



**Project Report**

**Advancing the conservation of sea turtles in India at a national scale through the monitoring of index sites and coordination of coastal management efforts with a network of partners**

Submitted to the US Fish and Wildlife Service under the Marine Turtle Conservation Act Fund

**2018-2021**

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# 1.

## Executive Summary

The Indian coastline has significant nesting and feeding grounds for four species of marine turtles, namely leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*) and olive ridley (*Lepidochelys olivacea*) turtles. The most remarkable of these are the mass nesting beaches of olive ridley turtles in Odisha, the nesting beaches of leatherback turtles in Little Andaman Island and the Nicobar Islands, and the feeding and nesting grounds for green and hawksbill turtles in the Andaman and Nicobar Islands and the Lakshadweep Islands. These sites are high priorities for conservation. Even though all four species are listed under Schedule I of the Indian Wild Life (Protection) Act, 1972, their populations in the Indian waters remain under threat due to coastal development and incidental catch in fisheries.

Sea turtles play an important role as flagship species for diverse habitats such as coral reefs, seagrass meadows, open seas, and sandy beaches. The threats that sea turtle populations face are representative of threats that impact other marine and coastal flora and fauna. In the Indian subcontinent, coastal and ocean resources play an important economic role in fishing and other coastal activities. Sea turtles have also been a part of legend and culture in this region for more than a thousand years. They move freely across socio-political boundaries, and many factors need to come together for their effective conservation.

The long-term monitoring and conservation project was initiated in 2008 and has since monitored key turtle nesting and foraging sites in India. In addition, the project has played a role in uniting organisations and individuals that work along the Indian coast on marine turtle ecology and conservation through a consortium of Non-Governmental Organisations (NGOs) called the Turtle Action Group (TAG).

From 2008 onwards, the project's activities have been supported through grants from the Marine Turtle Conservation Act (MTCA) Fund of the U.S. Fish & Wildlife Service (USFWS). In 2008-2009, the project was executed through the Ashoka Trust for Research in Ecology and the Environment (ATREE), Bangalore, India. From 2009 to 2016, the project was administered by the Madras Crocodile Bank Trust (MCBT), Chennai, in partnership with Dakshin Foundation, Bangalore. Since 2017, the grant has been administered solely by Dakshin Foundation.

The primary aim of the project is to monitor index nesting sites for sea turtles and provide a common platform for sharing information and experience amongst various groups and individuals working on sea turtles in India. It seeks to strengthen community-based NGOs from various coastal states with training and technical assistance. The project further facilitates the effective engagement of network members with other stakeholder groups, research institutions and government agencies in order to better

execute conservation action. It also supports the website, [www.seaturtlesofindia.org](http://www.seaturtlesofindia.org), the publication of outreach and educational material, and the production of the Indian Ocean Turtle Newsletter (IOTN).

From 2008-2017, for over 10 years, MTCA grants were used to conduct monitoring of olive ridley turtles in Odisha, leatherback turtles in the Andaman Islands, and monitoring of green turtles and seagrass meadows in the Lakshadweep Islands. The grant also facilitated the formation of TAG, a network of committed groups and organisations from across the country's coastline, and the initiation of activities undertaken by the network. During this time, the grant supported the organisation to conduct capacity-building workshops, and the production of outreach material of various types including posters, manuals and children's books.

TAG is a well-established network of over 25 organisations from across the country. The network has established a set of goals and action plans to address sea turtle conservation effectively through cooperative and collaborative efforts. Research and monitoring capacities of the member organisations in collecting uniform and reliable data are being developed through monitoring protocols and training programmes. This will lead to the standardisation of data collected during the nesting season at key sites along the Indian coast.

The current project seeks to continue to support and coordinate sea turtle conservation activities along the Indian coast, and undertake collaborative actions that can lead to better coastal and marine conservation.

This report details the project objectives and activities carried out during the current funding cycle, which includes sea turtle monitoring programmes at index sites in India, the functioning of the TAG network and its member organisations, and the outcomes and outputs from the project. It also lists plans to further the effective conservation of sea turtles in India.

# 2.

## Project Objectives

Goal:

To strengthen and sustain collective and collaborative sea turtle conservation through the monitoring of key sites and a network of partners in the Indian subcontinent.

**The project objectives for 2018-21 were:**

### **1. Research and monitoring**

1.1. Strengthening the long-term monitoring programme for olive ridley turtles in Odisha.

1.2 Monitoring the status of leatherback turtles in the Andaman and Nicobar Islands.

1.3 Monitoring the status of green turtles in the Lakshadweep Islands and increasing participation of local groups in these efforts.

1.4 Enabling the collation and analysis of data collected across sites to inform studies on population trends by the network of partner organisations.

### **2. Community Engagement**

2.1 Conducting training programmes for capacity-building to enable individual member organisations of TAG to become financially and programmatically independent.

2.2 Strengthening a larger regional network in the Northern Indian Ocean (NIO) region of the Indian Ocean South East Asia (IOSEA) through a regional-level workshop, and holding consultations to foster regional exposure and exchange programmes for members of the network.

### **3. Education and outreach**

3.1 Developing and supporting the establishment of coastal learning centres of the Forest Department in different states.

3.2 Developing appropriately-designed educational and outreach material that can broaden the reach of the network to address specific target groups including other stakeholder groups, educational institutions, government departments and the general public.

# 3.

## Project Activities and Outcomes

### 1.1 Monitoring programme for olive ridleys in Odisha

Odisha is home to some of the most significant olive ridley nesting beaches in India and around the world. Gahirmatha and Rushikulya in Odisha are among the largest olive ridley mass nesting sites apart from mass nesting sites in Central America, and constitute an important nesting habitat for the ridley population in India. Over the past 3 decades, activities such as mechanised fishing have resulted in large-scale turtle mortality across the Indian coast. Other factors that further affect the population are the rise in sea level, climate change, and development activities, both onshore and offshore. It is, therefore, imperative to protect their breeding habitat and monitor population trends to understand their biology and behaviour with respect to climate change.

With funding from the Marine Conservation Society, U.K., a long-term monitoring programme was initiated by the Indian Institute of Science (IISc), Bangalore, and MCBT at the Rushikulya rookery. Since 2008, the project has been coordinated by IISc, Dakshin Foundation and the Odisha Forest Department and funded by the USFWS MTCA grant. For the past 14 years, the project has worked in collaboration with the local Forest Department staff and various NGOs involved in marine turtle conservation. As part of capacity-building, the Forest Department staff, NGO employees, local community members and other researchers are trained in conducting a census of nesting populations during arribadas, shoreline monitoring techniques, hatchery management, and other activities related to sea turtle monitoring.

In addition to monitoring nesting and offshore populations, the project studies the impact of climate change on olive ridleys. Using data loggers, air, sand and nest temperatures are recorded to determine daily fluctuations in temperature and its influence on hatchling sex ratios. A small proportion of solitary nests are relocated to a hatchery from the nesting beach to study sex ratios, nest temperatures, hatching and emergence success. These nests are collected periodically across the nesting season.

To monitor at-sea aggregations, boat transects are carried out to estimate the abundance and distribution of single and mating turtles in the offshore waters of the Odisha coast. Since 2008, the mass nesting census has been carried out in collaboration with the State Forest Department and local community members. To estimate the mass nesting numbers, a strip transect method is used to count the number of ovipositing females in different

segments across the nesting beach. The nesting turtles are checked for tags and their morphometrics are recorded. The results suggest that the number of nesting females has increased over the years at Rushikulya. Despite significant offshore congregations, mass nesting did not occur at Rushikulya in 2016, but such fluctuations are not unusual. Two arribadas occurred within the same season in 2018, with the second wave of turtles coming ashore during the mass hatching event. There was no mass nesting observed in 2019 and 2021, but minor peaks in solitary nesting numbers were recorded. In 2020, a large arribada spanning 10 days was observed; however, a full census could not be carried out due to the national lockdown following the COVID-19 pandemic. In 2019, two minor projects on their foraging behaviour and hatchling performance were carried out. A detailed report can be found in Appendix I.

In response to the capacity-building training and workshops under this project, the Forest Department is actively involved in monitoring and protecting both offshore and onshore turtle habitats. Working with local NGOs helps in spreading marine turtle conservation awareness through education programmes. There has been a considerable increase in local awareness and interest generated by working in collaboration with the government and local NGOs.

## **1.2 Monitoring leatherback turtles in the Andaman and Nicobar Islands**

Within India, current nesting populations of leatherback turtles are entirely restricted to the Andaman and Nicobar Islands. In South Asia, Sri Lanka and India are the only sites to host nesting populations. Over the last 2 decades, monitoring by the Andaman Nicobar Environment Team (ANET) on Great Nicobar Island (2000-2004), and the collaborative long-term monitoring programme by the Forest Department, Centre for Ecological Sciences (CES), IISc, Bangalore, Dakshin Foundation and ANET on Little Andaman Island provides long-term data about these turtles.

Initiated in 2008, the long-term leatherback turtle monitoring programme in Little Andaman Island involves monitoring of nests, threats, and tagging of turtles. In 2010, with support from the Indian Space Research Organization (ISRO) and the Space Technology Cell of IISc, a satellite telemetry study was initiated at Little Andaman Island. Further support was received from the Department of Science and Technology - Fund for Improvement of S&T Infrastructure in Universities and Higher Educational Institutions (DST-FIST) programme support to CES. A total of 10 turtles were tagged with Platform Transmitter Terminals (PTTs) between 2010 and 2014 (tracks can be viewed at [www.seaturtle.org](http://www.seaturtle.org)). Alongside collecting long-term data on leatherback populations, the project aims to develop a conservation network in the region with a long-term education and outreach programme for different stakeholders in the islands. A detailed report is provided in Appendix II.

### 1.3 Monitoring green turtles and their foraging habitats in the Lakshadweep Islands

Green turtle feeding populations are found in the lagoons of many islands in the Lakshadweep. Intensive grazing by high-density green turtle aggregations has resulted in steep declines in seagrass and associated fish biomass. This has led to resentful attitudes of the fishers towards green turtles. Changing green turtle aggregations recorded in the literature indicate inter-island movements sequentially exhausting forage resources. In continuation of studies by Nature Conservation Foundation (NCF), Mysore, Dakshin Foundation and IISc, Bangalore, have initiated a collaborative project to monitor green turtle responses to reducing forage and their movements between the islands. As part of this project, a proposal was developed to continue monitoring these populations using photo-identification and low-cost indigenously developed transmitters. This project would also be supported partially by MTCA funding and would be integrated with the larger research and conservation programme of IISc, NCF and Dakshin Foundation in the region. The details of this study are provided in Appendix III.

### 1.4 Website and online data repository

The website [www.seaturtlesofindia.org](http://www.seaturtlesofindia.org) is a platform for information on the biology and conservation of sea turtles and their habitats in the Indian subcontinent. Numerous community-based groups, local, national and international conservation organisations (NGOs), academic institutions and government departments have contributed to studies and surveys over the last 2 and a half decades. The website hosts this information and makes it possible for students, researchers and others to get easy access to the material. The site also includes a repository of papers, reports, notes, historical records and other grey literature. The bibliography section currently includes over 700 references, with PDFs for a large number of publications, many of which are not available elsewhere.

The website also hosts a blog called ‘Talking Turtles’ with contributions from people working on or interested in marine turtles. From first encounters with turtles to unusual observations and expert insights, the website welcomes stories about marine turtles in the Indian Ocean. A collection of interviews by Kartik Shanker is also hosted on the site featuring some of the pioneers and key figures of sea turtle conservation in the country. Finally, it contains information about TAG such as the network’s activities, workshop reports, and detailed profiles of the member organisations.

#### Sea turtles of India Website

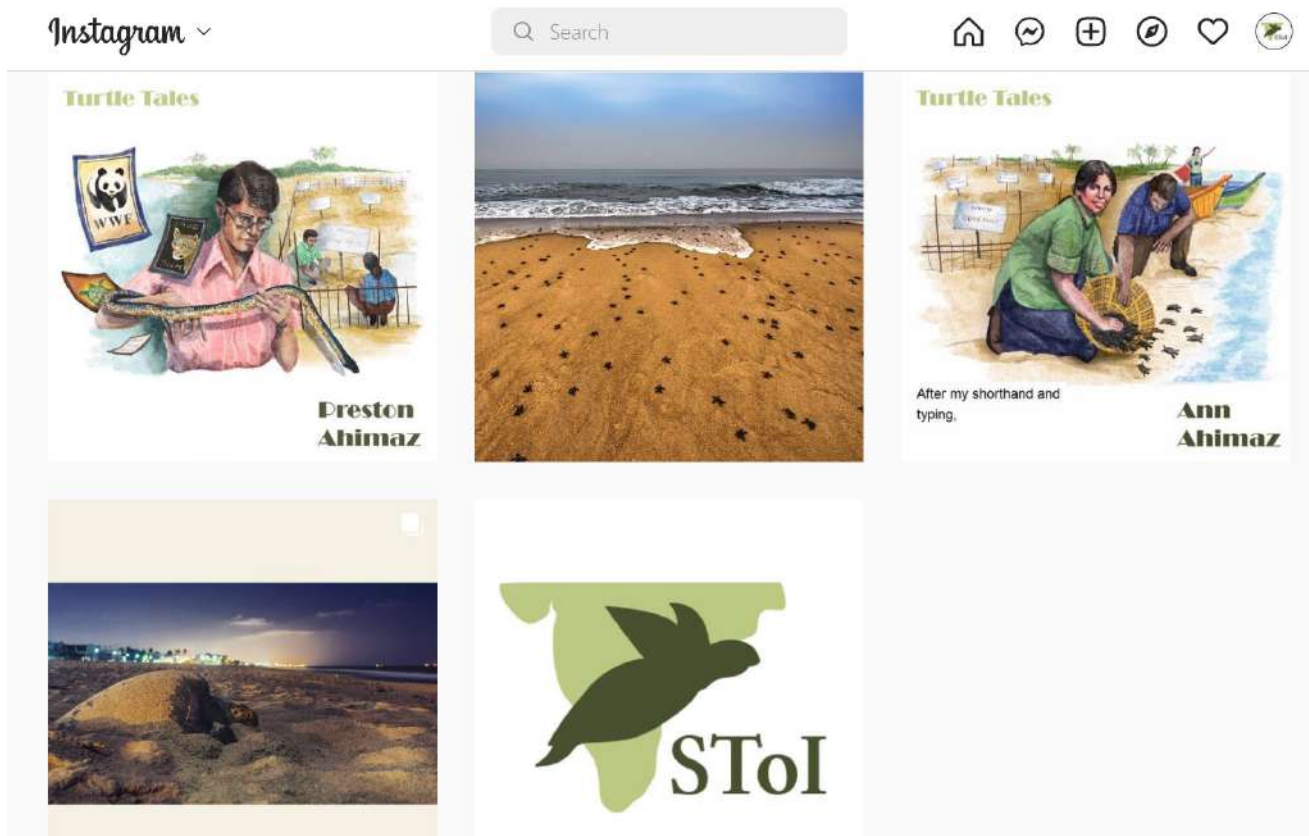


#### Talking Turtles Blog



During 2019 and 2020, newly generated outreach material from the monitoring programmes was uploaded to the website, and new blogs and interviews were also introduced. Furthermore, a new logo was designed for the website and, in an attempt to increase its reach, a social media page was created on Instagram (<https://www.instagram.com/seaturtlesofindia/>).

### STOI on Instagram



#### 2.1. Building capacities of local community members and government officials

TAG is a network of NGOs from across India working towards sea turtle conservation and coastal protection. These groups initially came together in January 2009 at a workshop held in Chennai, where the need for a national-level network to enable various groups to work together and collaborate towards more effective sea turtle conservation was acknowledged. There is a consensus that effective sea turtle conservation requires collaboration between agencies and various stakeholders to ensure long-term survival of the species and sustainable use of the resources in the habitats they occupy.

Such a collaborative effort at the national level was lacking and TAG was formed to fulfill this need. TAG seeks to benefit from the pooling of resources and knowledge, and to bridge the gap between conservation measures that are effective at local, state and national levels.

The initial focus of TAG was towards empowering community-based organisations by improving their capacities in raising grants, networking, improving their communication

skills and making them self-reliant, for them to effectively engage with other networks, stakeholder groups and government agencies.

## **2.2 Strengthening a larger regional network in the Northern Indian Ocean region of the IOSEA**

### *Regional training workshop for a leatherback monitoring camp in Indonesia*

In December 2018, Dakshin Foundation was invited to train the staff in a collaborative leatherback project between the Turtle Foundation and the Ministry of Marine Affairs of Indonesia in Sipura Island, Indonesia. Adhith Swaminathan, who has been leading the leatherback monitoring programme in the Andamans, visited the project site in Sipura and trained the staff in tagging leatherback turtles with external and PIT tags. A protocol manual was also developed for the project.

