacy/political significance |
| Provisioning | Food<br>Ornaments<br>Medicines<br>Trade<br>Tourism<br>Curative agent/sealant |
| Regulating | Biodiversity regulation<br>Habitat modification |
| Supporting | Host to epibionts, parasites and pathogens<br>Prey item<br>Biological transporter<br>Nutrient cycling |

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REPORT

# PRESIDENT'S REPORT FOR THE 40TH ANNUAL SYMPOSIUM ON SEA TURTLE BIOLOGY AND CONSERVATION, PERTH-ONLINE, AUSTRALIA, 25-28 MARCH, 2022

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40th International Sea Turtle Symposium

When the Board of the International Sea Turtle Society was forced to make the difficult decision to cancel the 40th International Sea Turtle Symposium in Cartagena, Colombia, in March 2020, the world was facing an unknown future as the reality of the COVID-19 pandemic started to emerge. It was a tough decision but in hindsight we feel it was the right one. The decision was also made to switch the location of the symposium to Perth, Western Australia and delay it until 2022.

The 40th International Sea Turtle Symposium (ISTS40) was therefore held between the 25th and 28th March 2022. The event was originally planned as a face-to-face symposium. However, with the ongoing global pandemic it was moved to an online event hosted on the Gather. Town platform and was managed by a team of people from Perth, Western Australia. Organising this event, the first ever online international sea turtle symposium, was incredibly challenging and would not have happened without the tireless work of our sea turtle biologist colleague, Dr Paul Whittock. In the two years leading up to the symposium, he single-handedly revamped the Society website, set up and managed the ISTS40 website (ists40perth.com.au), organised the online platform Gather.Town, managed the planning for regional meetings and workshops, worked out the program schedule, assisted the Session Chairs in session planning, drafted the Symposium Program, and responded to the hundreds of emails asking for help and advice. Paul's contributions to the Society and to the ISTS40 event were critical and without him it would not have been possible.

Over the four days of ISTS40, we attempted to recreate as many of the events found in a face-to-face Symposium as possible. On Friday 23rd March, we programmed and hosted 11 Workshops and seven Regional Meetings with up to 110 registered participants in some of them. On Saturday 24th March, we kicked off with a formal opening session which started with an Acknowledgement of the Traditional Custodians of the land upon which we met, for those of us in Perth the land of the Wadjuk Noongar, and a Welcome to Country by Traditional Custodian Nick Abrahams who welcomed the Symposium delegates to his Country. This was followed by keynote addresses by Abigail Ross (Principal Marine Environmental Advisor, Fortescue Future Industries), Dr Scott Whiting Principal Research Scientist and Coordinator of NWSFTCP, Department of Biodiversity, Conservation and Attractions (WA State Government), and Albert Wiggan, a Bardi, Nyul Nyul and Kija man, Indigenous Leader, Environmental Consultant and Social-Emotional Wellbeing Officer. This opening session started the three days of online presentations managed via the VirtualChair and ConfTool programs in the Gather.Town space. The space provided attendees the ability to view presentations in real time and for up to two weeks after the event, and gave people the opportunity to meet and chat via video streaming.

Statistics for this symposium :

- Held across 3 days and 43 hours of online content;
- Participants from 85 countries registered to attend (ranked #1 for all ISTS Symposia);

- o 675 registered individuals (ranked #14 for all Symposia; ranked #4 of all ISTS Symposia outside USA after Loreto (1,016), San Jose (1,000), and Crete (700));
- o 11 workshops were hosted;
- o 7 Regional Meetings were hosted;
- o 110 oral presentations delivered;
- o 130 posters presented;
- o Allowed students to attend for a cost of between US$5 - $20, making this the most accessible Symposium ever held by ISTS; and
- o Despite the low registration costs, the event was one of the most profitable ISTS Symposia ever held.

As the first online Symposium held by the ISTS there was an enormous learning curve since none of us had ever done anything like this before.

I want to recognise the huge effort by Dr Paul Whittock and the whole team at the Pendoley Environmental office for giving up their weekend to help out and make this Symposium possible.