During the field visit, two leatherbacks were observed, and external and PIT tagging procedures were demonstrated to the entire team. The protocol included standardised methods to be followed by the groups on leatherback nesting beaches along the Andaman, Nicobar and Sumatra Islands chain.



Figure 1. Photos from the regional training workshop: Rangers planning the night patrol (left); Leatherback tracks (top right) and turtle hatchery (bottom right) in Betunonga beach, Sipura Island.

### *Turtle conservation training workshops for Forest Department field staff in the Andaman Islands and Odisha*

ANET, Dakshin Foundation's field base in the Andaman Islands, conducted two training workshops at Betapur and Kalara for the North and Middle Andaman Forest Department staff. The workshops included front-line staff from Ramnagar, Kalupur, Lamia Bay and Cuthbert Bay, where the Forest Department runs hatchery programmes.

A field training workshop was conducted on hatchery management and sea turtle research along with Action for Protection of Wild Animals (APOWA) for the Forest Department staff of Puri and Kendrapara divisions at Konark in Odisha in January 2019 and March 2021, respectively.

These workshops helped build on and refresh the knowledge of the field staff who work on sea turtle projects in the region. The workshops included an introduction to sea turtles, turtle life cycles, different research components, and conservation strategies and needs.



Figure 2. Dakshin Foundation staff conducting workshops with Forest Department personnel in Odisha (left) and Andamans (right).

#### *Participating in the 8th Meeting of the IOSEA*

In October 2019, Muralidharan Manoharakrishnan participated in the 8th Meeting of the Signatory States of the IOSEA-MoU in Da Nang, Vietnam. As Chair of the Northern Indian Ocean Marine Turtle Task Force during this period, he reported on the common themes and knowledge gaps as well as the work plan that had been developed by the Task Force for sea turtles in the region.

#### *National Conference on Marine Turtle Conservation*

The ‘1st National Conference on Marine Turtle Conservation’ was held on the 2nd and 3rd of December 2019 in Kadmat, Lakshadweep, by Dakshin Foundation in collaboration with the Department of Environment and Forests, Government of Lakshadweep. The two primary themes of the conference were:

1. Research and Monitoring
2. Conservation Management and Conflict Mitigation

These themes were explored through a combination of plenary speeches, panel discussions as well as presentations from the participants. The presentations were further divided into ‘state-wise presentations’, consisting of representatives from NGOs, members of the Forest Department, and other researchers, and ‘research presentations’, which focussed on studies carried out by individual participants.



Figure 3. Participants at the 1st National Conference on Marine Turtle Conservation in Kadmat, Lakshadweep.

### 3.1 Design and development of learning centres in collaboration with the Forest Department

As part of the outreach and education initiative, an interactive life-size poster of the sea turtles of India was created. This poster was installed at the open day celebrations for ANET along with other materials that were prepared from the projects.



Figure 4. An interactive life-size poster of sea turtles displayed at the open day celebrations for ANET (top) along with other materials prepared from the projects (bottom).

### 3.2 Developing educational material and outreach activities for sea turtle conservation

*Protocol manuals were prepared for the monitoring of sea turtles in the Andaman and Nicobar Islands and Odisha.*



#### *Indian Ocean Turtle Newsletter*

The Indian Ocean Turtle Newsletter (IOTN) is a biannual international newsletter dedicated to marine turtle research and conservation. This was initiated to provide a forum for exchange of information on sea turtle biology, conservation, management, and education and awareness in the Indian subcontinent, Indian Ocean region, and South/Southeast Asia. The newsletter covers related aspects such as coastal zone management, fisheries and marine biology.

The newsletter aims to reach and serve:

- Central government agencies (Ministry of Wildlife, Fisheries and Environment)
- Coastal government agencies (local Forest Departments, Fisheries Departments)
- Coastal enforcement agencies (Navy, Coast Guard)
- Non-government organisations involved in environment and conservation
- Non-government organisations involved in social work in coastal areas
- Academic institutions
- Conservation organisations
- Community-based conservation organisations
- Individual researchers, field biologists and ecologists

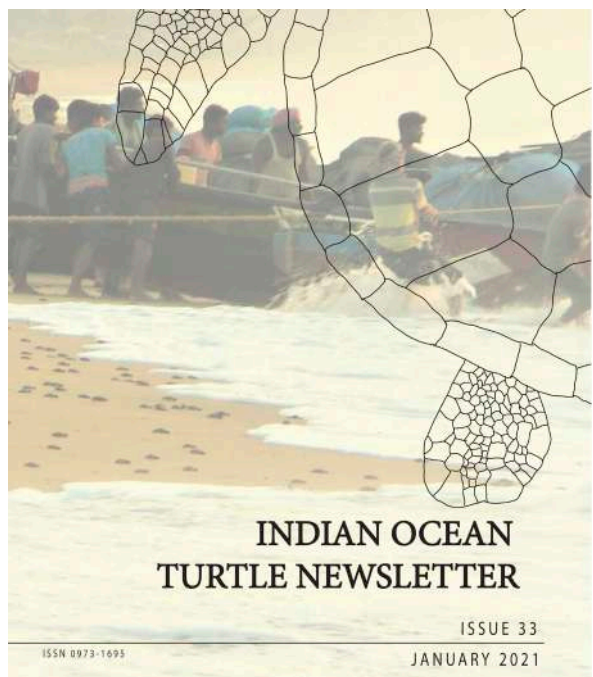
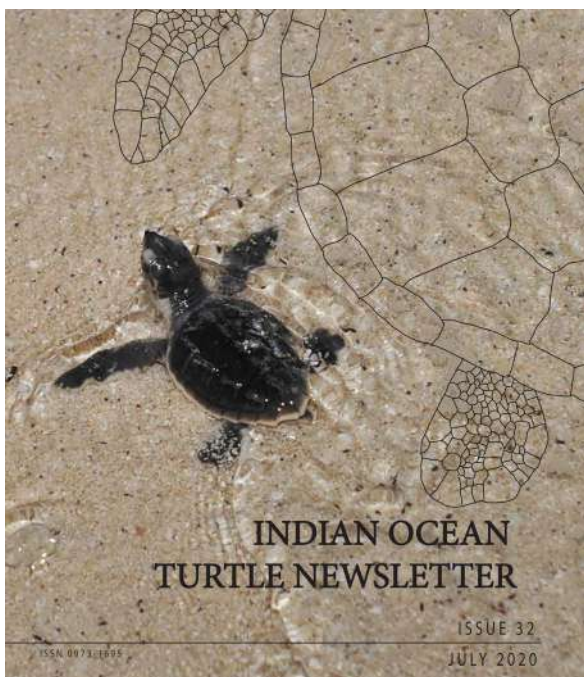
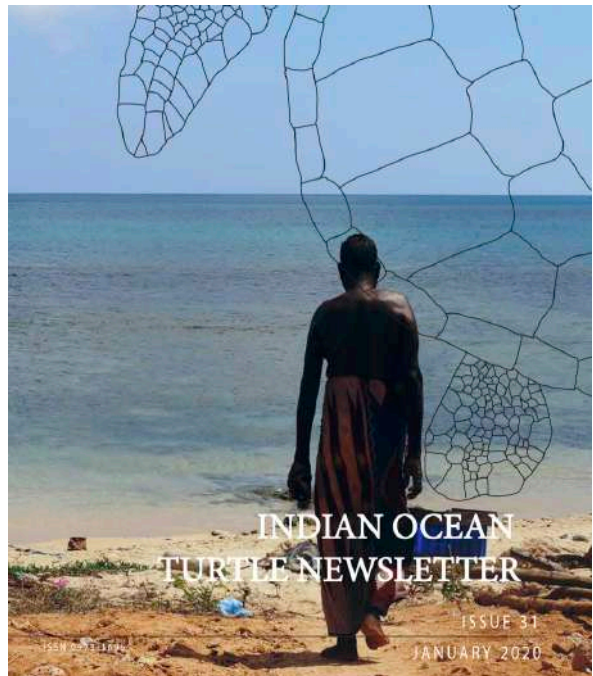
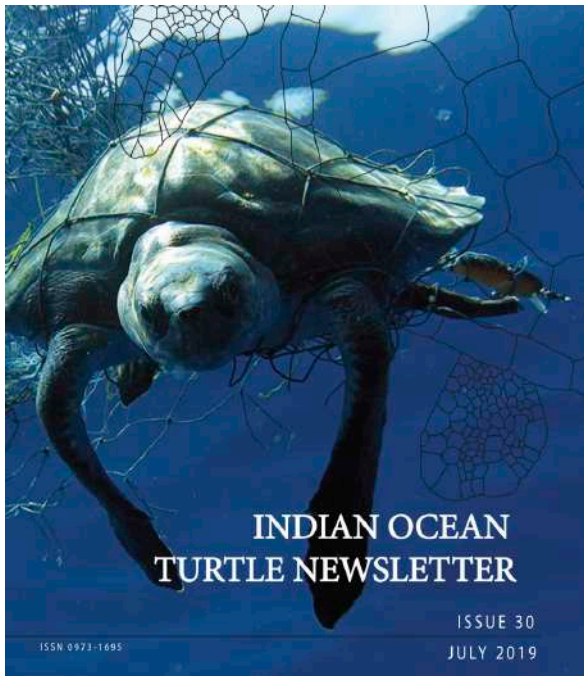
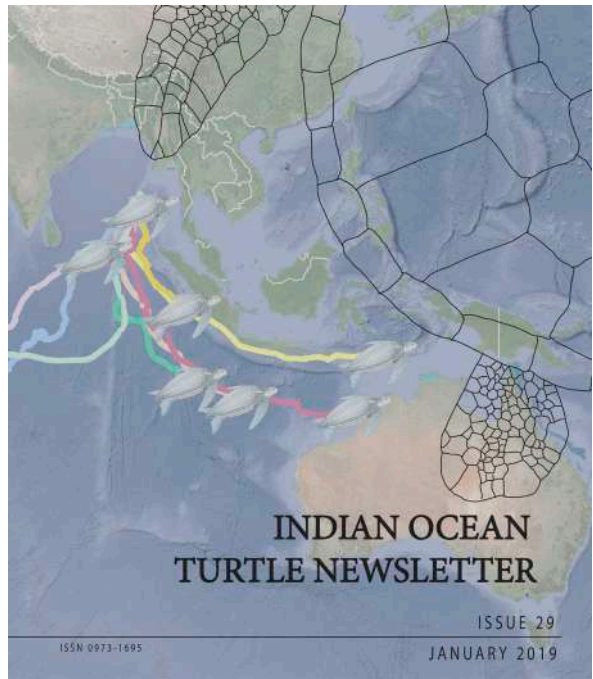
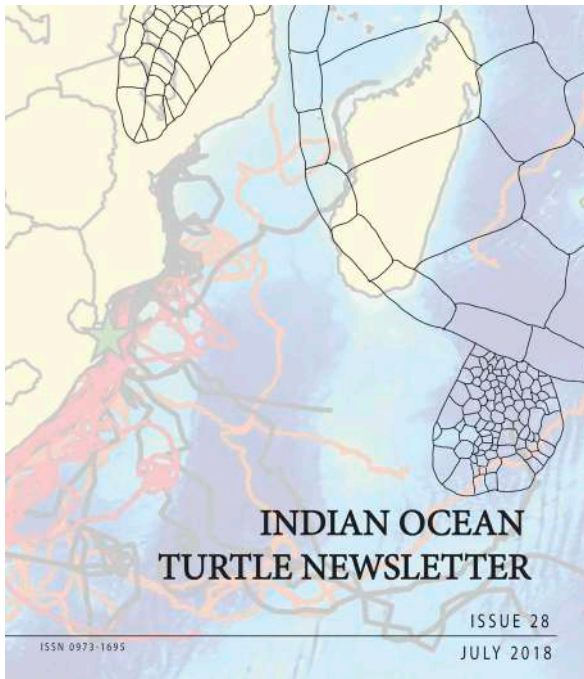
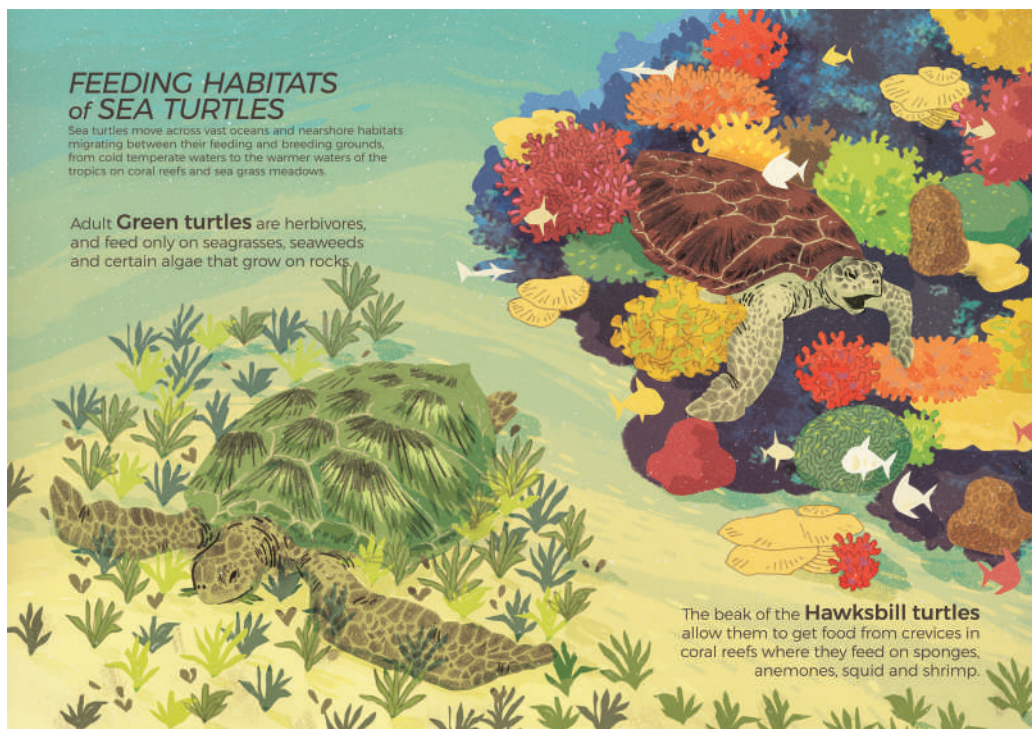
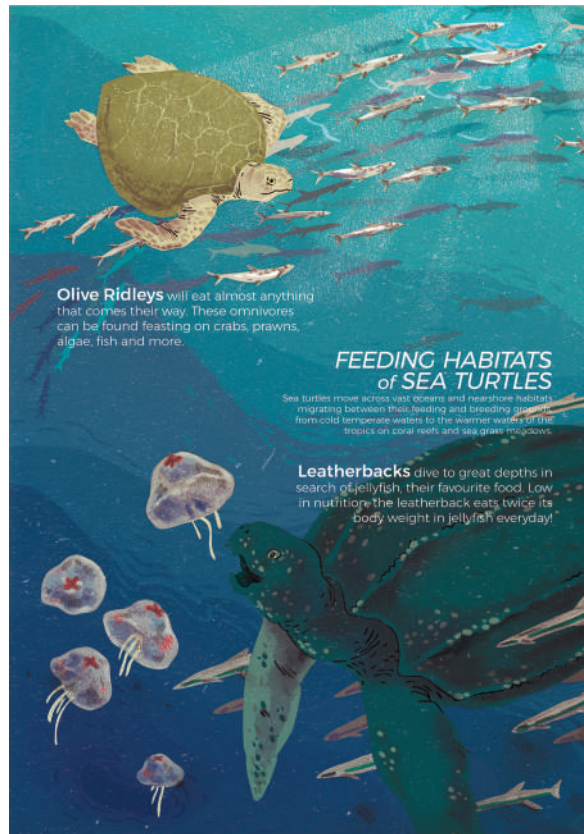


Figure 5. The issues of IOTN published during the reporting period.

*Educational material for outreach*

A set of posters on sea turtle biology and distribution were produced and later translated for distribution among TAG members and Forest Department officials in Maharashtra on the western coast of India.





A booklet on the sea turtles of India with content specific to the state of Maharashtra and its activities was also created.

**SEA TURTLES IN MAHARASHTRA**

The Bombay Natural History Society conducted a systematic survey of the entire coast of Maharashtra in 2000-01 and Viraj Giri and his team documented widespread nesting of olive ridleys in the months of November-February. He also encountered green turtles at sea particularly near rocky areas, or caught accidentally in fishing nets, hawksbill turtles were occasionally encountered.

In 2002, Vishwas (Bhau) Kaldare and colleagues collected information about sea turtles and discovered a fair number of ridleys nesting in the Ratnagiri coast. He observed that there was no poaching of eggs for local consumption. Sahaydai Nisarg Mitra (SNM) formally initiated their sea turtle programme in 2002 with the support of the local community, for this operation to be sustained on a long term. The community gradually swayed by the commitment of SNM who would return time and again to talk to them about sea turtles and their importance.

As a part of State Government and United Nations Development Programme (UNDP), Prof. Nagesh Daptardar, from S.H. Kelkar of Arts, Commerce and Science in Dnyanesh worked with the fisher community to protect nesting sea turtles and hatchlings. He also generated awareness regarding the ghost nets and their impact on turtles. Under his guidance Sagor Mahadkar a local from Sindhadurg protected and released olive ridley hatchlings near the Tumbaldeg fort area.

The Local Forest Departments of each of the regions have been active and supportive in turtle conservation on this coast.

**TURTLES OF MAHARASHTRA**

Four species of turtles are known to occur on the Maharashtra coast - olive ridley, hawksbill, green and leatherback. Only olive ridleys nest on this coast.

**TURTLES NESTING IN INDIA**

Of the seven species of turtles in the world, five are found in India. The olive ridley, green, leatherback, hawksbill, and loggerhead, occur in the Indian coastal waters of the Bay of Bengal and Arabian Sea. All species except the loggerhead nest on the mainland coast and islands.

**ARRIBADA**

Arribada is the Spanish word for arrival. It is an interesting nesting habit of the olive ridley sea turtles. This phenomenon of nesting occurs in seven locations across the world. In India this occurs at two sites in the state of Odisha (*Bachikulya and Gahirmatha*) and at Carriacou Bay in Andaman islands. At these arribadas they arrive in groups ranging up to 100000 to the nest.

**LEGEND**

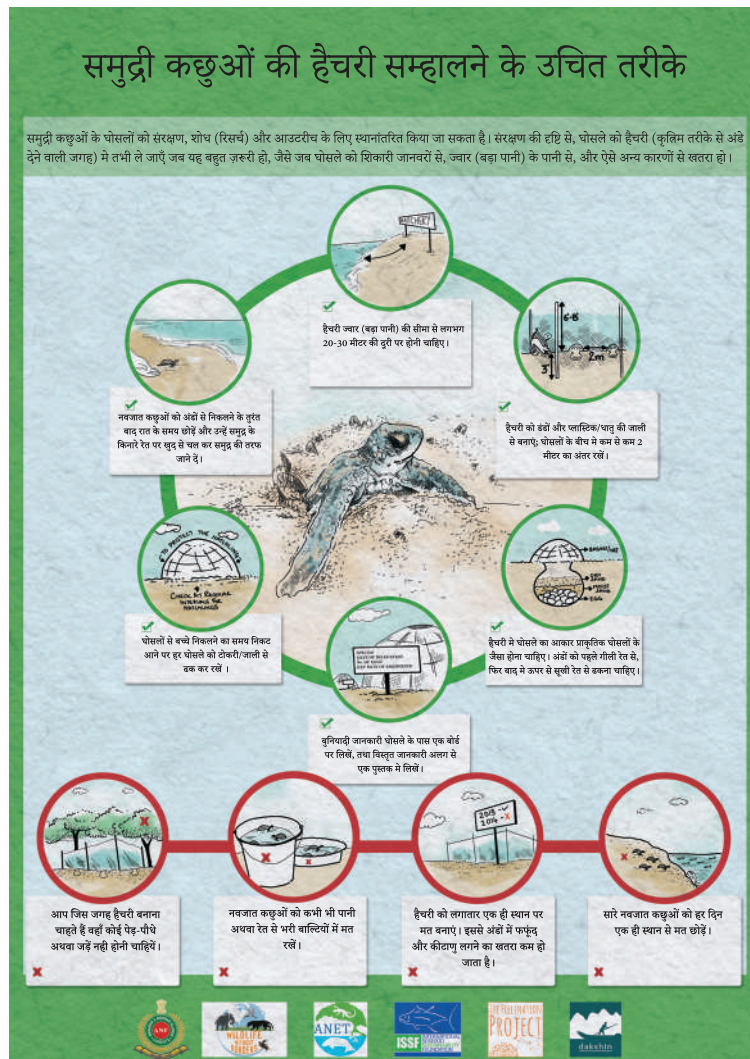
- Important sea turtle nesting sites of India
- Important sea turtle conservation areas of Maharashtra
- Arribada sites in India

**did you know?**

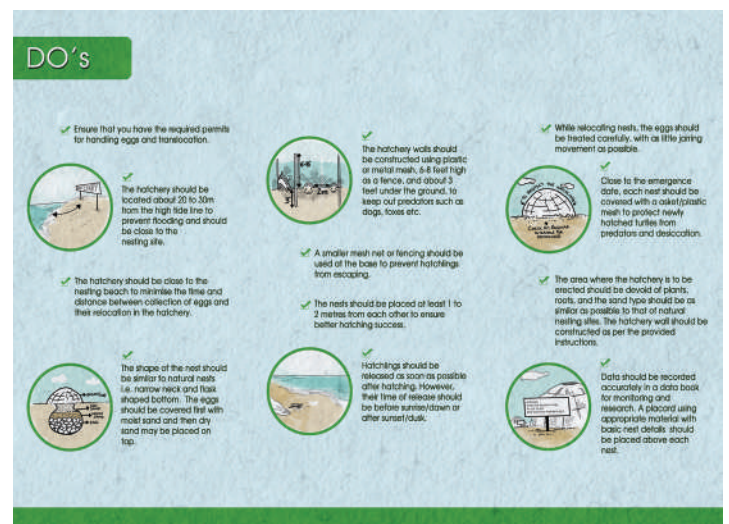
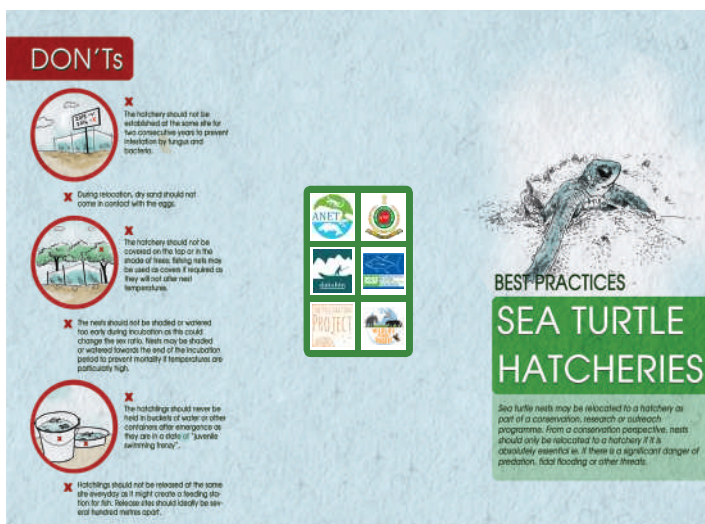
The Kasav Mahotsav Turtle Festival is held every year at Velas. Tourists can watch turtle hatchlings emerge from their nest and crawl towards the sea.

Posters and brochures were prepared in English and Hindi for the 'Best Practices for Sea Turtle Hatcheries' (samples below).

a. Poster in Hindi



b. Brochure in English



## *Outreach Activities 2018-2021*

### *Arribada: The Exhibition*

Turtle iconography is widespread in the world around us. Through this exhibition, turtle artefacts from three collectors (Kartik Shanker, Sejal Worah and Aradhana Seth) were displayed across India. Taking inspiration from the concept of *Wunderkammer* or cabinet of curiosities, the exhibition brought together stories from history, biology, culture, conservation and people associated with sea turtle conservation in India. Dakshin Foundation in collaboration with World Wide Fund for Nature-India (WWF-India) conducted these exhibitions in New Delhi and Goa prior to the start of the Covid-19 pandemic. Since then, the exhibition has been transformed into a website ([www.arribada.in](http://www.arribada.in)) that hosts various artefacts, stories and collections.



# 4.

## Future Plans (2021-26)

We are committed to sustaining research and monitoring as well as expanding community engagement and outreach work. The specific plans for the years 2021-2026 are:

### **a. Increasing the scope of research-based monitoring at the index-nesting beaches of sea turtles**

The index-nesting beaches in Odisha, Lakshadweep Islands and the Andaman Islands now have established sea turtle monitoring programmes which have the potential to expand the scope of their research. These could include aerial surveys of turtles, stable-isotope analysis, genomics, and detailed physiological studies to further expand on the knowledge of these populations.

### **b. Capacity-building and involvement and initiation of new community-based enterprises**

A primary focus area of the project is capacity-building for local Forest Department officials. By imparting knowledge on proper monitoring techniques and hatchery management, local communities can effectively work towards conservation. The potential of ecotourism as a means of generating revenue and opportunities for conservation has also been explored. We will be partnering with state Forest Departments to develop site-specific action plans for their conservation programmes. We hope to also partner with more local universities at some of the important nesting beaches along the mainland coast to establish long-term engagement with student groups for monitoring these populations.

### **c. Developing and executing new plans for outreach and communications**

As part of our expanded outreach efforts, we plan to launch a YouTube channel which will feature interviews with sea turtle experts from across the globe. Efforts are also being made to engage with individuals at the interface of community-based conservation practices to highlight their experiences through recordings, interviews, etc. to be hosted on social media. The outreach team is working to build a repository of materials which can be used and distributed at the long-term monitoring field sites. New materials in the form of site-specific posters and digital guides will be created utilising information and data collated over the years. Additionally, we aim to create products such as coffee mugs, postcards, etc. which will be used for contests and giveaways hosted on the social media page. Information and content prepared for the social media pages will also be utilised for the upcoming digital newsletter of the Marine Flagships Programme.

# 6.

## Acknowledgements

We are grateful to the U.S. Fish & Wildlife Service for providing funding support under the Marine Turtle Conservation Act Fund.

We are thankful to the staff at Dakshin Foundation for carrying out the research, outreach and administrative tasks under the project and lending their constant support as and when required. Special thanks to Srotoswini Majumdar and Debangini Ray for assisting with the compilation and editing of this report. We are extremely grateful for the long-term support from the field staff who have been the backbone of our monitoring programmes in Odisha and the Andaman Islands and continue to associate with us in field monitoring as well as local outreach activities. We would also like to extend our gratitude to the Forest Departments of Odisha, Lakshadweep and the Andaman and Nicobar Islands for their continued support.

We are thankful to the Ministry of Environment, Forests and Climate Change (MoEFCC) for endorsing the network. We would especially like to thank the Department of Environment and Forest, Union Territory of Lakshadweep Administration, for their help and support during the 1st National Conference on Marine Turtle Conservation in collaboration with Dakshin Foundation. We are hopeful that representatives of the Ministry and coastal state government agencies will be actively involved in network activities in the future.

We would also like to thank several individuals and organisations including the Indian Institute of Science, Bangalore, the Andaman Nicobar Environment Team, Wandoor, and DreamNotion Innovation (website design and management) for providing support. Special thanks to Sejal Worah of WWF - India, and Aradhana Seth for collaborating and assisting with the outreach activity 'Arribada'. Finally, we would like to thank all our member organisations, whose enthusiasm in sustaining the network and dedication towards sea turtle conservation has validated our efforts in initiating and facilitating TAG.

# 7.

# Appendices

## APPENDIX I

### **Monitoring olive ridley turtles in Odisha**

Olive ridleys (*Lepidochelys olivacea*) are found all along the Indian coast. They nest sporadically on the east and west coasts, although major nesting sites are located on the east coast. Olive ridleys are subject to numerous threats across habitats. With the introduction of mechanised fishing in the 1990s and incidental capture in shrimp trawls, several thousand olive ridleys die every year due to entanglement and suffocation in trawl nets. Their nests are also susceptible to predation by hyenas, jackals, feral dogs, kites and crows. Apart from these direct threats, they are also affected by the rise in temperatures due to climate change which influences the sex ratios, hatching and emergence success. Additionally, climate change-induced sea level rise, increased frequency of storms and extreme weather conditions, and multiple coastal development projects could result in habitat loss, further increasing the vulnerability of the population. A bias in sex ratios would have a profound effect on the population demography, which would subsequently affect the viability of the population. Considering the importance of the east coast population and these mass nesting rookeries, it is imperative to monitor the populations in the context of the changing climate.

#### Methods

The long-term project involves various onshore and offshore monitoring activities to study population dynamics and habitat characteristics at the Rushikulya rookery. To monitor solitary nesting, beach patrols are carried out every night throughout the nesting season. The night walks are carried out in collaboration with the State Forest Department, during which the number of active nests, predated nests and false crawls are recorded and dead turtles are counted. Annually, a few nests are relocated from the beach to a hatchery and data loggers are placed in the centre of the nests to monitor the incubation temperatures.

To monitor the offshore densities of turtles, boat transects are carried out to determine the density of turtles across the Odisha coast. Until 2017, barring a few seasons, offshore transects were carried out in 7 locations. Between 2018-2020, the offshore transects were carried out in Rushikulya, Bahuda and Chilika. However, since 2020 the offshore study has been restricted to Rushikulya due to logistic constraints imposed by the ongoing pandemic.

In 2021, a training workshop was conducted in collaboration with APOWA and the Forest Department for the capacity-building of local community members and Forest Department personnel on arribada census methods and hatchery maintenance. Following a theory session on the methods and techniques related to hatchery maintenance, a practical session was conducted and the techniques for identifying a turtle track, locating a nest, nest relocation and artificial nest building were practically demonstrated. A training workshop was also conducted for students in collaboration with the Zoological Survey of India (ZSI), where the students were briefed on the methods of carrying out an arribada census.

## Results

### *Monitoring nesting beach characteristics*

The mass nesting beach in Odisha is highly dynamic. Annually, it undergoes varying levels of erosion and accretion. To measure changes in the nesting beach, beach mapping is carried out to determine the slope and width of the beach at different sections. The results show that there is a high degree of variation in beach height within and between years and at different sections of the nesting beach.

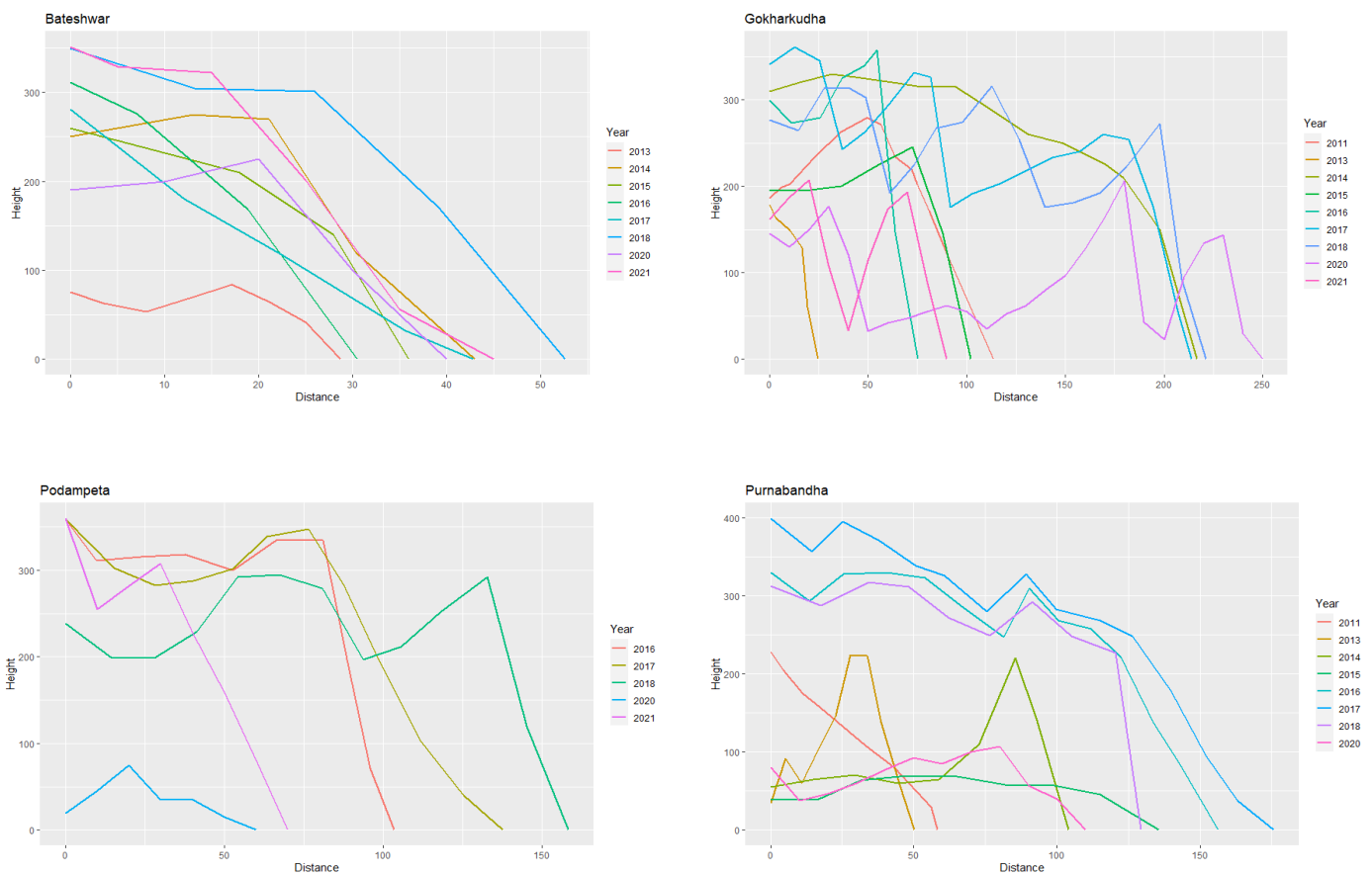


Figure 1. Variations in beach height over the years at different sections of the beach.