I also need to acknowledge all those people who embraced the online approach and went out their way to help make the event happen, specifically:

- Dr Nancy FitzSimmons for stepping up and taking on the Session Chair role, she and her committee were the heart of this Symposium, selecting and programming the 110 talks and 130 posters from 221 oral submissions. Nancy and the global committee accepted the challenge and embraced the new approach to accepting, reviewing, and selecting abstracts via a completely new abstract management program (ConfTool). This was all done while she was deep in our Southern Hemisphere field season, on a remote island with no internet and dodgy mobile phone reception that required a hike up a hill to communicate. In every way she went above and beyond.
- The oral and poster authors. When the call went out for abstracts, we were nervous that nobody would respond. But you did and in that typical last-minute flood of submissions you gave us a Symposium.
- Dr Manjula Tiwari for being the brains trust, holding all the thousands of pieces of information in her head that forms the corporate memory of the Society and always available to answer numerous questions. Her steadying hand, wisdom and gentle diplomacy guided us though, and was all the more important in these COVID impacted years.
- Student Award judges, Awards Committee, Nomination Committee, Speed Chatting with Experts volunteers, Student Committee, Workshop and Regional Meeting organisers and assistants, and our future proceedings compilers.
- Our keynote speakers, for their passion, enthusiasm, and firm belief in the messages they delivered. They brought us new and challenging ideas to think about and introduced us to concepts and ideas beyond our own worlds and our own way of thinking.

While the online forum was not the first choice for those people who regularly enjoy attending the face-to-face Symposiums, it <u>did</u> provide an opportunity for people who may not otherwise have been able to attend, the chance to join an ISTS event. There were many benefits that came out of this online meeting, including:

- Substantially reduced carbon footprint.
  - o Using published criteria, the online Symposium produced ~10kg $CO_2$ per person compared to an in-person Symposium which produces ~1900kg per person. Travel, primarily long-distance flights accounts for 91–97% of total emissions.
  - o Blaine Friedlander of Cornell University in a *Nature Communication* piece concluded that moving a professional conference completely online reduces its carbon footprint by 94%, and shifting it to a hybrid model, with half of attendees online, reduces the footprint to 67%.
- Consideration of our personal contributions to global warming, something that we as marine turtle biologists and conservationists should be conscious of since turtles are so hugely impacted by climate change.
- Accessibility, reduced discrimination, and promotion of diversity and equal opportunities; the online event provided an opportunity for anyone who was interested to attend and allowed a greater inclusion of:
  - o Non-European/non-North American researchers, students, and junior researchers and conservationists who otherwise would not have the opportunity to attend or present at the conferences due to travel, accommodation

and registration costs.

  - o Parents and family caregivers who may not be able to leave home.
  - o People who do not have the luxury of personal leave time to travel.
  - o People who need to present at a Symposium for career advancement are not discriminated against if they cannot afford the time or costs of attending or travelling to a Symposium.
- Pre-recorded presentations that were efficient, predictable, and had no time zone restrictions
- The availability of presentations online for 2 weeks after the meeting gave everyone the chance to watch at their leisure

While the online event did have a few teething problems, overall the feedback was very positive, particularly from students and people who had neither the time or money to attend otherwise. For many I spoke to it was the first ISTS Symposium they had ever attended, and they loved it. I believe now might be the time for the ISTS membership and board to seriously consider different models for the annual ISTS Symposium, including; biennial international face to face meetings, online meetings, domestic satellite regional meetings, or a hybrid mix of all options.

So, thank you all for trusting my team and I to bring you an online Symposium. Thank you for stepping up, interacting, and trying out this new approach to an ISTS. We hope you enjoyed the virtual world we created for you and we look forward to catching up with you next time, either face to face in Cartagena, at another online meeting, or at some hybrid of these options. Who knows where the world will be in 12 months?