### *Monitoring offshore congregations of olive ridleys on the Odisha coast*

IISc and Dakshin Foundation started offshore monitoring of olive ridleys at Rushikulya in 2010. A line transect approach is used to measure the offshore densities of turtles during the breeding season (Figure 2). Initially done only in Rushikulya, this was extended to cover the entire coastline of Odisha in January 2014. The other sites included in the survey are Bahuda, Chilika, South Devi (Puri-Konark), Devi, Hukitola and Jatadhar (Figure 3).

The 480 km coastline of Odisha was divided into transect blocks of 40 sq. km. All transects except Rushikulya are 4 km long and 2 km apart. To get a finer resolution of estimates, the transect effort in Rushikulya was intensified by surveying 3 km long transects that are 1 km apart (Figure 2). Along with observations of turtle numbers, abiotic factors (surface salinity and depth) were also sampled to understand the ecological correlates of these congregations. Due to logistical difficulties, only three sites, viz., Chilika, Rushikulya and Bahuda, were surveyed for offshore monitoring during 2019 and 2020, while the monitoring has been restricted to Rushikulya since 2021 due to logistical constraints associated with the pandemic.



Figure 2. Map showing transect design.

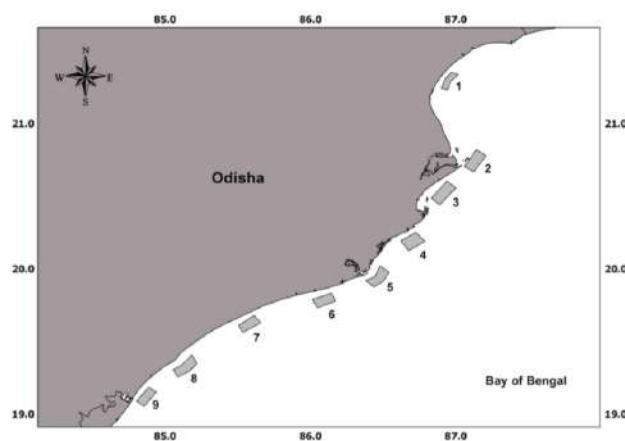


Figure 3. Map showing different survey locations.

### Monitoring solitary nesting

The nesting beach is patrolled every night throughout the entire duration of the nesting season. It is composed of 5 different sections which receive varying levels of nesting intensity through the season. A few nests are relocated to the hatchery for monitoring nest temperatures, hatchling sex ratios and hatching success.

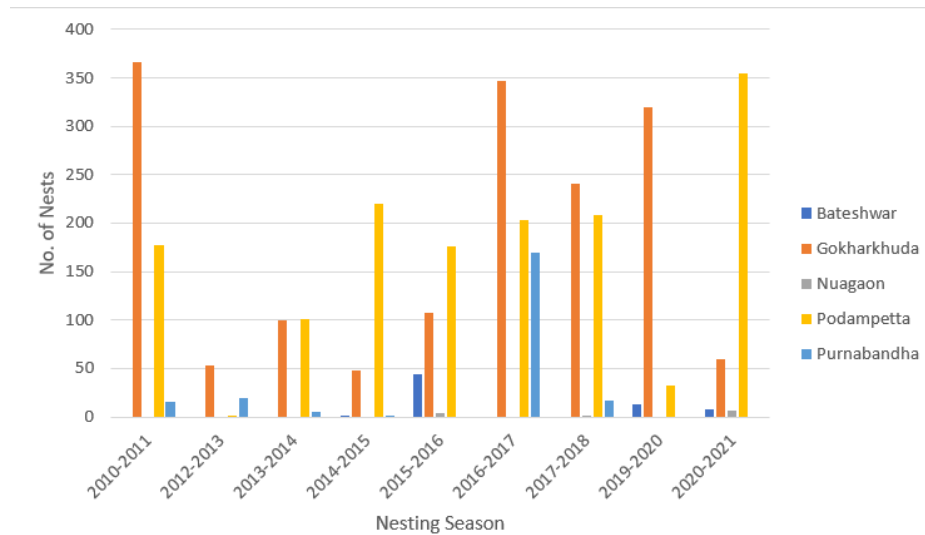


Figure 4. Nesting intensity recorded across years at different sections of the mass nesting beach.

### Arribada monitoring

Mass nesting events at the Rushikulya rookery were not monitored regularly using standardised methodology before 2007. Since 2008, IISc and Dakshin Foundation have been monitoring the Rushikulya beach, recording both solitary and mass nesting data, using a scientifically robust method known as the strip transect method. During each arribada, a 20 m strip transect method is used to count the nesting females. Table 1 provides estimates of mass nesting from 2007 to 2021. Table 2 gives day-wise estimate of nesting turtles in 2020 at Rushikulya.

During 2020, the team planned the monitoring using different strip widths to examine the efficiency of deriving estimates keeping sampling protocols amenable to field conditions. Earlier monitoring programmes have used a strip width of 20 m at the mass nesting sites in Odisha instead of the prescribed 2 m as proposed by the IUCN MTSG. It was observed that the 5 m strip widths tend to overestimate the nesting numbers in comparison to the 20 m strips. The estimates derived from 2018 had shown that the larger strip width of 20 m potentially underestimates the nesting numbers while smaller strip widths are prone to overestimates. During the 2020 arribada, 10 m and 5 m strip widths were used to estimate nesting numbers.

**Table 1.** Estimated number of nesting turtles at Rushikulya during arribada (2007-21)

<b>Year</b>	<b>Estimated Nesting Number</b>
2007	No arribada
2008	70985.9
2009	71645.1
2010	99887.3
2011	151828.5
2012	42931.1
2013	142550
2014	14849
2015	170939
2016	No arribada
2017*	405783.9
2018	419414.5
2019	No arribada
2020*	217103.7
2021	No arribada

\*Expected overestimate due to shorter strip widths in comparison to previous years

**Table 2.** Estimated numbers of nesting turtles during arribada 2020 at Rushikulya

<b>Day</b>	<b>5m</b>	<b>10m</b>
Day 1	75512.55	52916.43
Day 2	84071.9	58295.78
Day 3	57519.24	49425.46
<b>TOTAL</b>	217103.69	160637.77

### *Monitoring temperatures*

To measure the incubation temperatures of hatchery nests, data loggers are deployed at the centre of the nest during relocation. Additionally, one data logger is placed at the top of the hatchery and one is buried below the sand at a depth of 25-30 cm at the beginning of every season to measure air and sand temperatures, respectively. Incubation temperatures can be used to determine its effect on hatchling sex ratios, hatchling physiology and morphology.

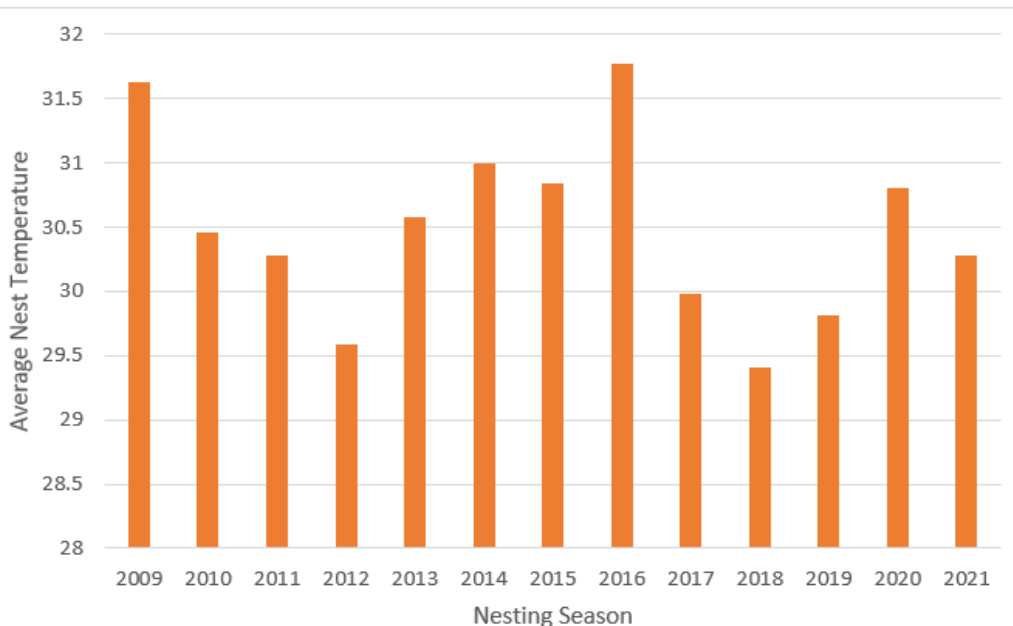


Figure 5. Average nest temperatures recorded in hatchery nests across different years.

### Monitoring hatchling sex ratios

Sea turtles have temperature-dependent sex determination. To understand the effect of climate change on sex ratios, hatchling sex is determined through histology studies. Dead hatchlings are collected from the nests after excavation and transported to the lab, where the hatchling gonads are dissected to determine their sex. Nest temperatures are also monitored using data loggers. The hatchling sex ratios have been largely female-biased, although there are years when a large proportion of males were produced owing to the low nest temperatures recorded.

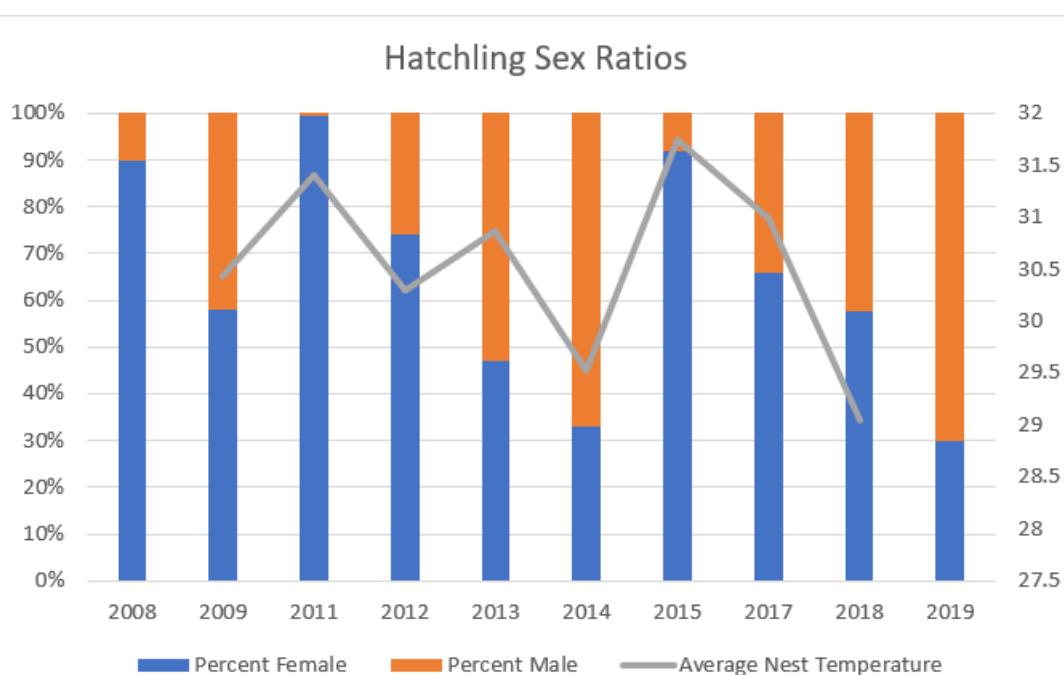


Figure 6. Hatchling sex ratios observed over the years during arribada at the Rushikulya rookery, Odisha.

## *Effect of nest environment on olive ridley hatchlings*

The nest environment influences various life history parameters in sea turtles such as embryonic development, gas exchange, sex determination, hatchling morphology and physiology. With increasing sand temperatures around the world, sea turtle hatchlings face an imminent threat in the form of reduced size and locomotor ability due to high nest temperatures, leaving them vulnerable to predators on land and sea. The study looked at the effect of nest environment, especially temperature, on hatchling morphology and fitness. A few nests from Rushikulya, Odisha, and Chennai, Tamil Nadu, were chosen as samples. To understand the influence of different temperature ranges, the nests were sampled across different months of the nesting season including early, mid and late-season nests. On emergence, hatchlings from each of these nests were measured for various morphological parameters such as carapace length, flipper length, neck length and scute number as well as fitness parameters such as crawl speed, self-righting ability and righting propensity score. The results revealed that temperature has a significant effect on hatchling size and locomotor performance. Higher sand temperatures led to reduced hatchling size which in turn led to lower hatchling fitness. Temperature also influenced hatchling fitness independent of hatchling size. However, the results varied between Rushikulya and Chennai hatcheries, suggesting that there could be site-specific factors influencing the fitness of hatchlings.

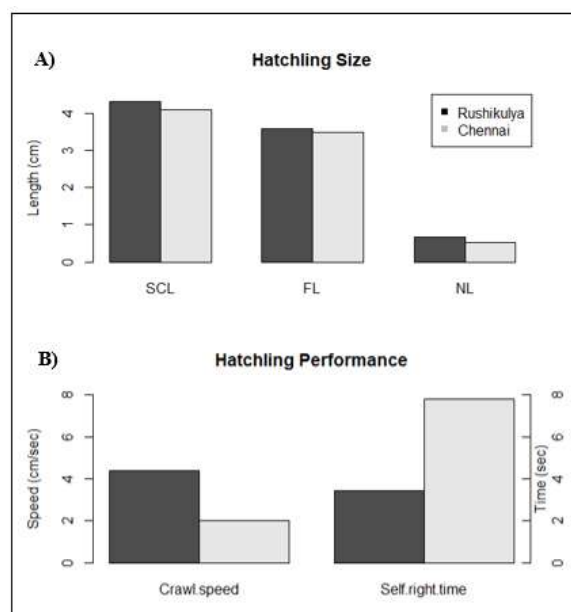


Figure 7. Effect of nest temperature on hatchling morphology and fitness in Rushikulya, Odisha, and Chennai, Tamil Nadu.

## *Nesting habitat and foraging pattern*

We compared the carbon isotope ratios in the bone tissue of olive ridley sea turtles in Chennai, Tamil Nadu and Rushikulya, Odisha. Physical beach characteristics such as slope, sand moisture, sand size and sand salinity for different beaches in Rushikulya were compared and microplastic concentration in the main arribada beach sediment was determined. The carbon isotope ratios of samples from Chennai and Rushikulya turtles were found to be significantly different from each other, signifying a probable difference in their foraging areas. The

beach characteristics of various nesting areas of Rushikulya rookery were not significantly different. We did not find a significant difference in the physical characteristics of arribada and solitary nesting beaches. Sediments of the main arribada beach were found to have a high concentration of microplastics.

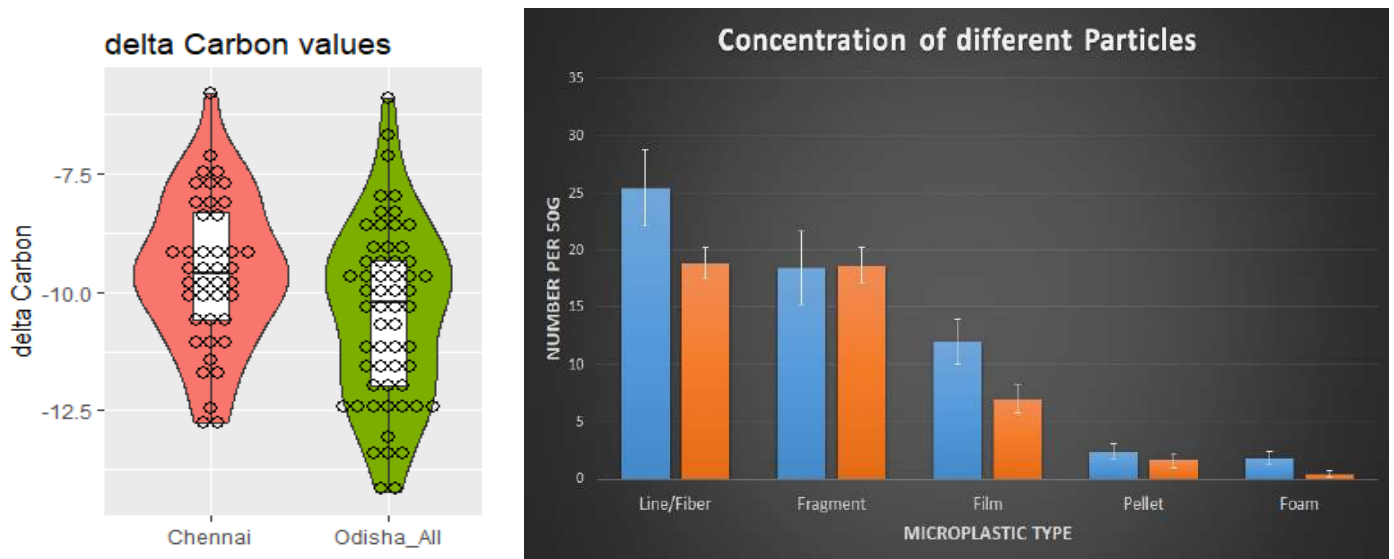


Figure 8(A). Carbon isotope ratio from Chennai and Odisha & (B). Microplastic concentration at the nesting beach.

### *Local involvement*

A majority of the NGOs working along the Odisha coast are community-based and employ local youth in carrying out their monitoring activities. They are trained in the latest arribada population census, hatchery maintenance and nest relocation techniques. However, despite their interest and enthusiasm, many individuals from local NGOs are also forced to seek alternate options to secure a steady income (particularly during the non-nesting season). Therefore, projects are being initiated, like coastal monitoring and beach profile data collection, which would keep them involved all through the year. By developing skills in sea turtle monitoring, a few individuals from local community-based NGOs have managed to find employment in sea turtle research and monitoring programmes carried out by academic research institutions and by the Forest Department. This has helped create synergy not just between the NGOs and academic institutions, but the Forest Department as well. As a result of this sustained partnership over the past five years, it has been possible to involve a considerable number of field staff from the local communities and organisations in the arribada census and in collecting scientific data on sea turtle mortality and hatchling production. A further step would be to initiate community-based ecotourism for income generation for these groups. The local NGOs involved with the programme are Orissa Marine Resources Conservation Consortium (OMRCC), Rushikulya Sea Turtle Protection Committee (RSTPC), Sea Turtle Action Program (STAP), Green Life Rural Association (GLRA) and Action for Protection of Wild Animals (APOWA).



Figure 9. Local sea turtle monitoring staff at Rushikulya, Odisha.

## APPENDIX II

### Monitoring leatherback turtles in the Andaman and Nicobar Islands

Leatherback sea turtles (*Dermochelys coriacea*) grow over 6 feet in length and are the only extant species of the family Dermochelyidae. They are the largest of all sea turtle species, weighing up to 900 kg, and survive entirely on a diet of jellyfish. They are known for their leathery and flexible carapace and are the only species of sea turtles that lack a bony shell. They have the widest distribution of all the seven species of sea turtles and are found in tropical and temperate waters of the Atlantic, Pacific, and Indian Oceans. The leatherback was listed as Vulnerable in the International Union for Conservation of Nature (IUCN) Red List of Threatened Species during the most recent assessment in 2013 and is under Schedule I of the Indian Wild Life (Protection) Act (1972). There has been great concern over the decline in nesting populations of this species throughout the world, especially in the Pacific and South Asia. The Malaysian rookeries have undergone a well-documented decline from approximately 10,000 nests per year in the 1960s to less than 20 nests per year in the 2000s. Based on the lessons learnt from the population decline in the Pacific and Southeast Asia, it is imperative to understand the nesting trends of leatherback turtles in the Andaman and Nicobar Islands, where these turtles migrate, and the threats they face throughout their range.

Information on leatherback populations from India is still very patchy. Though there are earlier records of sporadic leatherback nesting from the Indian mainland, current nesting populations are entirely restricted to the Andaman and Nicobar Islands. Over the last two decades, monitoring by the Andaman Nicobar Environment Team (ANET) on Great Nicobar Island (2000-2004), and the collaborative long-term monitoring programme by the Forest Department, Centre for Ecological Sciences (CES), Indian Institute of Science (IISc), Bangalore, Dakshin Foundation and ANET on Little Andaman Island provides long-term data about these turtles (Figure 3).

Many prime nesting sites for leatherback turtles in the Andaman and Nicobar Islands were severely affected by the December 2004 earthquake and the subsequent tsunami. Not much was known about the impacts of this calamity on the populations of leatherbacks. Further, there was no information on the turtles once they left the coast of the Andaman and Nicobar Islands, especially with respect to their migratory patterns, feeding and foraging behaviour, breeding aggregations and many other parts of their life cycle. Recently, new approaches using satellite telemetry and molecular genetics have been used to gain insights into some aspects of the leatherback's life cycle.

Given the lack of knowledge on these populations, long-term spatiotemporal monitoring of leatherbacks using conventional tagging, satellite telemetry and genetic analysis was imperative. Therefore, the project was initiated in 2008 with the objective of monitoring post-tsunami leatherback nesting recovery in Little Andaman Island.

Over the years, the objectives have evolved to continue the long-term monitoring of leatherback nesting in South and West Bay, Little Andaman Island, through a tagging and nest monitoring programme. Intensive surveys have been carried out to monitor tag recaptures of leatherback turtles from previous seasons (Figure 5). The surveys were carried out in collaboration with the Forest Department, Andaman and Nicobar Islands. This study is also part of the ‘Long-term monitoring of coastal and marine ecosystems of the Andaman Islands’ project under the Long-Term Ecological Observatories (LTEO) programme of the Ministry of Environment, Forests and Climate Change (MOEFCC).

The South Bay nesting beach was monitored through daily night surveys from 2008-2011. Since 2011, night surveys of the nesting beach were logistically constrained due to the large river openings (Benyabol and Tothibue) and the presence of saltwater crocodiles. Though opportunistic night surveys were conducted in South Bay between 2011-2020, the beach was regularly surveyed only during the day. Since the establishment of the West Bay monitoring camp in 2010, our efforts have been concentrated here through daily night surveys.

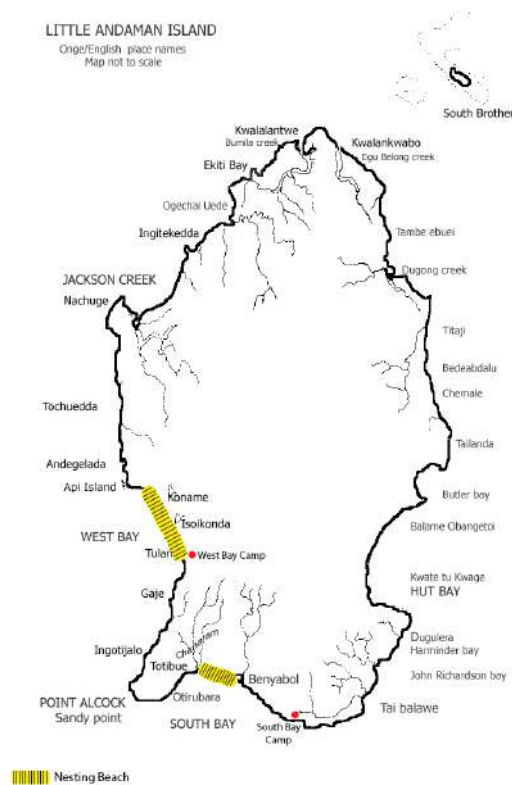


Figure 1. Map of Little Andaman Island.

### Monitoring

The current monitoring programme at the beaches of South and West Bay, Little Andaman Island, aims to understand trends in leatherback nesting at these sites, the threats they face, and changes in their nesting habitats. These beaches serve as index sites for monitoring leatherback populations in the islands. Annual surveys of the nesting sites at Great and Little Nicobar Islands will help in assessing the status of these beaches and the abundance of leatherback nesting at these sites. Monitoring throughout the season helps provide insights into predation patterns, hatching and emergence success of nests laid at these index beaches.

Since 2008, the nesting beaches in Little Andaman have been monitored annually, focusing on tagging, habitat monitoring, satellite telemetry and population genetics. The findings indicate that leatherback nesting on beaches of Little Andaman Island has recovered substantially after the 2004 tsunami and is stable with some fluctuations (Figure 2). Rapid surveys conducted in 2016 and 2019 in the Nicobar Islands also confirmed the recovery of previously known nesting beaches and nesting numbers comparable to earlier reports from the Great and Little Nicobar Islands. With over 1000 nests per season across the islands, this is a significant nesting population in the South Asian region.

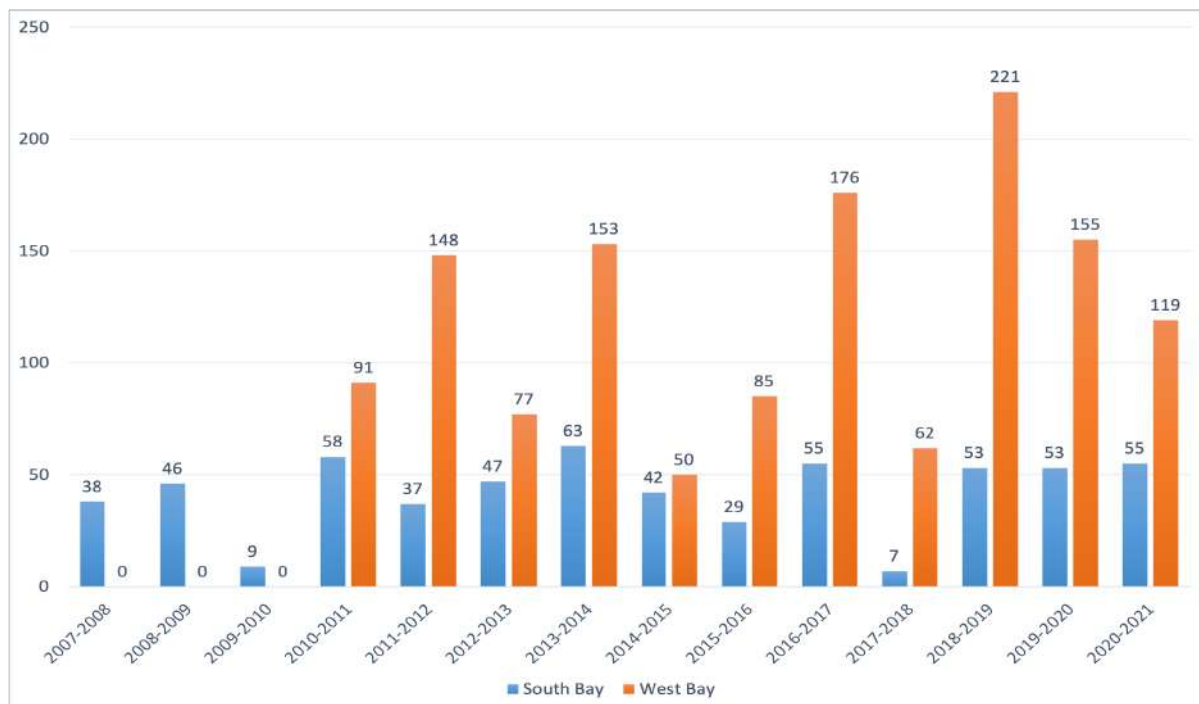


Figure 2. Leatherback nesting patterns in South and West Bay.

### *Satellite telemetry*

Between 2010-2014, 10 turtles were tagged with satellite transmitters but only 5 of these turtles provided data for more than 100 days. Only 3 turtles transmitted extensive data where we were able to identify their foraging grounds.

While we have some insights into the post-nesting movement patterns of leatherbacks in the Indian Ocean, more satellite telemetry studies need to be carried out in subsequent years to assess if there are other migratory routes taken by the turtles nesting in Little Andaman Island. A better sample size will also help us assess their exposure to fishery-related threats in the high seas. Additional funds have been sanctioned through the LTEO programme of the Government of India to carry out satellite telemetry studies in the upcoming seasons.

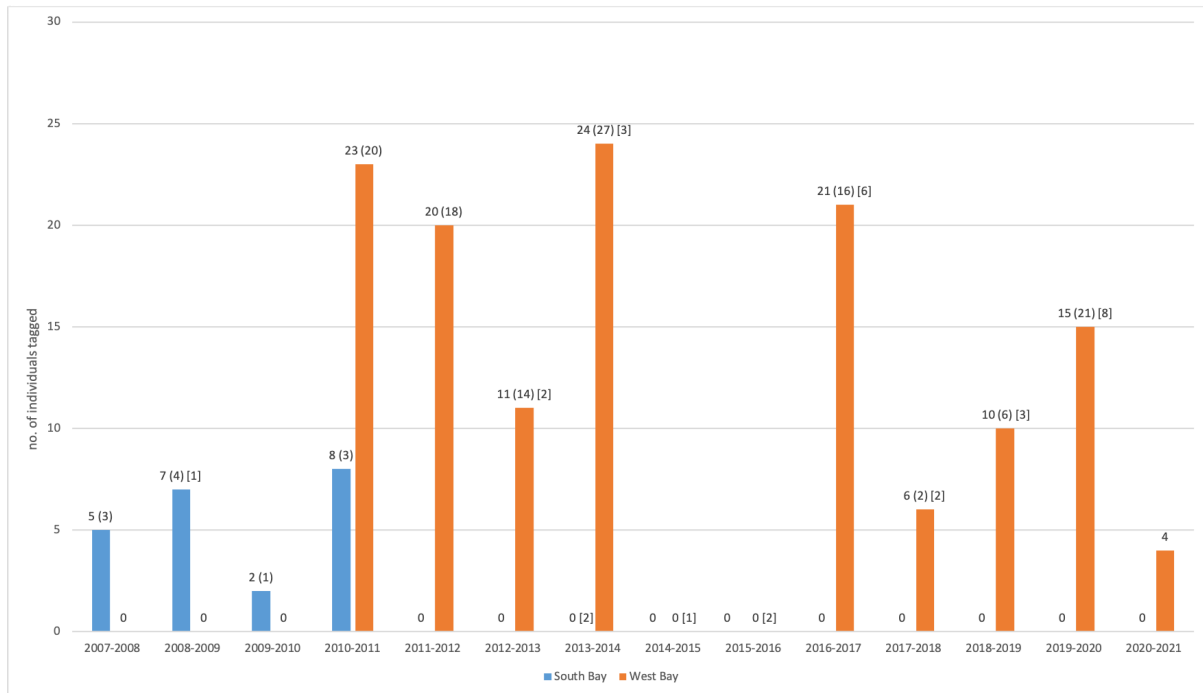


Figure 3. ( ) Represents inter-nesting captures; [ ] Represents remigration captures.

### *Population genetics*

The preliminary study of the Little Andaman population has indicated the presence of three (I, A, and E) of the four haplotypes found in the region. Additional funds will be raised to assess the stock to which the Andaman and Nicobar leatherback turtles belong.

### *Capacity-building and outreach*

The long-term conservation and management of leatherback turtles in the Andaman and Nicobar Islands depends on the involvement and support of local civil society and the government. Since the leatherback turtle nesting beaches are currently in areas not accessible to the general public, the main focus of training is the Forest Department field staff. In addition, awareness programmes can inform the local communities about leatherback turtles and their value as the natural heritage of the islands.