ANNOUNCEMENT

# 41ST ANNUAL INTERNATIONAL SEA TURTLE SYMPOSIUM: AN UNFORGETTABLE GATHERING!

DIEGO AMOROCHO

President of the International Sea Turtle Society, 2022-2023

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Between 18th and 24th March, 2023, the 41st International Sea Turtle Symposium will be held in Cartagena, Colombia. This event will bring together more than 600 people from 70 countries, including technical experts and researchers, government and private environmental entities, research institutes, academics, students, and members of coastal communities, to exchange knowledge, share experiences, propose measures, and move towards a better future for the turtles and us. Colombia will host this face-to-face event that will be held for only the second time in a South American country. It will be a unique opportunity to catch up with colleagues and friends from all around the world after the COVID-19 pandemic. The venue is the Hilton Hotel, Cartagena de Indias, Colombia. Under the theme '***Vision 20/20: Bridging Communities and Technology for Marine Turtle Conservation***', a series of topics will be addressed ranging from science, medicine, education, public policies, and community-based conservation efforts, in order to protect these legendary creatures that do not recognise political borders and which, without a passport or luggage, freely roam the seas of this Blue Planet.

More information about the 41st Symposium will soon be available at the International Sea Turtle Society webpage. So, please keep tuned to be part of this **Unforgettable Gathering!**

# INSTRUCTIONS FOR AUTHORS

Please refer to the style requirements listed below. Manuscripts should be submitted in MS Word or saved as text or rich text format. Appropriate files should be submitted by email to: iotn.editors@gmail.com. For further details please see www.iotn.org or consult a recent issue of IOTN.

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**Tables and figures:** Figures should not be embedded in the text file, they may be sent separately as JPEG, TIFF, BMP or PNG files. All figures and tables should carry a caption. Figures and illustrations must be accompanied by the appropriate credit/source. High resolution figures may be requested after acceptance of the article.

**References in text:** References should appear first in chronological then alphabetical order.

Two authors to be separated by '&' symbol, e.g., as Rai & Sahu, 2001

More than 2 authors: first author *et al.* (*et al.* in italics) e.g., Roy *et al.*, 2004

Two publications of the same year for the same author(s), the reference in the text should be Sharma 1960a, b not 1960a, 1960b and the two publications should be dated accordingly in the references.

Multiple references to be separated by a semi colon and in chronological order (Zade, 1995; Mathew, 1996a, b, 1998; Sharma, *et al.,* 2004; Forman & Gordon, 2005, 2007)

Page numbers are essential when quoting or referring to some aspect or information from a report (Sharma 1960: 22 or Sharma *et al.,* 1960: 22).

References that are long and/or have acronyms: Only acronym in text, e.g., INRA 2008

List personal communication references in text only. e.g. (Hariya pers. comm., 2011)

Unpublished/Undated references: In press, Forthcoming, In review, etc.

**References in list:** References should appear first in alphabetical then chronological order.

For references with more than 7 authors: first 7 names, *et al.*
Use complete page ranges. e.g., 371-379 (not 371-9); 227-235 (not 227-35).

Reference that are long and/or have acronyms: Full name followed by acronyms in parenthesis in reference list, e.g.,
Instituto Nacional de Reforma Agraria (INRA). 2008.

Unpublished/Undated references: In press, Forthcoming, In review, etc.

**Examples:**
Vijaya, J. 1982. Turtle slaughter in India. *Marine Turtle Newsletter* 23: 2.

Silas, E.G., M. Rajagopalan, A.B. Fernando & S.S. Dan. 1985. Marine turtle conservation and management: A survey of the situation in Orissa 1981/82 & 1982/83. *Marine Fisheries Information Service Technical & Extension Service* 50: 13-23.

Pandav, B. 2000. Conservation and management of olive ridley sea turtles on the Orissa coast. Ph.D. thesis. Utkal University, Bhubaneswar, India.

Kar, C.S. & S. Bhaskar. 1982. The status of sea turtles in the Eastern Indian Ocean. In: *The Biology and Conservation of Sea Turtles* (ed. Bjorndal, K.). Pp. 365-372. Washington, DC: Smithsonian Institution Press.

Forman, R.T.T. & M. Gordon (eds.). 1986. *Landscape Ecology*. New York: John Wiley.

Ozinga, S. 2003. Parks with people. World Rainforest Movement/FERN. http://www.fern.org/pubs/ngostats/parks.htm. Accessed on February 25, 2006. ▪

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