In recent years, we have expanded our efforts in the capacity-building and outreach components of the programme. The Forest Department officers and frontline staff at various sites have been supportive and dedicated to sea turtle conservation efforts. Between 2018-2020, several capacity-building programmes were conducted in the North, Middle and South Andaman Islands for the field personnel working on sea turtle projects from the Forest Department. These workshops equipped the field personnel to standardise protocols for data collection and also improved existing conservation programmes across the islands.

In 2020, we also expanded our outreach component through extensive education programmes conducted opportunistically for schools and local communities of the Andaman and Nicobar Islands. No capacity-building or outreach programmes were conducted after March 2020 as all the educational institutions were closed and inter-island travel was severely restricted due to the COVID-19 pandemic.

## APPENDIX III

### **Monitoring green turtles and their foraging habitats in the Lakshadweep Islands**

Green turtles (*Chelonia mydas*) are the most abundant species found in the Lakshadweep Islands. Calm, shallow lagoons in the archipelago are ideal habitats for extensive meadows of seagrasses and marine algae, resulting in prime foraging sites for these turtles. Green turtles nest on the sandy beaches of the islands, primarily in Suheli Valiyakara, Tinnakara, Bangaram and Agatti. In the late 1990s, green turtle abundance in the archipelago suddenly increased. This sudden rise in the population numbers could be attributed to its protection status and the conservation efforts in the Indian Ocean. The resultant intensive grazing of two major seagrass species (*Thalassia hemprichii* and *Cymodocea rotundata*) led to a reduction in the diversity, biomass, and abundance of associated fish species (including species targeted by lagoon fisheries). As a result, local fisher communities have developed resentful attitudes towards the turtles and blame them for the decline in fish catch. Dwindling seagrass resources and increased conflict with fishers makes this population vulnerable.

Dakshin Foundation, in collaboration with the Indian Institute of Science (IISc), Bangalore, began monitoring the seagrass and green turtle distribution and density in 2012. This study was re-initiated in 2016 as a long-term monitoring programme to examine green turtle density and distribution as a function of forage quality and availability. In 2018 and 2019, in addition to the standardised monitoring surveys, fisher-turtle conflict and green turtle diet were also examined. Previously published literature and data from the long-term monitoring programme indicate that green turtle abundance has peaked in different lagoons since the mid-2000s. High-density foraging aggregations of green turtles exhausted seagrass resources in one lagoon before moving to another. The decline in green turtle density in each lagoon corresponded with a decline in the seagrass densities of *T.hemprichii* and *C.rotundata* (their preferred forage).

In order to manage this population and facilitate seagrass recovery, information on their demography, movement, distribution, and foraging behaviour is important. Moreover, it is crucial to develop ways to reduce the turtle-fisher conflict, which if allowed to persist, could be detrimental to the green turtle population.

The objectives of the study include determining the spatial and temporal distribution of green turtles, monitoring seagrass communities, densities and distributions, examining the diets of green turtles, investigating the extent of conflict between fishers and turtles and identifying mitigation strategies, and studying the movement and habitat use of green turtles.

Long-term monitoring is conducted in the lagoons of Agatti, Kadmat, and Kalpeni. These islands were selected as high densities of green turtles have been reported from these islands at different points in time.

### Monitoring green turtle densities and distributions

Single-observer boat transects were conducted in the lagoons of Agatti, Kadmat, and Kalpeni. The transects were 1 km long and parallel to the shore. While the boat travels at a constant speed of 8 km/hour, a single observer stands at the bow and counts the number of turtles in a 5 m belt on either side. A total of 9 transects in Agatti and 12 transects in Kadmat and Kalpeni were surveyed.

A low density of turtles was recorded in Agatti and Kadmat in both 2018 and 2019. Kalpeni saw a drastic reduction in turtle encounters within a year. No green turtles were observed in the reef region in Agatti, while they were uniformly distributed between shore, mid-lagoon and reef strata in Kadmat. A clear preference for the mid-lagoon region was observed in Kalpeni.

Island / Year	2018	2019
Agatti	9	3
Kadmat	5	0
Kalpeni	48	11

Table 1. Number of turtles encountered on transects in 2018 and 2019.

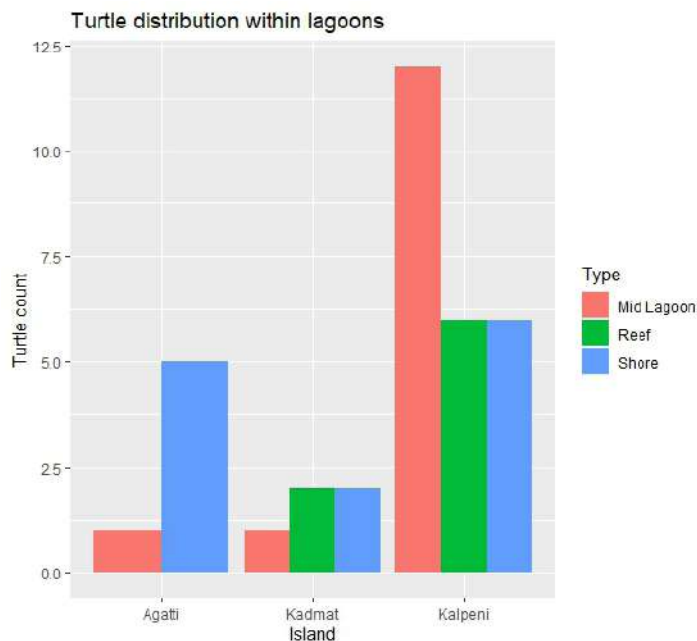


Figure 1. Distribution of turtles inshore, mid-lagoon and reef regions of the islands.

*Monitoring seagrass communities and meadow structure*

Each lagoon was divided into grids of 500x500 m of which centres of 28 grids were randomly chosen using QGIS. The centres of these grids are surveyed for substrate in four directions: North, South, East and West by snorkelling. Seagrass patches, when encountered, are sampled for species.

Seagrass surveys indicated a decline in the density of the slow growing *Thalassia* species in the Kalpeni lagoon from 2018 to 2019. This is the preferred forage resource of green turtles. Although there was an observed increase in seagrass density in the Agatti lagoon, it was accounted for by a faster-growing species, *Halophila*, rather than *Thalassia* or *Cymodaceae*. The Kadmat lagoon did not see any change in seagrass densities, which remained low in 2018 and 2019.

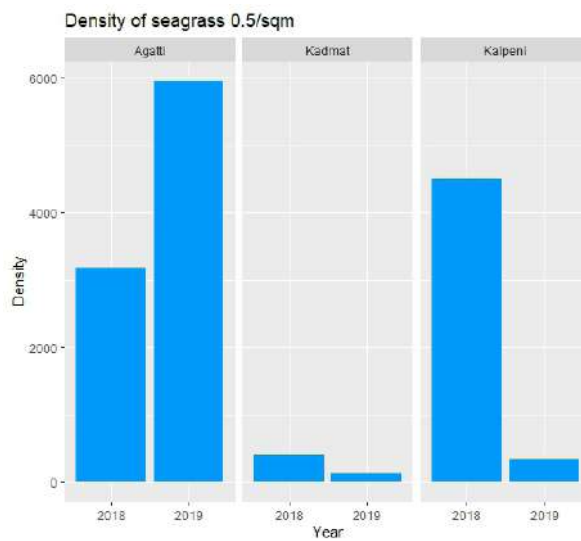


Figure 2. Species of seagrass observed in the lagoons.

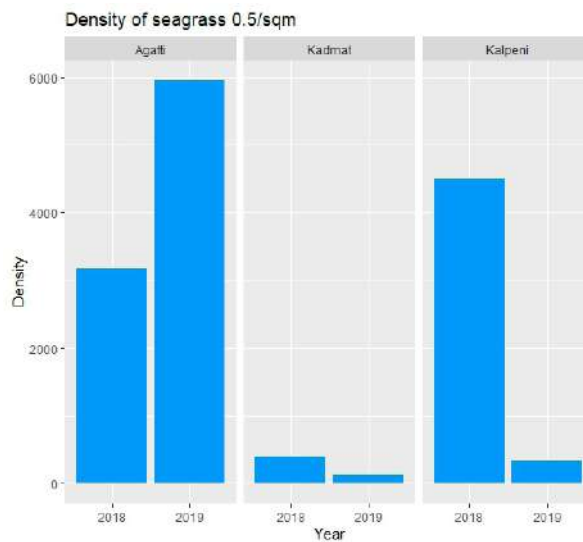


Figure 3. Density of seagrass observed in the islands.

## Faecal analysis

Green turtle faecal samples were collected and analysed to examine the composition and potential change in their diet. Faeces were collected from the beaches and lagoons, following which they were sun-dried and then observed under the microscope. Shoots of *Thalassia* and *Cymodoceae* found in the faeces confirmed feeding observations from previous studies that identified them as the major foraging resources of green turtles. Undigested shoots of *Halodule uninervis* found in the faeces may indicate accidental ingestion of this seagrass species as it closely resembles one of their preferred seagrass species. Green turtles probably dig for seagrass roots with their flippers, as reported in Derawan Island, Indonesia, because rhizomes were also found in the faecal analysis.

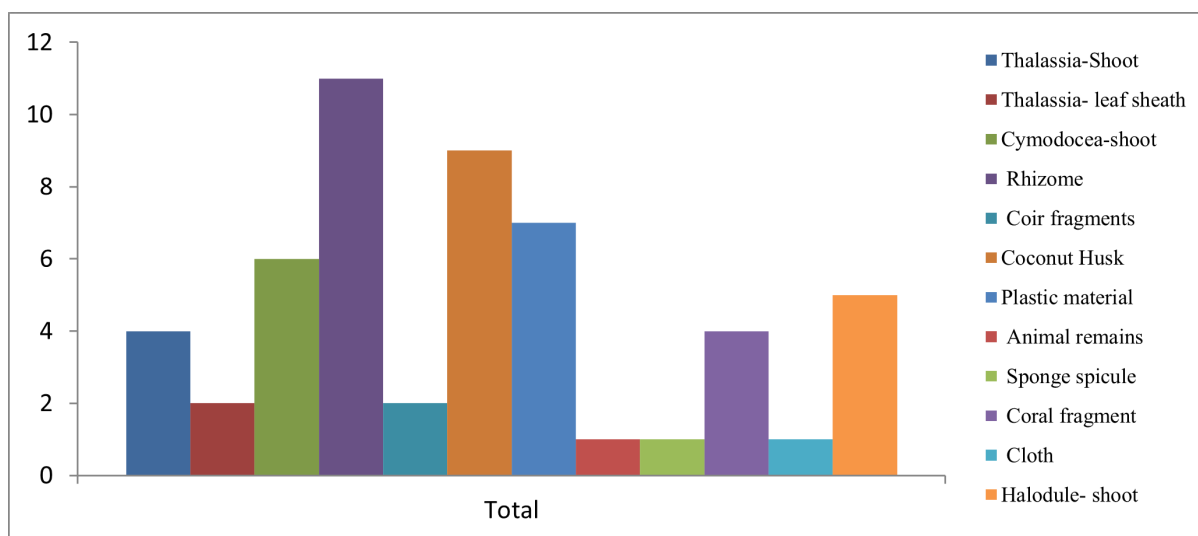


Figure 4. Content of green turtle faecal samples.

## Examining potential fisher-turtle conflicts

Questionnaire surveys were conducted to understand fisher attitudes towards green turtles considering the recent increase in the mega herbivore's numbers. We sought to understand their behaviour towards sea turtles when they got entangled in fishing nets in the lagoon. In these surveys, most fishers responded that they would release turtles by lifting the nets so the turtle could swim away, disentangle the turtle from the nets, or simply lift it out by holding its carapace. Some fishers have also had to cut their nets if the turtle's flippers got entangled in them. Other common responses were that the turtles would break the nets and escape unseen or fishers would scare the turtles away. To scare turtles away, they would hit turtles with sticks on the carapace, make a sound in the water or on the boat, or catch turtles and tie floats/plastic bottles to their flippers to keep them from swimming towards the net. Some fishers chose not to respond or elaborate on their reactions to encountering a turtle or gave multiple responses. Most fishers mentioned that only when thin mesh-sized nets were used and/or when the nets were left overnight or for a long period would turtles get caught and break the nets. The bigger nets were sturdy and rarely broke, so the fishers would just release the turtles. Moreover, due to strict laws in place against the mistreatment of turtles, most fishers said that they resorted to the removal of turtles from the net rather than harming them.

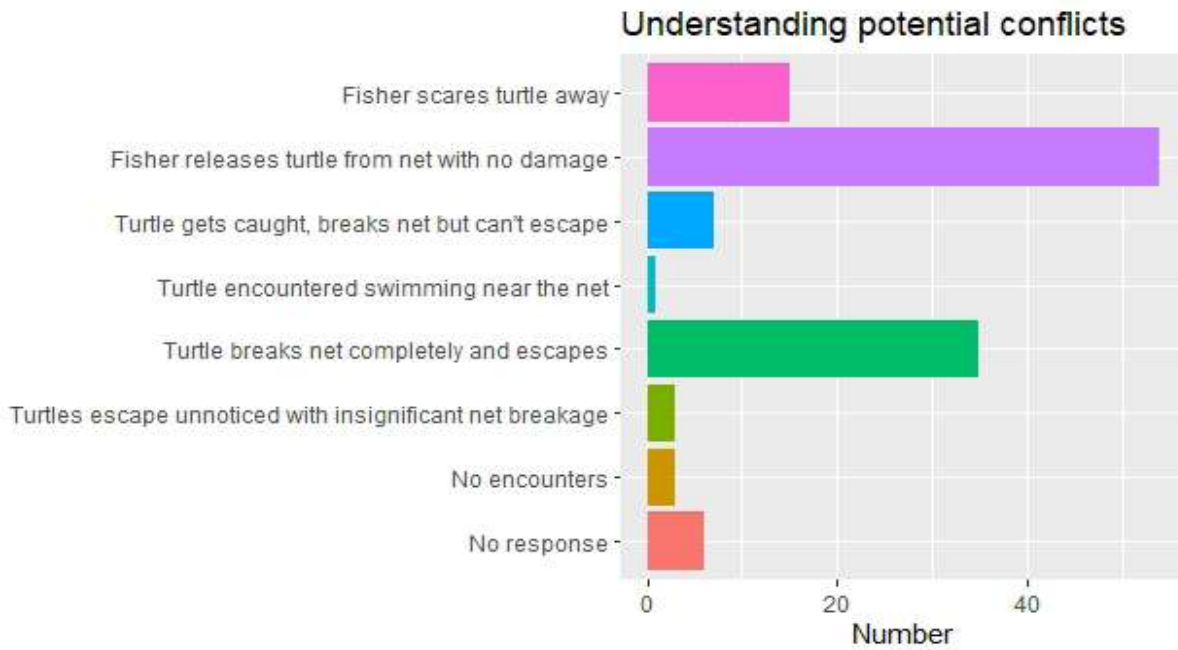


Figure 5. Summary of fisher responses to the questionnaire.

In 2019, most fishers in Agatti perceived a decrease in green turtle numbers. Half the fishers in Kalpeni and Kadmat believed that numbers had increased while the other half believed that numbers had decreased.

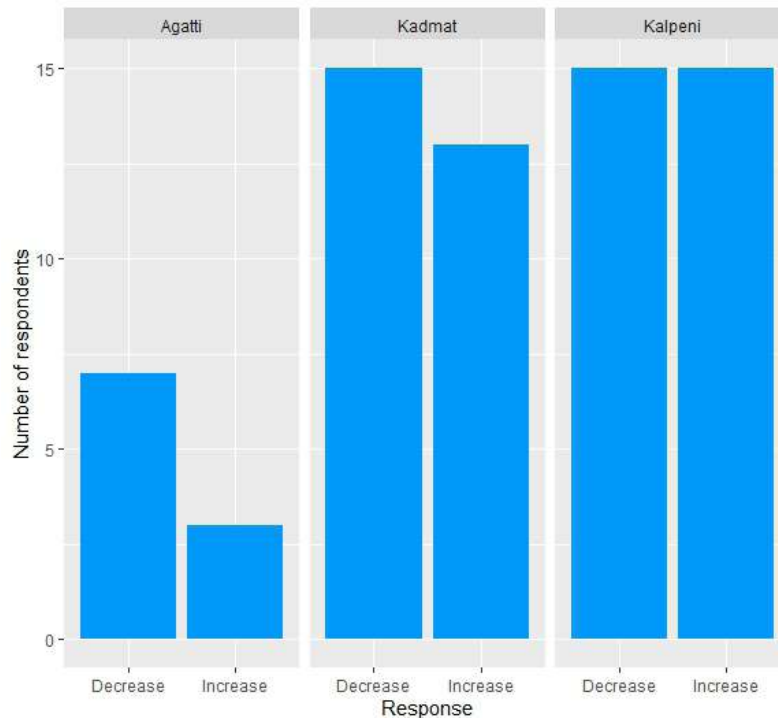


Figure 6. Perceived changes in turtle numbers by fishers.

### *Overlap with fishing activities*

The prime foraging habitats of green turtles are also valuable fishing grounds for fishers of the local community. This overlap sometimes results in damaged nets when a turtle gets entangled. We generated and overlaid maps of high turtle encounters from researcher observations and fishing areas identified by fishers.

Kadmat had fewer areas where overlap was observed, because of low turtle densities. A high density of green turtles in the northern and southern regions of the Kalpeni lagoon resulted in increased overlap with fishing activities. There is a high spatial overlap in Agatti despite the low densities of turtles recorded there. This is because fishers leave their nets in the water for extended periods and sometimes overnight. Fishing activity, thus, has a high spatiotemporal overlap with regions frequented by turtles. Moreover, in recent times, more turtles were also observed on the eastern side of the islands due to the presence of seagrass, which resulted in encounters with fishers.

To keep the fishers informed of regions with turtle presence, the generated maps were distributed to them. These maps could potentially ameliorate direct fisher-turtle conflicts by informing them of regions with high turtle densities.

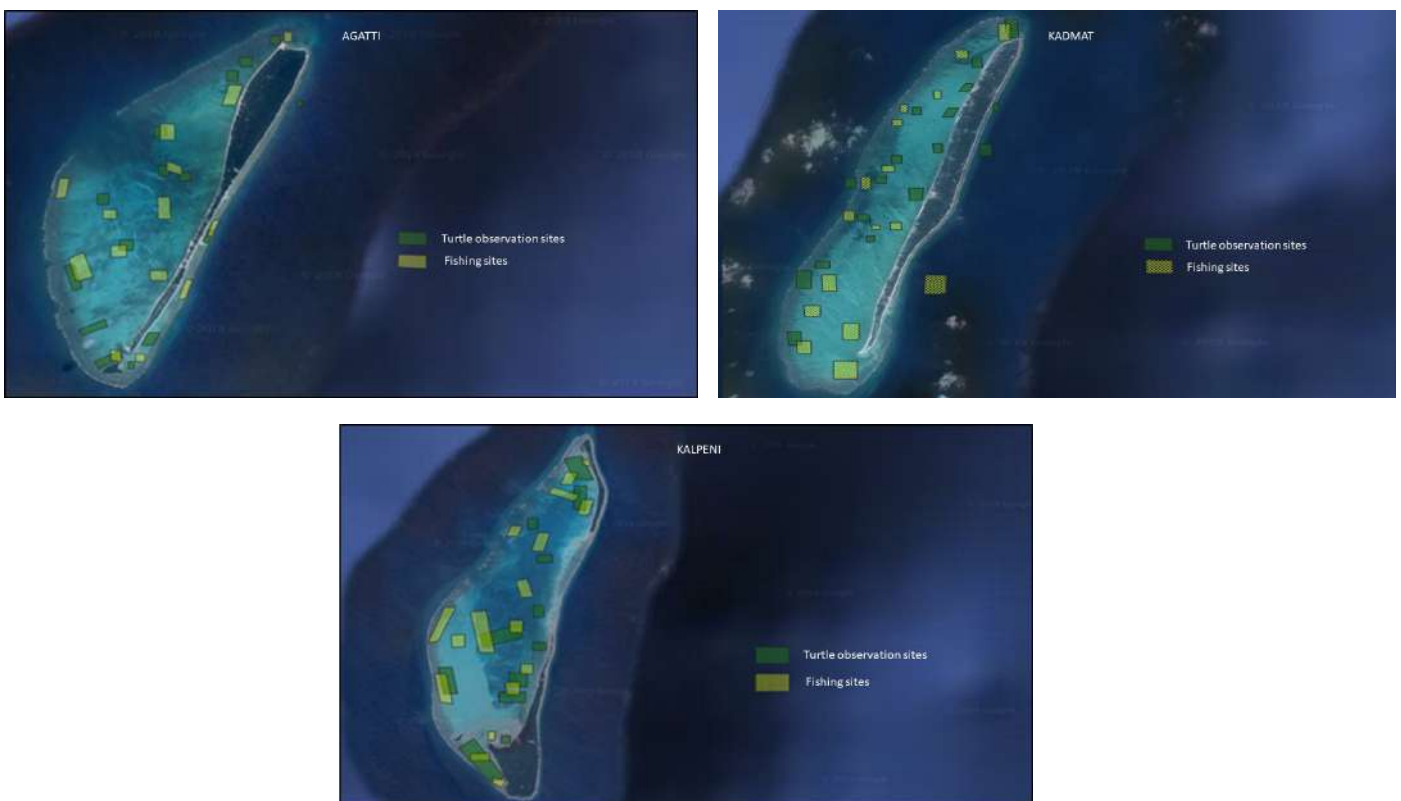


Figure 7. Spatial overlap of fishing activities and turtle encounters in the Agatti, Kadmat and Kalpeni lagoons.

## GPS-LoRa Telemetry System

Initial models of a GPS – LoRa based telemetry system developed by a local tech company, Arcturus Inc., in collaboration with Dakshin Foundation are being tested to be deployed on green turtles in the upcoming field season. The telemetry system will consist of tags equipped with high-sensitivity GPS loggers, long-range radio transmitters, batteries, a salt-water switch (to mount on individual turtles) and receivers in the form of base stations installed in islands and hand-held receivers. Additional funds will be raised to develop 20 tags and 6 base stations to be deployed in the Lakshadweep Islands.



Figure 8. Components of the GPS-LoRa tag.

## Photo-Identification Study

GoPro®s were distributed to professional divers in the islands of Agatti, Kadmat, Kavaratti and Minicoy in December 2019. In the following months, due to Covid-19, tourism in the Lakshadweep Islands was suspended to curb the spread of the virus. However, we received 7 photos (6 green turtles and 1 hawksbill from the Kavaratti island dive centre).



4-115-125-135-145-215-224-235-246-314-323-336-345-354



4-116-125-134-145-216-225-234-244-256-315-324-333-345-414-425-434



5-118-125-135-145-155-216-224-236-246-314-324-336-347-414-425-434-446



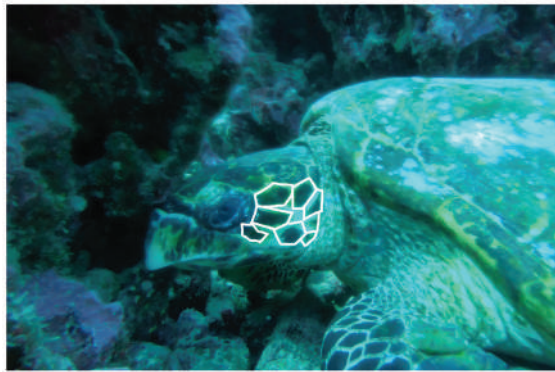
4-116-125-134-145-215-224-235-244-254-315-325-334-346-415



4-116-125-134-145-214-226-235-244-255-315-325-335



4-114-125-135-145-215-225-236-247-314-324-334-344-354-416-426



3-117-125-136-216-225-315-324-335

Figure 9. Green turtles and a hawksbill turtle (last image) observed in Kavaratti (Facial ID code at the bottom).

Outreach material to help professional divers engage with tourists and the public has been designed and will be distributed to dive centres and government offices. These resources are in the form of a fold-a-booklet with a full page sea turtle identification poster on the back and a poster with instructions on how to participate in the study safely and ethically.

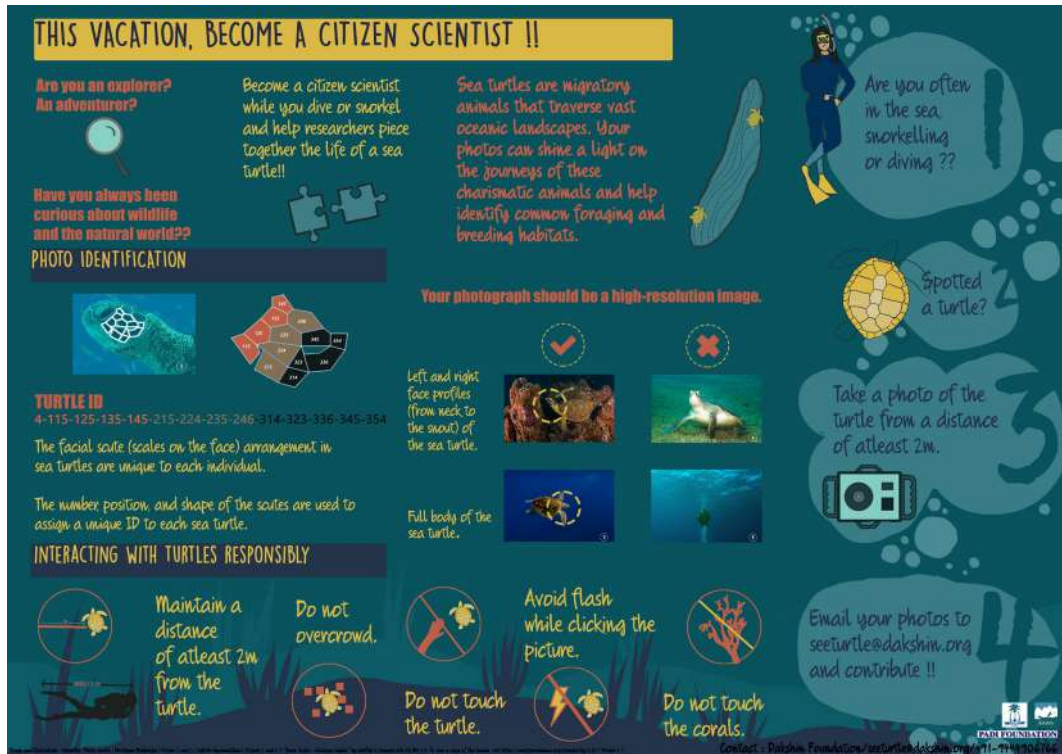


Figure 10. A poster on contributing responsibly to the study.

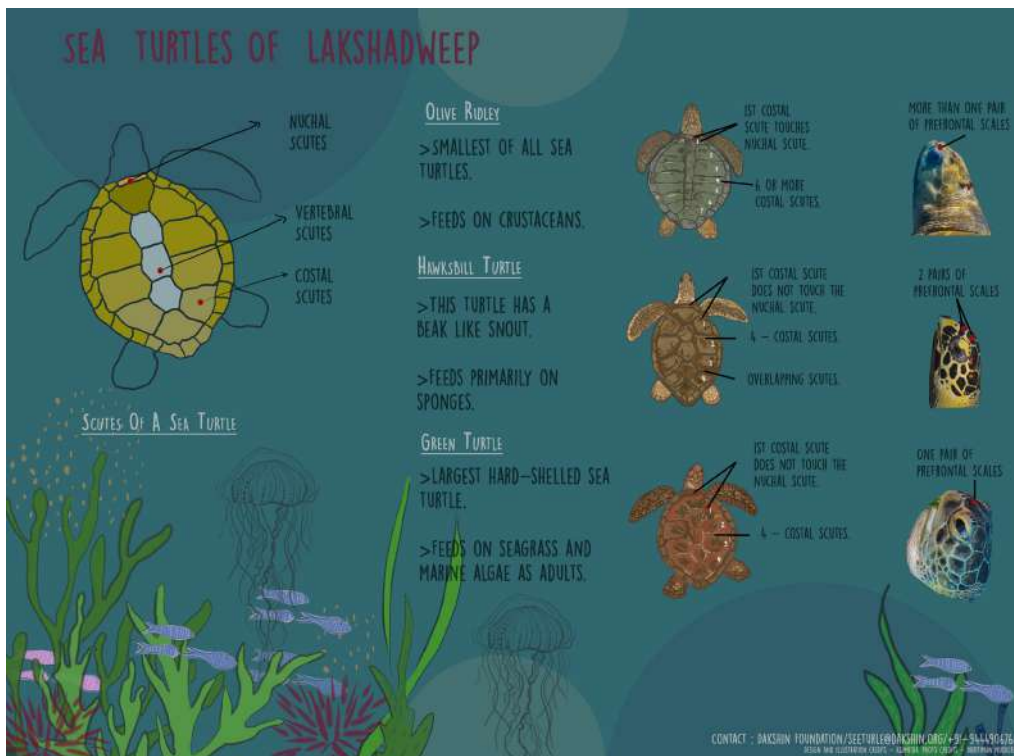


Figure 11. Front view of the fold-a-booklet.



Figure 12. Sea turtle identification guide on the back of the booklet.

### *Future plans*

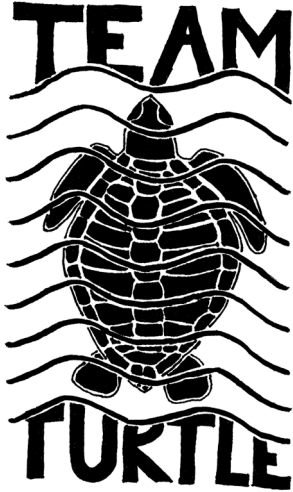
In the upcoming field seasons, we will examine the movement of green turtles at the scale of individuals. We will employ complementary methods of radio telemetry, flipper tagging and photo identification to understand green turtle movement ecology. We will attempt to understand how individual turtles respond to dwindling resources and high intra-specific competition and the mechanisms (environmental triggers) of movement to a new foraging site. Flipper tagging will be used to opportunistically keep track of individual movements, demography, resource use and growth rates. Collection of skin tissue and carapace samples can provide details on genetic structure and past and present dietary components, respectively.

Collectively, these methods will be important in filling the knowledge gaps in green turtle ecology and will effectively inform conservation and management of both green turtles and seagrass.

## APPENDIX IV

### Field staff and project personnel

#### Monitoring personnel



Adhith Swaminathan



Ashwini Petchiappan



Avik Banerjee



Chandana Pusapati



Chetan Rao



Hariprasath R.



Mohit Mudliar



Nupur Kale

## **Project coordinators**



Kartik Shanker



Muralidharan M.

## **Outreach coordinators**



Prakriti Mukerjee



Rhea George

## Odisha field personnel



Bipro Behera



Kedar Rao



Surendra Behera



Shankar Rao



Judishtir Behera



Sriramulu



Magata Behera



Mahendra Nayak



Madhusudan Behera

## Andaman and Nicobar Islands field personnel



Saw Thesorow



Sushil Lakra



Saw Momong



Saw Colombus



Saw Kenik



Vipin Tirkey



Saw Thoma



Yakub Kerketta



Suresh Kujur



Jonsan Topno

## APPENDIX V

### Other achievements by project personnel

#### *Publication & Translation of a Children's Book*

'Moonlight in the Sea' by Kartik Shanker was released on the Storyweaver platform in English and Malayalam. The Malayalam version of this book was also made available in print.



**APPENDIX VI**  
**Member Organisations of TAG**

<b>State</b>	<b>Name of Organisation</b>
Andaman and Nicobar Islands	Andaman and Nicobar Environment Team (ANET)
Andhra Pradesh	Visakha Society for the Protection and Care of Animals (VSPCA)
Andhra Pradesh	Manthini Ujwala Welfare Society
Goa	Coastal Impact
Gujarat	Prakruti Nature Club (PNC)
Gujarat	Green Future Foundation
Karnataka	Field Services and Intercultural Learning (FSL)
Karnataka	Canara Green Academy (CGA)
Kerala	Green Habitat
Kerala	Naythal
Lakshadweep	Lakshadweep Marine Research and Conservation Centre (LMRCC)
Maharashtra	Sahayadri Nisarga Mitra
Odisha	Action for Protection of Wild Animals (APOWA)
Odisha	Alacrity
Odisha	Green Life Rural Association (GLRA)
Odisha	Orissa Marine Resources Conservation Consortium (OM-RCC)
Odisha	Podampeta Ecotourism and Olive Ridley Protection Club (PEORPC)
Odisha	Project Swarajya
Odisha	Rushikulya Sea Turtle Protection Committee (RSTPC)
Odisha	Sea Turtle Action Program (STAP)
Odisha	Odisha Paryavaran Sanrakshan Abhiyan (OPSA)
Odisha	Greenpeace - India
Odisha	WWF - India
Odisha	Wild Orissa
Tamil Nadu	Students' Sea Turtle Conservation Network (SSTCN)
Tamil Nadu	TREE Foundation

National-level organisations and research institutions that support TAG

- Centre for Ecological Sciences, Indian Institute of Science
- Dakshin Foundation
- Greenpeace – India
- International Collective in Support of Fishworkers

- Madras Crocodile Bank Trust
- Wildlife Institute of India
- Wildlife Protection Society of India

Core Committee members of TAG

Odisha - Mr. Mangaraj Panda

Andhra Pradesh - Mr. Pradeep Kumar Nath

Tamil Nadu - Mr. Harish

Kerala - Mr. Sudheer Kumar P.V.

Karnataka - Mr. Jeevan

Maharashtra - Mr. Bhau Katdare

Gujarat - Mr. Dineshgiri Goswami

Islands - Mr. Adhith Swaminathan

## Members organisations of the Turtle Action Group



## **APPENDIX VII**

### **TAG Members Profile**

1. Andaman Nicobar Environment Team (ANET): Andaman and Nicobar Islands  
Unique in being the only organisation based on an island. The Andaman and Nicobar Islands are prime nesting sites for sea turtles of all four species that occur in India, namely green, hawksbill, olive ridley and leatherback.
  
2. Green Mercy: Andhra Pradesh  
An NGO based in Srikakulam, they carry out intensive surveys to give a better picture of the status of sea turtles on the coast of Andhra Pradesh. They also contribute to the conservation of marine and coastal life by holding consultative meetings with fisherfolk and local communities.
  
3. Visakha Society for Protection and Care of Animals (VSPCA): Andhra Pradesh  
Through its innovative awareness programmes, VSPCA intends to educate the masses and build a strong and lasting bond between animals and human societies. They have the field-related expertise necessary for the effective conservation of sea turtles.
  
4. Manthini Ujwala Welfare Society: Andhra Pradesh  
This NGO works in Karnataka to bring awareness to fishermen as well as the community on the importance of conserving sea turtles and the potential of using other forms of nets for fish catch in coastal areas.
  
5. Coastal Impact: Goa  
They conduct webinars on marine life to spread awareness about the marine environment and marine conservation, as well as recruit a number of volunteers to do the same in their individual cities.
  
6. Prakruti Nature Club (PNC): Gujarat  
PNC works along the Saurashtra and Gujarat coasts. Their main focus is the protection of sea turtles, their nests and habitats, whale sharks and other sea creatures. Having an excellent relationship with the Forest Department, they hope to contribute through the collection and distribution of information and data related to turtles.
  
7. Canara Green Academy (CGA): Karnataka  
CGA's main mission has been the conservation of turtles, mangroves and medicinal plants. Along with the Karnataka Forest Department, they have established 40 sea turtle breeding centres all over the Karnataka coastline. Potential sea turtle nesting beaches have been identified and both ex-situ and in-situ conservation is carried out, depending on the security of the nests identified.

#### 8. Field Services and Inter-Cultural Learning (FSL India): Karnataka

They have been successful in creating awareness amongst the fishing community along 60 km of the North Udupi district of Karnataka state. They are unique in placing international volunteers in local community projects to support sustainable development and to bring inter-cultural dimensions to community projects.

#### 9. Green Habitat: Kerala

Green Habitat came into being in 2002 as an independent organisation. The organisation pilots activities for wildlife and environmental conservation in Chavakkad taluk in Kerala. Their areas of focus include the mangroves of Chettuwai, nesting turtles of Chavakkad beach, birds of Enamakkal Kole Island and house sparrows among others. A major part of their efforts at conservation is directed towards environmental awareness and education among local communities in the area.

#### 10. Naythal: Kerala

It is an NGO based in the Kasargod district of Kerala that works on coastal information, conservation and action. It was established in 2001 by a group of local enthusiasts. They have also worked on sand mining issues and work extensively on sea turtle conservation.

#### 11. Lakshadweep Marine Research and Conservation Centre (LMRCC): Lakshadweep

The organisation, established by a group of islanders, is the first that has a primary focus on community-based marine conservation. Lakshadweep has a significant population of endangered green and hawksbill turtles. LMRCC works with the local community, school students, fishermen and the Forest Department to reduce the threats to these ocean ambassadors through education and awareness programmes.

#### 12. Sahyadri Nisarga Mitra (SNM): Maharashtra

They work towards the conservation, awareness and research of the region's biodiversity, focusing on conservation of marine turtles, white-rumped vultures and Indian swiftlets.

#### 13. Action for Protection of Wild Animals (APOWA): Odisha

APOWA believes in finding solutions to animal welfare and conservation challenges that provide lasting benefits for the animals and the community. They have ten years of experience in sea turtle conservation in Odisha through research, conservation and action. Their work is carried out in the buffer zone of the Gahirmatha sea turtle rookery site, the world's largest olive ridley mass nesting site.

#### 14. Alacrity: Odisha

Amongst several others, their sea turtle activity involves imparting awareness to the fishing community residing within the periphery of the Gahirmatha area. They have also developed around 60 'eco-development' groups within the region for the conservation of natural resources including mangrove forests.

#### 15. Podampeta Ecotourism and Olive Ridley Protection Club: Odisha

They address various threats to the nesting turtles by carrying out awareness programmes that inform people in nearby villages about the importance of turtles to the coastal ecosystem and the illegal nature of activities that would harm the turtle population.

16. Rushikulya Sea Turtle Protection Committee (RSTPC): Odisha

With the primary aim to help conserve olive ridley turtles and safeguard their nesting beaches along the Rushikulya coast, they began to monitor the nesting population and assist in the release of hatchlings during mass hatching. They also collect data on tagged turtles, recapture studies, distribution of mating congregations, satellite transmitter ranging studies and monitoring hatchling mortality rates.

17. Sea Turtle Action Program (STAP): Odisha

This is an NGO based at Devi, another mass nesting site in Odisha. They work on sea turtle protection and community empowerment.

18. Green Life Rural Association (GLRA): Odisha

GLRA was formed in 1993 by a group of thirteen committed village youths, who were then working on the Wildlife Institute of India's sea turtle project. Members of GLRA also worked in Operation Kachhapa when it was launched at the time as a joint operation with the Forest Department and Wildlife Protection Society of India. GLRA's activities are focused in the Devi river mouth region.

19. OMRCC: Odisha

It brought together different groups comprising of conservationists, biologists and fisherfolk to meet and interact, with the aim of providing solutions that benefit both conservation as well as livelihoods. They continue to work on the ongoing olive ridley project in Odisha.

20. Odisha Paryavaran Sanrakshan Abhiyan (OPSA): Odisha

It is a voluntary non-profit trust working for the betterment of the local environment, marine wildlife and wildlands by motivating the youth. It believes that, for the long-term maintenance of wildlife populations, connectivity between habitats should be ensured. Its focus area is to promote/facilitate the participatory mode of working between villagers and the government on conservation issues related to olive ridley sea turtle protection, mangrove forest protection, beach clean-ups, promoting awareness among students, etc.

21. Students' Sea Turtle Conservation Network (SSTCN): Chennai, Tamil Nadu

Sea turtle conservation began in 1971 when a few dedicated wildlife enthusiasts began walking the beaches of Chennai to document the status of and threats to sea turtles. The group has been mainly organised and operated by students from colleges, schools and a few young, working adults. The motive has always been conservation and awareness creation.

22. TREE Foundation: Chennai, Tamil Nadu

It involves the fishing community youth (Sea Turtle Protection Force - STPF) in sea turtle protection and conservation programmes in South India. Education and creating awareness at the community level is an integral part of their conservation programme.

More information about the TAG members can be found in the 13th and 14th issues of IOTN.

The links to the issues are:

IOTN-13: <http://www.iotn.org/iotn-13.php> and

IOTN-14: <http://www.iotn.org/iotn-14.php>

## APPENDIX IX

### Statement of Expenditure



Dakshin Foundation  
www.dakshin.org

#### STATEMENT OF EXPENDITURE

**Project Title:** Advancing the conservation of sea turtles in India at a national scale through the monitoring of index sites, and coordination of coastal management efforts with a network of partners.

**Investigator:** Naveen Namboothri

**Consolidated report: 09/08/2018 to 30.09.2021**

Item (Description)	Sanctioned Amount	Expenditures	Sanction Balance	Applicant	Other Sources
Salaries	\$ 116381.00	\$ 116381.00	\$ 0	\$6000.00	\$21000.00 <sup>2</sup>
Travel	\$ 29130.00	\$ 29130.00	\$ 0	\$3000.00 <sup>3</sup>	\$15000.00 <sup>3</sup>
Activities of Partners	\$ 13533.00	\$ 13533.00	\$ 0	\$0.00	\$15000.00 <sup>5</sup>
Production of Outreach material	\$ 32998.00	\$ 32998.00	\$ 0	\$3000.00 <sup>6</sup>	\$24000.00 <sup>7</sup>
Training and workshops	\$ 9054.00	\$ 9054.00	\$ 0	\$0.00	\$42000.00 <sup>8</sup>
Equipment	\$ 6760.00	\$ 6760.00	\$ 0	\$4500.00 <sup>9</sup>	\$12000.00 <sup>10</sup>
Consumables	\$ 4144.00	\$ 4144.00	\$ 0	\$0.00	\$6000.00 <sup>11</sup>
Communication	\$ 2921.00	\$ 2921.00	\$ 0	\$4500.00 <sup>12</sup>	\$3000.00 <sup>12</sup>
Field station rent and maintenance	\$ 8863.00	\$ 8863.00	\$ 0	\$9000.00 <sup>13</sup>	\$3000.00 <sup>13</sup>
Institutional overheads (@10%)	\$ 23165.00	\$ 23165.00	\$ 0	-	
<b>Total</b>	<b>\$ 246950.00</b>	<b>\$ 246950.00</b>	<b>\$ 0</b>	<b>\$30000.00</b>	<b>\$141000.00</b>

  
Naveen Namboothri  
Director



  
Gopi T R  
Finance Manager

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Dakshin Foundation  
www.dakshin.org

**Reporting Period: Year 1 – 2018 to 2019**

Item (Description)	Sanctioned Amount	Expenditures	Sanction Balance	Applicant	Other Sources
Salaries	\$ 37386.00	\$ 37386.00	\$ 0	\$2,000.00	\$7,000.00 <sup>2</sup>
Travel	\$ 7971.44	\$ 7971.44	\$ 0	\$1,000.00 <sup>3</sup>	\$5,000.00 <sup>4</sup>
Activities of Partners	\$ 3225.42	\$ 3225.42	\$ 0	\$0.00	\$5,000.00 <sup>5</sup>
Production of Outreach material	\$ 8981.46	\$ 8981.46	\$ 0	\$1,000.00 <sup>6</sup>	\$8,000.00 <sup>7</sup>
Training and workshops	\$ 5853.59	\$ 5853.59	\$ 0	\$0.00	\$14,000.00 <sup>8</sup>
Equipment	\$ 2311.91	\$ 2311.91	\$ 0	\$1,500.00 <sup>9</sup>	\$4,000.00 <sup>10</sup>
Consumables	\$ 784.97	\$ 784.97	\$ 0	\$0.00	\$2,000.00 <sup>11</sup>
Communication	\$ 898.35	\$ 898.35	\$ 0	\$1,500.00 <sup>12</sup>	\$1,000.00 <sup>12</sup>
Field station rent and maintenance	\$ 2386.38	\$ 2386.38	\$ 0	\$3,000.00 <sup>13</sup>	\$1,000.00 <sup>13</sup>
Institutional overheads (@10%)	\$ 6980.00	\$ 6980.00	\$ 0	-	
<b>Total</b>	<b>\$ 76780.00</b>	<b>\$ 76780.00</b>	<b>\$ 0</b>	<b>\$10,000.00</b>	<b>\$47,000.00</b>



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**Reporting Period: Year – 2 – 2019-2020**

Item (Description)	Sanctioned Amount	Expenditures	Sanction Balance	Applicant	Other Sources
Salaries	\$ 35000.00	\$ 35000.00	\$ 0	\$2,000.00	\$7,000.00 <sup>2</sup>
Travel	\$ 12000.00	\$ 12000.00	\$ 0	\$1,000.00 <sup>3</sup>	\$5,000.00 <sup>4</sup>
Activities of Partners	\$ 4000.00	\$ 4000.00	\$ 0	\$0.00	\$5,000.00 <sup>5</sup>
Production of Outreach material	\$ 8000.00	\$ 8000.00	\$ 0	\$1,000.00 <sup>6</sup>	\$8,000.00 <sup>7</sup>
Training and workshops	\$ 3200.00	\$ 3200.00	\$ 0	\$0.00	\$14,000.00 <sup>8</sup>
Equipment	\$ 1600.00	\$ 1600.00	\$ 0	\$1,500.00 <sup>9</sup>	\$4,000.00 <sup>10</sup>
Consumables	\$ 1600.00	\$ 1600.00	\$ 0	\$0.00	\$2,000.00 <sup>11</sup>
Communication	\$ 1600.00	\$ 1600.00	\$ 0	\$1,500.00 <sup>12</sup>	\$1,000.00 <sup>12</sup>
Field station rent and maintenance	\$ 2800.00	\$ 2800.00	\$ 0	\$3,000.00 <sup>13</sup>	\$1,000.00 <sup>13</sup>
Institutional overheads (@10%)	\$ 6980.00	\$ 6980.00	\$ 0	-	
<b>Total</b>	<b>\$ 76780.00</b>	<b>\$ 76780.00</b>	<b>\$ 0</b>	<b>\$10,000.00</b>	<b>\$47,000.00</b>


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**Reporting Period: Year – 3 – 2020-21**

Item (Description)	Sanctioned Amount	Expenditures	Sanction Balance	Applicant	Other Sources
Salaries	\$ 43995.00	\$ 43995.00	\$ 0	\$2,000.00	\$7,000.00 <sup>2</sup>
Travel	\$ 9159.00	\$ 9159.00	\$ 0	\$1,000.00 <sup>3</sup>	\$5,000.00 <sup>4</sup>
Activities of Partners	\$ 6308.00	\$ 6308.00	\$ 0	\$0.00	\$5,000.00 <sup>5</sup>
Production of Outreach material	\$ 16017.00	\$ 16017.00	\$ 0	\$1,000.00 <sup>6</sup>	\$8,000.00 <sup>7</sup>
Training and workshops	\$ 0.00	\$ 0.00	\$ 0	\$0.00	\$14,000.00 <sup>8</sup>
Equipment	\$ 2848.00	\$ 2848.00	\$ 0	\$1,500.00 <sup>9</sup>	\$4,000.00 <sup>10</sup>
Consumables	\$ 1759.00	\$ 1759.00	\$ 0	\$0.00	\$2,000.00 <sup>11</sup>
Communication	\$ 423.00	\$ 423.00	\$ 0	\$1,500.00 <sup>12</sup>	\$1,000.00 <sup>12</sup>
Field station rent and maintenance	\$ 3677.00	\$ 3677.00	\$ 0	\$3,000.00 <sup>13</sup>	\$1,000.00 <sup>13</sup>
Institutional overheads (@10%)	\$ 9205.00	\$ 9205.00	\$ 0	-	
<b>Total</b>	<b>\$ 93390.00</b>	<b>\$ 93390.00</b>	<b>\$ 0</b>	<b>\$10,000.00</b>	<b>\$47,000.00</b>

*N. N. N.*  
  
*T. R. Gopi*

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**Dakshin Foundation**  
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- 1 – Based on the revised research scholar pay scales assigned by the Central Ministry
- 2 – Salary support for Project supervisors Naveen Namboothri from Dakshin Foundation, Bangalore & Kartik Shanker from the Ashoka Trust for Research in Ecology and the Environment
- 3 – Travel support from MCBT
- 4 – Travel support from Indian Institute of Science and Dakshin Foundation
- 5 – Contributions from the Andaman and Nicobar Environment Team (ANET) and Dakshin Foundation
- 6 – In kind contributions from MCBT towards production of outreach material Andaman and Nicobar Islands
- 7 – Support for the Indian Ocean Turtle Newsletter and other materials from Dakshin Foundation
- 8 – Support from Dakshin Foundation and local government agencies for training and workshops
- 9 - In kind support (equipment, material, etc.) from MCBT
- 10 - In kind support (equipment, material, etc.) from Indian Institute of Science and partner organisations
- 11– Support for general consumable resources from MCBT and Indian Institute of Science and Dakshin Foundation
- 12 - Support for communication expenses from MCBT and Indian Institute of Science and Dakshin Foundation
- 13 – Support for field stations from Indian Institute of Science and Dakshin Foundation



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*For more information visit  
[www.seaturtlesofindia.org](http://www.seaturtlesofindia.org)*

Cover photo: An olive ridley sea turtle coming ashore to nest at Rushikulya, Odisha

by Arghya Adhikari

